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WHERE IS THE EARTH OBSERVATION INDUSTRY *HEADING?*

The combination of improvements in launch systems, advancements in sensors and innovations such as the use of commercial-off-the-shelf technology for space applications has unleashed a plethora of opportunities for the earth observation industry.

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- ***Policies for Earth Observation P35***

P06

Corner Office
Payam Banazadeh
Founder and CEO
Capella Space

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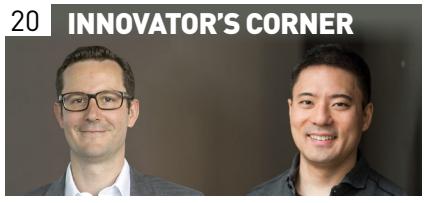

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Making the EO Magic Work

Prof. Arup Dasgupta
Managing Editor,
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One of the geospatial highlights of the month of July is the Esri User Conference at San Diego. This time, there was an interesting conversation between Jack Dangermond, Jane Goodall and EO Wilson. In a freewheeling discussion, they talked about what ails the Earth and what we can do about it. Kicking off the discussion, Wilson spoke about the major dangers that included Climate Change, water shortage and mass extinction of species. He spoke about a project called 'Half Earth', which aims to create reserves all over the world to foster and protect the biodiversity of different ecological regions. One of the key factors in this effort is the mapping of biodiversity and the identification of possible reserve areas.

This brings us to the theme of this edition of *Geospatial World*, earth observations — the most important tool for all mapping. Though earth observation has been around for several decades, somehow, one gets the feeling that we haven't seen the best yet. It is not about sensors, their variety, their radiometric, spatial and temporal resolutions. It is more about the accessibility of data and applications. Capella Space Founder & CEO Payam Banazadeh has made an interesting comment in an article in this issue. He says that in a world where business is conducted through emails and text messages within seconds, waiting eight hours to receive a satellite image just seems "archaic and impractical". It might be added here that for some users, even an eight-hour wait is magical, when the norm is days and weeks, if not months.

What holds up the data delivery is the centralization of data processing and the regulatory environment and the processes therein. Earth observations and its applications are no longer the preserve of national governments. Private industry has made significant inroads, but the irony is that governments are the biggest, and in many cases, the only customer. Thus G2B and B2G rule, while B2B and B2C are expected to become significant only by 2025. Meanwhile, global enterprise and national laws often work at loggerheads, thus complicating the process of assimilation and institutionalization of the technology.

Add to this the discovery of the Middle Earth Orbit by both EO and communications players and we have a scenario for the Kessler Syndrome to kick in. As CubeSats abound and SpaceX and Amazon get into the game, the challenge will be faced both by Planet, the company and planet Earth. Thus the interest in space environment has become significant enough for the UN to address long-term sustainability of the space. So far, 21 out of 28 recommendations have been adopted by consensus and await the General Assembly's nod to turn into principles. When these will become part of the Outer Space Treaty or a treaty by themselves is an issue to be addressed.

Returning to terra firma, the UN efforts on Sustainable Development Goals need to be better addressed and while earth observations can play a strong role, the actual scenario belies this hope. Efforts by the UNGGIM in addressing this lacunae show promise. EO can be used very effectively for providing actionable information for three major goals for public good: Climate Change, water and sustainability. This requires both government and non-government agencies to work together and address these areas. It goes without saying that these three are interlinked. For example, Climate Change is affecting biodiversity and causing flora and fauna to migrate to cooler climes, a fact brought out by Jane Goodall. This brings about the unsustainability of present practices to the changing scenario. The water crisis is also an effect of Climate Change, as precipitation patterns change causing both drought and violent weather events to become common all over the globe, with both hitting vulnerable populations.

Earth observation is an excellent tool for commerce, administration, natural resources management and environmental management, but it is not a magic wand. It needs governments, industry, academia and the public to put their efforts together to make the magic work. It needs enabling policies and regulations for both Earth and space environments.

Building a Real-Time, On-Demand Solution for the 21st Century

In a world where business is conducted through emails and text messages within seconds, waiting eight hours to receive a satellite image just seems archaic and impractical, says **Capella Space Founder & CEO Payam Banazadeh**, as he explains how he plans to change that

Before founding Capella Space, you were employed at the NASA Jet Propulsion Lab, where your work on two missions got you the Mariner Award. How and when did you decide to move, and how was the idea of Capella Space conceived?

I started my career as a Systems Engineer at JPL after having interned there four times in a variety of capacities. I was lucky to have been part of the founding team for a few very innovative and exciting small-satellite projects, including the Lunar Flashlight — a micro-satellite flying to the moon using a solar sail that mapped ice-water deposits in the permanently shadowed craters, and NEA Scout — a micro-satellite flying to a near Earth asteroid for imaging and reconnaissance.

After a few years, I decided to go back to school and completed a business degree from Stanford University. Immediately after I arrived on the campus, the Malaysian flight MH370 tragically went missing and was never found. I was shocked and disappointed, that with all the resources and technology at our disposal, we could not locate or determine what happened to a plane!

Capella was born out of that frustration. I spent the next two years of my graduate degree asking myself why we are not able to monitor our planet much more frequently and work on a plan to ensure that an unexplained tragedy like MH370 never happens again.

As I understood more about the challenges of timely and reliable remote sensing, Synthetic Aperture Radar (SAR) emerged as an all-weather, all-condition imaging technology for increasing the coverage and frequency with which we could observe change on Earth. If you look across the market, there actually aren't that many SAR providers. Majority of small satellite players are focused on traditional sensors such as optical. Capella is uniquely positioned as the only commercial American SAR company and we will play a key role in shaping the next generation of geospatial information from space. We intend to be the gamechanger by being the most frequent, flexible and timely in delivering satellite imagery.

Which are the sectors that you are serving primarily and new areas you plan to tap into?

Defense and Intelligence is a critical vertical for our company as governments are the traditional

users of SAR data. We are bringing a key value proposition to our government customers as the fastest to task, acquire and deliver high-resolution imagery with the Capella constellation of satellites. We are also unclassified, which means our data can be shared easily throughout the government, and we will have the fastest reactivity and best revisit time over any other satellite provider in the world.

However, we also see tremendous opportunity outside of government, as businesses look for a competitive advantage. By monitoring key areas of interest like major cities, ports, shipping lanes and critical infrastructure, we can provide reliable and consistent information flows to many verticals, from insurance and finance to agriculture and shipping. We are looking to open up new possibilities, markets and applications for remote sensing data, as we move closer to real-time and on-demand capability.

Capella plans to soon offer hourly coverage of every point on Earth, rendered in sub-meter resolution, through the world's largest constellation of radar satellites. What is the current status of your constellation and near-time launch plans?

We launched our first pathfinder satellite called Denali in December 2018. Denali is operational and we have validated both our space system design as well as our network of ground infrastructure. Our next satellite, Sequoia, will be our first commercial imaging satellite, which will be launching on an Indian PSLV by 2019 end. After Sequoia, we have Whitney, a constellation of six satellites, already in production, that will launch in mid-2020, and will get us global coverage every six hours. We plan to continue adding batches of six satellites until we are at the full constellation of 36 by 2022, which will meet our target of one hour revisit to any point on the globe.

A very important development in the small satellite industry has been the use of commercial-off-the-shelf (COTS) electronics in satellites, popularized by Planet. How much of COTS electronics does Capella use and how you think this has a bearing on the total operational cost?

We certainly use COTS where and when it makes sense. As an example, we are flying an NVIDIA GPU on all our satellites which allows us to do real-time on-board processing of our imagery for advanced missions. However, we have been careful when it comes to sourcing components in order to balance reliability with cost. Our satellites are designed to work for three years; so, what matters to us is consistent and reliable service to our customers, which we provide by replenishing the constellation at regular intervals with more advanced spacecraft. This allows us to keep improving capabilities in space at pace with advancements in technology.

Capella has an archive on the Cloud where users can search for high-resolution images and download them. How do you maintain such an extensive archive and make it user-friendly?

This is absolutely critical. There are many barriers that have limited the availability of useful satellite imagery, and as a result we haven't seen the kind of software and application development using this data that you see in other industries. Our industry is completely outdated when it comes to providing a user-friendly, timely and easy service. We still rely on manual processes — phone calls, fax machines, hard drives through the mail, FTP sites – to service orders. At Capella, we are building our entire infrastructure on the Cloud, paying significant attention to the user experience, and providing instant access to the most timely and fresh data available.

Our 'live maps' product, for example, will draw from regular observation of thousands of most active ports, cities and points of commerce in the world, and make this information available at the click of a button and at a fraction of the price of current SAR data providers. You don't have to order this data, wait for the order to be received, wait for a satellite to be tasked, wait for the image to be processed and delivered — it is already there for you in the Cloud, ready to be used. By opening up access to the most timely data available from places that people care about the most, I firmly believe that satellite imagery will become a critical piece in how businesses, NGOs, governments, and analysts and developers make decisions, build applications and bring value to their work.

Space 4.0, which is closely intertwined with the Fourth Industrial Revolution, is going to shape the future of earth Observation. Do you think we aren't too far from a scenario where technologies like AI, Machine Learning and Big Data will be literally driving the industry?

> Capella is uniquely positioned as the only commercial American SAR company, and we will play a key role in shaping the next generation of geospatial information from space

We are seeing the merger of a few key technologies that are critical in satellite imagery analysis. These technologies are becoming accessible and easy to use — miniaturization of electronics, increase in computational power and its scalability at a reasonable cost, Machine Learning that feeds off Big Data and dedicated small launch vehicles lowering the barriers to entering space. These are all critical to the rise of the remote sensing industry. There would simply be too much data and not enough eyes to look through it if we couldn't store it in the Cloud, use edge computing to process quickly, and deploy Machine Learning algorithms for automated extraction of information.

How, according to you, will commercialization and democratization of Earth observation impact social, economic and industrial processes?

I think about this a lot. I generally am of the belief that democratizing access to information about our planet at the global level will bring a layer of transparency, and therefore accountability, across all domains, including social, economic and even political. In a world where "fake news" is spreading virally, the ability to provide ground truth and to quantify and qualify what's happening on the ground, will allow us to better validate what we hear in media or in politics. I also believe that our world is too globalized for us to not have access to a global archive of our social, economic and political interactions. A century ago, we could have ignored events that are happening in a neighboring continent or country, and only focused on our own local problems. In the 21st Century, we are simply too intertwined and connected as a species to ignore such interactions. Space is one of the only vantage points where that global archive can be created. We need to get a lot better at understanding the links between events and people in our global world.

The threat of global warming has become more real than ever. In such a scenario, do you see earth observation data playing a key role in disaster planning/ management, and will its use for near and real-time environmental monitoring become mainstream?

Absolutely. This one is really close to my heart. We are taking more resources out of the environment while pumping back into it enormous quantities of waste and poison, thereby changing the composition of soil, water and atmosphere.

Habitats are getting degraded and animals and plants are becoming extinct. Satellite imagery can give us insight into some of these changes, such as the Great Barrier reef off Australia and in the Amazon rainforest. The best scientific estimates indicate that unless we dramatically cut the emission of greenhouse gases in the next 20 years, average global temperatures will increase by more than 3.6 degree F, resulting in expanding deserts, disappearing ice caps, rising oceans, and frequent extreme weather events. The impact of such events will go as far as endangering our food security through decrease in agriculture production, and will create mass migration crisis as people move from uninhabitable regions.

We need to build non-terrestrial infrastructure that allows us to monitor, predict, manage and help mitigate and control such disasters before, during and after they occur. And space, again, is going to be critical in all those phases, especially in an all-day, all-weather system like Capella's.

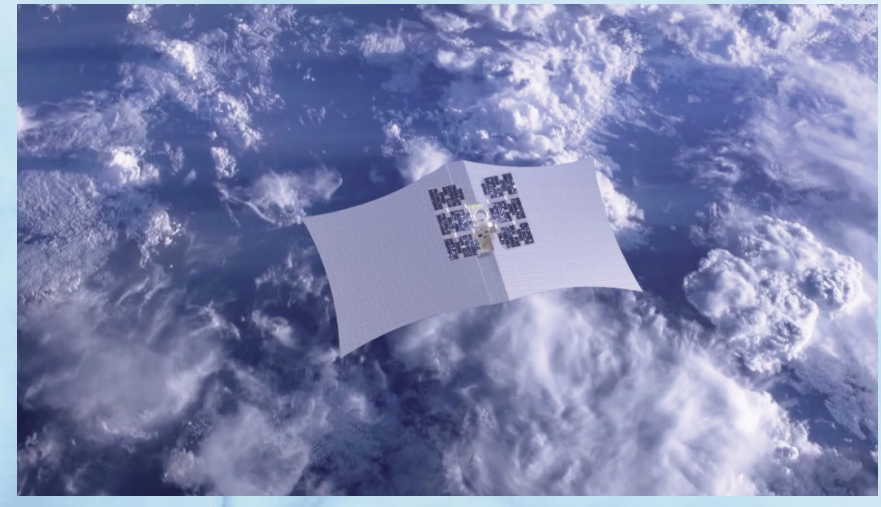
What has prevented people from adopting remote sensing in business applications and how does Capella plan to change that?

There are countless barriers to using satellite imagery in business today. Lack of consistency and reliability, fixed imaging windows, latency and slow reactivity, insufficient resolution, cost and complexity are some of them.

If you are a commercial business you would have to spend thousands of dollars to order a single SAR image through a very painful ordering system that is outdated, slow and hard to work with, only to realize that you might get bumped, cancelled, or have to wait hours or even days to have your order fulfilled.

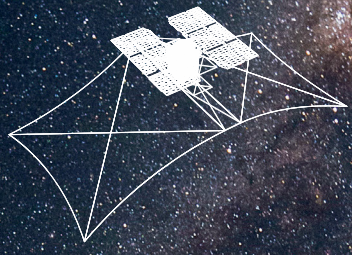
In a world where business is conducted through emails and text messages within seconds, waiting eight hours to receive a satellite image just seems archaic and impractical. Add to this the inability of the majority of satellites to do imaging when it's cloudy or dark, and you are left with a service that is unreliable, data that is out of date, and a transaction that is prohibitively expensive for many who would benefit from better geospatial information.

SAR solves the reliability issue by allowing us to guarantee a collection independent of weather and light conditions, and Capella is building the infrastructure and customer experience to create a real-time, on-demand solution for the 21st Century.



Capella's satellite uses synthetic aperture radar; it can see through clouds and also collect imagery at night time

PERSISTENT MONITORING FROM SPACE



Capella Space provides the most frequent and timely SAR data for monitoring change on our planet.

With flexible imaging modes and the fastest reaction time from order to tasking to downlink to delivery, we make reliable, high resolution Earth observation more available, accesible and affordable for governments and businesses.

FREQUENT

Maximum hourly revisit to any point on the globe and InSAR repeat passes every 4 hours*

TIMELY

90 minutes or less to task, acquire, and deliver SAR imagery

FLEXIBLE

Left and right looking imaging modes with 0.5 m resolution

Capella Space

*with full constellation

SUSTAINABLE PUBLIC TRANSPORT

The world has united to turn UN's Sustainable Development Goals into reality. A practical and efficient transport system plays a crucial role in this process. **By Ananya Narain**

Sustainable public transport is at the heart of United Nation's 2030 Agenda for Sustainable Development and the 17 Sustainable Development Goals (SDGs). An efficient public transport system connects people, communities and societies, builds new markets and enhances the overall quality of life. To achieve SDGs, governments all over the world are recognizing the significance of reliable and affordable public transport. And like in all other sectors, technology has a crucial role to play here too!

Connecting people with sustainable transport & SDGs

Many countries have identified the impact of an efficient public transport system on socio-economic conditions and its importance in meeting the goals, targets and indicators of the 2030 Agenda. A sustainable mobility system ensures that the benefits of public transport are concentrated around three crucial goals — Goal 3: Good Health and Well Being (road safety); Goal 11: Sustainable Cities and Communities; and Goal 13: Climate Action (Climate Change adoption and mitigation). Interestingly, efficient public transport also enables countries to achieve Goal 8: Decent Work and Economic Growth; Goal 9: Industry, Innovation and Infrastructure; Goal 10: Reduced Inequalities; and Goal 12: Responsible Consumption and Production.

A good example of public transport contributing to SDGs can be found in Norway, where an efficient system has ensured more employment, economic development, checks on Climate Change and environmental impact, and of course, better road safety. "In Oslo, the number of people using public transport has rapidly increased, while the number of car journeys has remained same, which is in a way good for climate and livability of the city," says Bernt Reitan Jenssen, CEO, Ruter AS, Norway.

Citing the example of Stockholm, Henrik Henriksson, CEO, Scania, Sweden, stresses on the critical role played by sustainable public

Navya Group's Smart Mobility vehicle 'Holo'

transport in achieving Goal 13 (Climate Action). "Stockholm is one of the first capital cities to have taken Climate Change into account and have built public transport entirely on non-fossil. It has taken a stand to have non-fossil public transport by 2030." For cities to transform so that they become more livable and competitive, there is a need for 'holistic thinking', which can provide sustainable solutions to benefit the environment and the people alike. "That is the best way for us to protect our sanctuary. What was agreed in Paris (Climate Change Agreement) was to not wait for a perfect technical solution by a company — we need to act here and now and public transport is one of the solutions," says Henriksson.

The story is no different in Asia-Pacific region. As urbanization and traffic congestion get closer to the tipping point, governments have taken several measures to develop mass public transport systems. For instance, Singapore has expanded its transportation network with

Scania's 'NXT', a new battery electric self-driving urban concept vehicle

ease. Hoon Ping Ngien, CEO, Land Transport Authority, Singapore, underlines that public transport is the economic lifeline of the country and is built to achieve the goals outlined in the Land Transport Master Plan 2040. "The Land Transport Master Plan 2040 is based on the research of last 20-30 years and includes public consultation from industry, users, passengers and academia. The entire transport ecosystem in Singapore is involved in innovations. For example, we are a testing ground for autonomous vehicles. We welcome innovation and look forward to working with companies to help solve issues concerning public commuting." Singapore's mass transit network is directly linked to Goal 8, 9 and 11 of the 2030 Agenda.

Autonomous vehicles for sustainable transport

To achieve sustainable mobility, adoption of technology is a must. Corporate organizations and national and local authorities need to be open to new public transport mobility systems and new technology innovations to provide better services, plan road systems, regulate traffic, etc. Autonomous vehicles have the potential to transform public transport by tackling the challenges of road safety, Climate Change and air pollution. Policy-makers are foreseeing autonomous vehicles as a crucial technological breakthrough for safe and sustainable cities. The new generation autonomous vehicles are expected to be electric, leading to reduction in fossil fuel consumption in the near future. Further, several emerging renewable energy sources are expected to power these vehicles, bringing down carbon emissions and air pollution levels.

"The action is happening in the cities; we need to use biofuels and electrification to transform public transport. Self-driving vehicles will change the whole ecosystem of our cities," says Henriksson. David Brown, CEO of Go-Ahead Group, United Kingdom, points out that to address the issue of air pollution, London has chosen to focus on UN's goal on Climate Change as it can have a greater impact. "Going ahead, we have the largest electric bus fleet in the UK. We plan to increase the number of such buses on streets for city sightseeing tours (in Oxford and Brighton) and everyday use," he says.

The way forward

By 2050, two-third of the world's population is expected to live in cities. In a way, we are racing against time, and innovations in electric and autonomous vehicles are necessary to minimize Climate Change and enhance road safety. That's why new designs and innovations, and spatial data and technology are critical to building a sustainable public transport system. There is need for better technology, large-scale investments, efficient infrastructure development and security to ensure that transport systems are in sync with our cities' design.

According to El Hadji Oumar YOUM, Minister of Infrastructure, Land Transport and Accessibility, Senegal, the current scenario presents a whole lot of challenges and opportunities. "When it comes to public transport, our objective is to develop roads by looking at our customers. We need to optimize public transportation with regulation at the national level; we need to increase train and bus rides and converge all economic activities. Only then can we achieve SDGs," he says.

A sustainable and efficient transportation system is fundamental to good living. During the recent Global Public Transport Summit (2019) organized by International Association of Public Transport (UITP) in Stockholm, world leaders unanimously recognized this fact. "We have to ask important questions while framing urban transport policies. We have to ask how can public transport increase livability and address Climate Change; how does public transport bring value to cities; and how can technology innovations drive the public transport ecosystem in countries?" asks Bernt Reitan Jenssen.

Maybe we need to collectively ask these questions and find answers to them.

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NEW SPACE NEW BUSINESS MODELS

Improvements in launch systems and innovations such as the use of commercial-off-the-shelf technology for space applications are driving down costs, while a diverse range of sensors are bringing in greater spatial resolution, higher temporal cadence and richer spectral coverage. This combination of decreased cost and increased capabilities is unleashing a plethora of opportunities for the earth observation industry, opening the doors for new-age startups and innovations. **By Anusuya Datta**

January 1999: *Two professors from California Polytechnic State University and Stanford University developed the concept of a very small spacecraft to enable students and researchers worldwide perform space exploration.*

June 2003: *World's first six cubesats were placed in orbit by Germany's Eurockot vehicle from Russia's Plesetsk launch site.*

January 2014: *Planet Labs, a California-based company founded by three former NASA engineers, launched 33 cubesats in orbit from the International Space Station.*

February 2017: *The Indian Space Research Organisation launched a record 104 satellites on a single rocket. The combined payload of about 1,380 kg consisted of 101 nanosatellites from five different countries, including 88 from US-based Planet.*

The Planet satellites, each weighing as much as a bread loaf — as against the traditional school bus-sized satellites that took years to build and millions of dollars of investment — opened up a new era in earth observation. Since 2014, hundreds of small satellites have been launched. What was once niche has today become a booming business, with estimates putting the number of small satellites to be launched between 2018 and 2027 in the range of 6,500-7,000.

Such advancements not only promote innovation and democratize access to space, but also mean easy availability of a lot of data. At the same time, improvements in launch systems and innovations such as the use of commercial-off-the-shelf technology for space applications are driving down costs, while a diverse range of sensors are bringing in greater spatial resolution, higher temporal cadence and richer spectral coverage. This combination of decreased cost and increased capabilities is unleashing a plethora of opportunities in earth observation — from monitoring pollution and agriculture to tracking commercial shipping and pre-empting/managing disasters.

In addition to heavy government push, the surge in investments by billionaires such as Elon Musk, Jeff Bezos and Richard Branson, and more recently venture capitalists, has provided the much-needed fillip to the industry. Nearly $3 billion in equity capital was invested in space companies globally in the first two quarters of 2019, according to a report by Space Angels, a leading source of capital for early-stage space ventures. This brings the cumulative total invested in 476 space companies since 2009 to $22.3 billion.

With 200+ satellites in orbit and the ability to monitor all of Earth once a day, Planet is a veteran of the game, a game that compelled industry heavyweight Maxar (formerly DigitalGlobe) to get into the small satellite business. Maxar is currently building WorldView Legion, a constellation of numerous small satellites that will replace its three oldest satellites (WorldView-1 and 2 and GeoEye-1). While the exact number of satellites that will make Legion is not known, the first launch is scheduled in

early 2021. Once complete, Legion will be able to revisit spots 15 times a day.

New technologies opening new vistas

Optical imaging has benefited from smaller and cheaper spacecraft for a long time. Now, a crop of new brave space startups is venturing into the niche market of synthetic aperture radar (SAR).

"Fitting synthetic aperture radar technology into a satellite under 100 kg was deemed largely impossible before we did it," points out **Mikko Keränen, Vice President (Marketing) of Finland-based ICEYE**.

While NASA has been using synthetic aperture radar since the 1970s, it is only recently that the US has started allowing commercial SAR satellite players to operate. In 2015, Arlington-based XpressSAR became the first American company to get a license from the Department of Commerce to operate a private, commercial, space-based, SAR remote sensing system. While the first XpressSAR satellite is to be launched in 2022, San Francisco-based Capella Space, a startup founded in 2016, seized the opportunity and launched its satellite in December 2018 — the first of its 36-satellite constellation planned by 2022.

Capella will use radio waves to provide hourly coverage of every point on Earth, rendered in sub-meter resolution. "SAR has emerged as an all-weather, all-condition imaging technology for increasing the coverage and frequency with which we could observe change on Earth. [But] if you look across the market, there actually aren't that many SAR providers, with majority of small satellite players focused on traditional sensors such as optical," says **Payam Banazadeh, Founder & CEO of Capella Space.**

"The demand for radar imaging (SAR data) has always been very high. It has simply been incredibly costly and plain difficult to make these satellites in the past, which has limited its use more broadly," explains Keränen.

After its maiden launch last year, on July 5 this year, ICEYE launched two more SAR satellites — each weighing less than 200 pounds — on a Soyuz rocket. The company is on track to launch a total of five missions this year.

"ICEYE is aiming to serve commercial customers with imaging from their locations of interest as often as every few hours. This would require an 18 SAR satellite constellation," says Keränen. However, the number is highly dependent on customer needs.

HawkEye 360, headquartered in Herndon, Virginia, has a more innovative approach as it seeks to deliver a brand new geospatial data layer that has never been available commercially — precise mapping of radio frequency emissions. This too was a domain of governments, but technology advancements have enabled the company to deploy the first-of-its-kind commercial constellation of formation flying satellites that can identify and independently geolocate a broad range of RF signals on Earth through triangulation.

"Among our distinctive capabilities, we are able to identify and independently geolocate a variety of RF signals. Common signals of interest include locating emitters such as maritime radars, VHF push-to-talk radios, vessel Automatic Identification System (AIS) transponders, satellite terminals and cellular towers," says **Adam Bennett, Product Marketing Director, HawkEye 360.**

Currently, the company has three satellites in orbit — launched in December 2018 by a SpaceX Falcon 9 — with each one capable of tuning across most of the frequency range from 144 MHz to 15 GHz. These low-Earth orbiting satellites are in a sun-synchronous polar orbit and their large field of view makes it possible to sense RF signals at every point on the planet multiple times a day. "Our second cluster of satellites is already under development and our goal for a fully operational constellation is to reach six clusters (18 satellites), allowing us to achieve a revisit rate every 30- 45 minutes," adds Bennett.

Hyperspectral imaging, again a domain of military agencies and governments, is coming up as another major area of innovation. Narrow spectral signatures generated by hyperspectral sensors allow unprecedented precision in the classification of land and water, and a window into the chemical and molecular processes of crops, soil, aerosols and effluents. This offers an added

> **Fitting synthetic-aperture radar technology into a satellite under 100kg was deemed largely impossible before ICEYE did it**

Mikko Keränen
Vice President
ICEYE

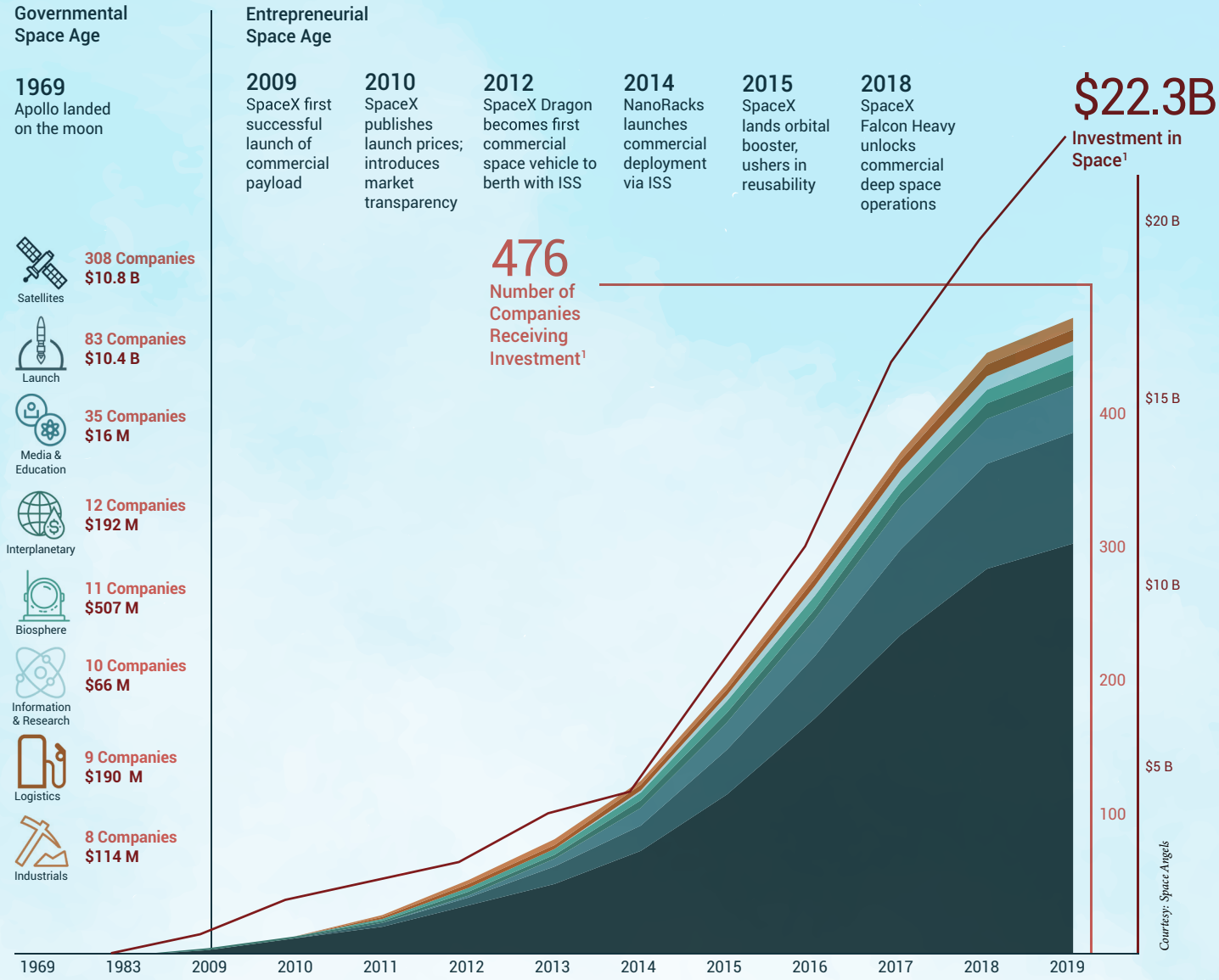
> **We are deploying a constellation of formation flying satellites that can identify and geolocate a broad range of RF**

Adam Bennett
Product Marketing Director
HawkEye 360

> **Multispectral and hyperspectral sensors on our satellites can discern different spectral bands with nanometric precision**

Emiliano Kargieman
Founder & CEO
Satellogic

DAWN OF THE ENTREPRENEURIAL SPACE AGE: CUMULATIVE EQUITY INVESTMENTS FROM 2009 TO 2018



dimension to geospatial data, further enhancing and complementing existing data streams to provide a competitive edge.

With eight satellites in orbit, Satellogic, a Buenos Aires-based space imaging company, is currently the sole supplier of commercial hyperspectral satellite imagery in the world. The firm has plans for three more satellites by the end of 2019. "Each of our commercial satellites carries two payloads — one for multispectral imaging and the other for a hyperspectral camera of 30m GSD and 150km swath (at a 470km flying altitude). This unique sensor can discern hundreds of different spectral bands positioned arbitrarily in the spectrum with nanometric precision," says **Satellogic Founder and CEO Emiliano Kargieman.**

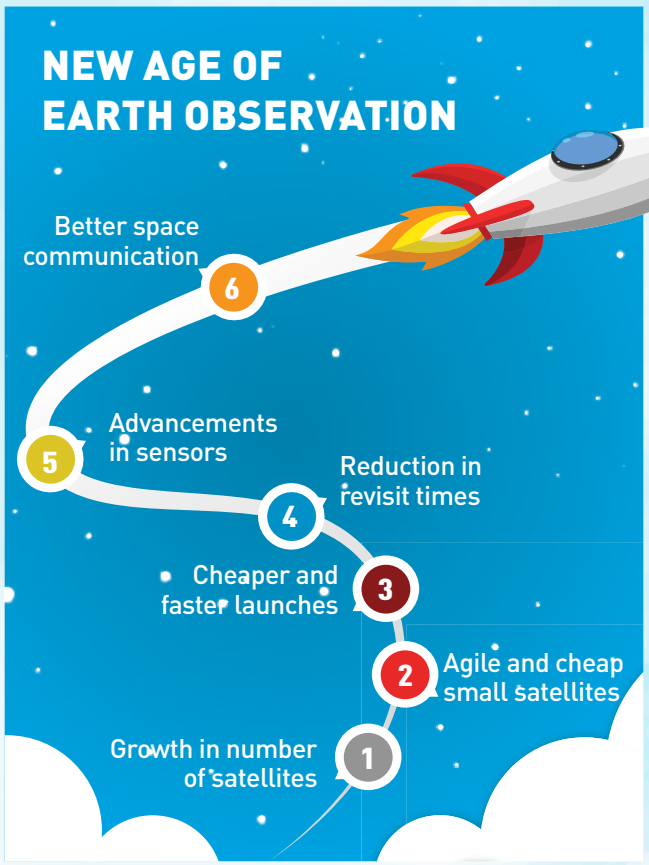
The company plans to launch a 300-satellite constellation to build the first scalable earth observation platform with the ability to remap the entire planet at both high-resolution and hyperspectral. Once complete, the constellation will provide daily remaps of the Earth at 1-meter resolution and deliver best-in-class frequency with a fully automated platform.

Satellogic has tied up with China Great Wall Industries Corporation (CGWIC), the company that commercializes Chinese space technology outside the country, to launch a constellation of 90 satellites in a series of dedicated LongMarch-6 and LongMarch-2D rockets. The first LongMarch-6, carrying 13 satellites, is expected to launch in the second quarter of 2020, which will be followed by one launch per quarter throughout 2021.

UK-based Satellite Vu is developing a fleet of small satellites equipped with special sensors that will be used for monitoring plastic pollution and heat and thermal mapping. Again, the capability of sensing the thermal characteristics of objects, particularly buildings, has been the preserve of military systems or environmental applications. Satellite VU plans to change that by providing commercial data at a much higher resolution.

"Plastic has become the scourge of our society and it is choking our maritime areas. Existing methods to track these threats are not as effective either in terms of technology or cost. These include shipborne and airborne monitoring techniques," explains **Anthony Baker, CEO, Satellite Vu**. The company has come up with a technology that will decrease the time required to measure the plastic problem from years to weeks.

The satellites are the size of a shoebox and they need a special telescope to achieve the required resolution. They can also be maneuvered to a point towards specific targets of interest. The rapid revisit time of the satellites coupled with their sensors ensures that a real-time picture of what is built up and happening is available. "By enabling rapid identification of where the plastics are located and where they are originating from, governments and organizations can act fast," says Baker. By 2020, its future satellite sensor will be in the final stages of completion and the data platform will also become operational.



Similarly, Bluefield, founded in 2017 in Palo Alto, California, is launching micro satellites to track methane emissions. The satellites, the first of which will be launched in 2020 and eight more by 2023, uses a proprietary, miniaturized version of a sensor technology previously deployed by NASA on 12 missions. By mounting this sensor on several backpack-sized microsatellites — and enhancing the raw data with its proprietary machine vision algorithms — Bluefield will provide methane emission monitoring at a previously unthinkable combination of global coverage, high resolution and low cost.

"We will be mapping every critical emitter on the planet every day. That would make for a better tomorrow because methane is responsible for 25% of global warming. By bringing this powerful data, we will play a significant role in slowing down Climate Change," says **Yotam Ariel, CEO and Founder, Bluefied.**

Bluefield, which is funded in part by Village Global LP, a venture capital firm backed by tech moguls such as Jeff Bezos and Mark Zuckerberg, uses an optical technique, which when combined with proprietary machine vision algorithms, enable unprecedented precision, frequency and affordability to pinpoint the millions of emitting sources on the planet. The company plans to expand to tracking other greenhouse gases like SO2, NO2 and CO2. Ariel says Bluefield will also expand from its initial focus on oil and gas emitting sources to monitoring landfills, wastewater, livestock, heavy industries, etc.

Colorado-headquartered PlanetiQ is focused on atmospheric remote sensing and plans to have a 20-satellite constellation by 2021 in sun-synchronous orbits to gain global coverage. "The first two satellites will be deployed by the end of 2019," says **Steve Joanis, CEO, PlanetiQ.** The company specializes in remote sensing instrument design and manufacturing, and seeks to make the seven-day forecast as accurate as a one-day forecast reading.

New areas of application

Currently, most of the demand for AI-powered earth observation comes from defense, government and humanitarian organizations. Profusion in the availability of EO data has led to better insights, improvement in data analytics and service delivery, opening up a whole new set of application areas.

For instance, in addition to traditional users, Capella sees great business opportunities in monitoring key areas of interest such as major cities, ports, shipping lanes and critical infrastructure. "We can provide reliable and consistent information flows to many verticals, from insurance and finance to agriculture and shipping. We are looking to open up new possibilities, markets and applications for remote sensing data as we move closer to real-time and on-demand capability," Banazadeh explains.

ICEYE's current customer base is built out of data users who are already familiar with SAR data and need more of it. Additionally, the company plans to target commercial information users who

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Anthony Baker
CEO
Satellite Vu

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Bluefield

> We see opportunities for highly accurate weather forecasting and aims to produce the climate record of Earth

Chris McCormick
Founder
PlanetiQ

aren't necessarily savvy with SAR data itself, but rely on customized analytics services based on the original imagery. For instance, insurance and finance sectors, and development organizations.

Likewise, Satellogic is developing solutions for areas such as forestry, agriculture, energy, finance and insurance, cartography and critical infrastructure, among others. High-resolution and high-frequency satellite data can be used to map land use and monitor infrastructure, track agricultural development and respond quickly to natural disasters, monitor borders and coastal waters, evaluate the health of crops and natural resource production, track economic activity like transportation and factories, observe and protect the environment, and describe and predict the impact of natural phenomena or provide insights into environmental health and protection of natural habitats, elaborates Kargieman.

Tracking 'dark ships' (vessels that are engaged in activities like smuggling or illegal fishing) is one area HawkEye 360 is looking to target. "The company is also interested in helping customers analyze how spectrum is being deployed for the most efficient use of telecommunication frequencies, aiding defense and security missions in identifying and evaluating potential threats, and assisting search and rescue operations," says Bennett. It is also capable of providing quick assessment of communications infrastructure after disasters.

ICEYE is also collaborating with Spire, a data and analytics company with 84 satellites in orbit, for detection of dark vessels and illegal activities at sea. With the economic value of illegal fishing estimated to be upwards of $23 billion annually, the partnership will allow a new level of accuracy in tracking vessels involved in trafficking of arms, drugs and people.

Satellite Vu is developing a dual-use solution that will help tackle the scourge of Urban Heat Islands (UHI) using high value data that will enable the commercial sector to analyze its impact on UHIs and how to mitigate it. This data can be fused with other data sources to produce computer models of smart cities, also known as Digital Twins. The heat maps can help determine the carbon footprint, energy waste and the impact on surroundings of a building.

The company has a variety of customers ranging from environmental organizations, government bodies to financial investment institutions. "Currently, we are partnering with specialist analytics firms to identify end users. We are also concentrating on making our products more insightful to a larger scope of customers by for example producing maps and highlighting features that change over time," elaborates Baker.

"Our satellites rely on high signal-to-noise ratio to operate, which requires large antennas. So, we are larger than the normal 6-12U cubesats, though we use a lot of technology developed for cubesats," explains **Chris McCormick, Founder, PlanetiQ.** The company sees opportunities for highly accurate weather forecasting in governments, military operations, commercial entities, and individuals, and aims to produce the climate record of Earth.

Rezatec, a UK-based geospatial data analyst company, applies data science to satellite imagery and other geospatial data to deliver sophisticated, Cloud-based analytics to customers owning and operating high value, distributed land-based assets. Its customers are industry leaders across vertical markets such as water, agriculture, infrastructure and forestry sectors that use the data services for improved margins, enhanced competitive advantage and optimized asset management.

"We see demand coming from all sectors where there is the need to monitor and manage assets accurately and precisely to reduce risk and be more cost effective," says **Philip Briscoe, Chief Operating Officer at Rezatec.**

Handling all these yottabytes

With so many satellites in space, there is a growing need to quickly get all this yottabytes of data back on Earth for processing. Amazon's AWS Ground Stations is a real game changer in this regard — the tech giant intends to provide ground station as

a service through a network of 12 satellite facilities around the world. Capella, Spire, Maxar, Myriota and Thales Alenia Space are among the major customers and partners availing AWS Ground Station service. Amazon's idea is to invest in plenty of expensive infrastructure and then charge startups only for what they use, making it easier and more affordable to run a business up in space.

Colorado-based Bridgesat is an innovator in this space. It is offering small form factor laser communication terminals at a reduced price compared to equivalent RF data throughput solutions. The company is also engaged with laser communication terminal manufacturers to ensure compatibility with the BridgeSat ground network. Its first ground station is already in operation in California. The company plans to have 10 around the world. ICEYE is one of its first customers.

Rapid advancements in AI-based analytics is also leading to a situation where data processing via Machine Learning techniques can occur on-board since that would reduce clutter. Polish firm KP Labs is building a unique satellite that would be able to analyze and summarize data collected by it. Aptly named Intuition-1, the satellite will be equipped with an AI-based neural network modeled on the human brain. Intuition's hyperspectral imager will take pictures of a 15-km-wide swathe of Earth at a resolution of 25 meters per pixel. However, instead of beaming back on Earth, the onboard neural network will stitch together the images using powerful graphics chips hardened against radiation.

> **Demand will come from sectors where there is a need to monitor assets for risk reduction and cost effectiveness**

Philip Briscoe
CEO
Rezatec

The data deluge needs cutting edge analytics

What will make this sea of data even more powerful is the ability to process it in large quantities. "So far, the EO industry has been completely outdated when it comes to providing a user-friendly, timely and easy service. We often still rely on manual processes — phone calls, fax machines, hard drives through the mail, FTP sites – to service orders," stresses Capella's Banazadeh.

This increase in the amount of data capture necessitates the use of Artificial Intelligence to parse through the information and find valuable insights. "There

would simply be too much data and not enough eyes to look through it if we couldn't store it in the Cloud, use edge computing to process quickly and deploy Machine Learning algorithms for automated extraction of information," he adds.

Satellite imagery providers and service providers alike are recognizing that the real value is in delivering AI-driven data analytics. AI-driven EO startups raised $96 million in 2017 — nearly three times more than in 2016.

This has led to the rise of data analytics companies like Orbital Insight and Descartes Labs, which feed visual data into algorithms to make sense of any kind of imagery. The biggest example is of Planet, which threw its hat firmly into the data analytics ring when it launched Planet Platform. The platform makes it easy to build tools, ingest imagery and run analytics at scale. It downloads, processes, and manages 6+ terabytes of data every day.

"Machine Learning, data analysis and data science applied to satellite imagery and other sources of data are all critical to bring the promise of earth observation to more mainstream markets. Nobody can expect to do change-tracking, object identification or classification manually over trillions of pixels per week; we need AI to do these things and others, like predictive modeling, on a planetary scale," explains Kargieman. Satellogic is already employing AI and deep learning to great effect to make sense of the huge amount of multispectral as well as hyperspectral data (which multiplies the amount of information for each image as the spectrum gets broken into multiple bands) it is collecting.

With users demanding more insights than just pretty pictures, there is a definite shift from data to analytics that will define the EO industry in the near future. Looking ahead, the EO market will be increasingly driven by AI-enabled data analytics. "More and more we will see organizations just wanting to suck in data from multiple sources for wider analysis so the image itself is no longer relevant," stresses Briscoe of Rezatec.

McCormick of PlanetiQ thinks suppliers will need to "up their game" by adding more spectral bands, not just "red, green, blue", and calibrate each band in order to let the EO consumer know what materials and condition of the materials (crops in particular) the images are conveying.

The NewSpace edge

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

The Earth observation industry is going through a transition now from the traditional satellites to 'NewSpace'. "There are a handful of traditional players that are trying to reinvent themselves and a bunch of new entrants, coming up with disruptive models," points out Kargieman.

The market conditions have been right over the last few years for innovative startups to begin playing in the space sector, not least in the satellite applications sector, undelines Briscoe. These conditions include proliferation of Cloud-based computing; increased data storage and processing capabilities; increase in the supply of satellite data (including the European Space Agency's Copernicus program); and general education and understanding across multiple sectors that satellite data can provide a cost-effective new means of combating challenges historically solved using expensive or labor-intensive methods.

Agrees HawkEye's Bennett: "It is now possible to design powerful capabilities into a compact package because of the emergence of small satellite technology. And space is much more accessible given the variety of launch providers and general decrease in launch costs. This combination has made it feasible for smaller companies to develop effective satellites and get them into orbit."

Ariel of Bluefield points out that there are just six launch options available today, which will double by next year. The boom in the satellite industry is also creating interest among people, thus opening up a greater pool of talent and experience in satellite operation and data processing.

The NewSpace movement is bringing down the cost of manufacturing a satellite and sending it to space considerably. "Opportunities to operate satellites in low-Earth orbit are opening up new vistas and a small satellite can be just as capable as one of its large GEO cousins," says Baker of Satellite Vu.

The promise of AI and ML applied to satellite imagery, in conjunction with higher frequency and higher resolution of data, is to expand the earth observation market by orders of magnitude in the upcoming decade. "This market expansion will benefit both traditional satellite operators that will have to adapt and integrate some of the new technologies and techniques to remain competitive, and new entrants that can deliver on their promises." Kargieman couldn't have summed it up better.

The Earth observation industry is going through a transition now from the traditional satellites to 'NewSpace'. There are a handful of traditional players that are trying to reinvent themselves and a bunch of new entrants, coming up with disruptive models

Anusuya Datta, Executive Editor
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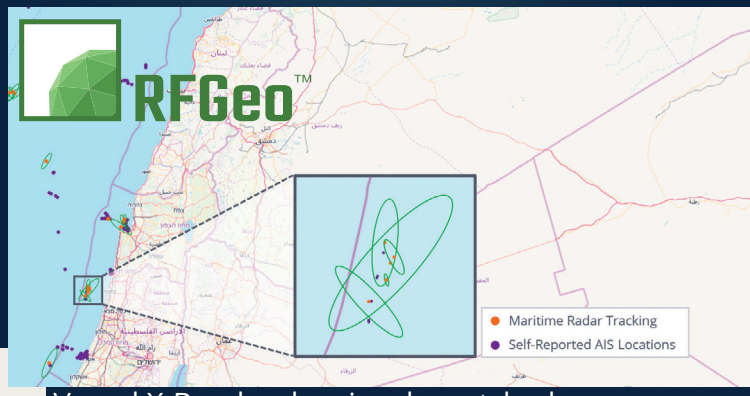
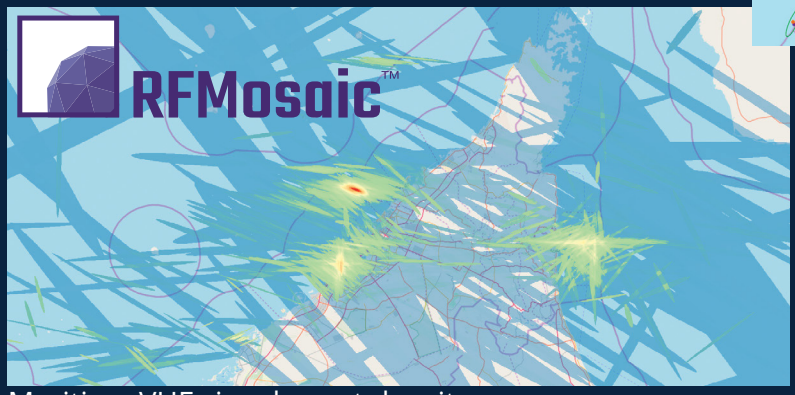
HawkEye 360

GLOBAL RF KNOWLEDGE FOR ACTIONABLE INTELLIGENCE

HawkEye 360 operates first-of-its-kind commercial satellites that identify and geolocate radio frequency (RF) signals. This new geospatial data layer reveals patterns of activity and new insights for maritime, defense, telecommunications, and emergency response applications.



Vessel X-Band radar signals matched with AIS in the Mediterranean Sea.



Maritime VHF signal event density near the Strait of Hormuz.

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Making the Most of Geospatial Data

By bringing together satellite, drone and IoT data, while processing algorithms to study specific insights, UP42, a startup powered by Airbus, lowers the barrier to entry for companies that can benefit from geospatial data. In an exclusive interview, **François Lombard,** Director of Intelligence Business at Airbus Defence and Space, and **Eli Tamanaha,** CEO, UP42, tell us about the platform.

How is UP42 different from any of the existing Airbus platforms and how does it work?

François Lombard: At Airbus, we follow a strong digitalization strategy. Our digital services are already at the heart of many of our activities and will be even more so in the future. In February 2019, we launched the OneAtlas Platform to disseminate and provide immediate access to Airbus premium data and analytics. UP42 has been set up to offer a fully open environment to target developers and users willing to build their own geo-based solutions. We answer different customer needs in term of data and service access (speed, volume, format, data from various sources and suppliers), and the business models are aligned with their operational constraints.

With UP42, we reach out to all businesses that want to develop new solutions using top-notch geospatial data, but do not necessarily have the infrastructure or know-how to do so. We give them the necessary data blocks, tools and processes to develop, test and scale their solutions. By reaching out to new customers and users, we believe UP42 will help grow an attractive and vibrant ecosystem for geospatial solutions. Most industries are developing open marketplaces, and this is the next evolution in the imagery services market. We wanted to be at the forefront of that change for our industry, and went a step further from creating a platform: we built a company, UP42. We are based out of Berlin and are tapping into the city's unique startup ecosystem.

Eli Tamanaha: UP42 lowers the barrier to entry for companies that can benefit from geospatial data. So far, the vast amount of information collected from space is not available to commercial businesses. UP42 works by bringing together satellite, drone, traffic, weather and IoT data, while simultaneously processing algorithms to study specific insights. Firstly, we reach out to data and processing algorithm providers across the industry. Then, we integrate them as partners onto our platform so that customers can easily access everything they need. Finally, our customers select combinations of data and processing algorithms before picking their area of interest on a map of the planet. This way, anybody can derive insights at both small and large scales.

UP42 is an open platform and marketplace for our customers and partners. Customers can easily access a variety of data and tools to build their products. Partners can access a large customer base for their services. We enable companies to use powerful geospatial data to build their products. We don't own data or build algorithms. Our entire business revolves around offering our customers data and algorithms from our partners, who view us as a huge distribution channel — through which they can access customers that they previously couldn't reach. We are a group of impact-driven individuals who are on a mission to bring geospatial insights within reach.

How has the market responded to UP42; which all prominent clients have you been able to attract so far?

ET: So far, the response has been very positive. Ray Richardson, CTO of Simularity, one of our partners, told us, "This is the platform I have been looking for since I started working in this industry." We have been working with various partners and have opened up the platform to a longer list of beta testers, while growing our marketplace portfolio. Companies such as LiveEO are working with us to make the most of geospatial data. They used satellite data to measure the height of trees alongside railway tracks in Germany for Deutsche Bahn — making rail travel safer and more efficient. Other companies include Pinkmatter, Simularity, Spacemetric and Ito World.

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In future, we see potential in doing business with forward-thinking companies across the world that want to use technology to get an edge. We are seeing interest from all sectors (infrastructure, environmental monitoring, agriculture and construction), locations and company sizes.

The global space and EO industry has seen a large number of small companies and startups in the past. How will UP42 position itself in a fast-changing EO market?

FL: Many companies in the geospatial domain are planning to build or proposing platform offerings, but we see UP42 as a unique open ecosystem-based approach that can openly invite small and medium businesses and freelancers to develop and mature geospatial solutions. By combining Airbus' unique datasets, third party data and 'plug-and-play' processing blocks, we are answering to a market need that is currently not met.

ET: While there are competitors who are creating innovating solutions, we believe that we are the only truly open two-sided geospatial marketplace. We are unique because we don't own data. We encourage all our data and processing providers to distribute their products on UP42 and encourage our customers to easily consume these products. We see our competition working with us in the future as this innovative market grows.

Despite the focus on open data policies, geospatial data has been restricted to governments and large businesses. How will UP42 break the traditional barriers?

FL: We see a large untapped potential in using geospatial data to solve the world's problems. UP42 allows to quickly build, scale and market geospatial products and game-changing solutions. Small and medium businesses require flexibility and speed to test their solution and change, for instance, the data set or algorithm to reach commercial maturity quickly and cost-effectively. The choice that we give in terms of high quality data, algorithms, processing blocks and services is unique.

ET: UP42 was born from the idea to democratize access to geospatial data. Whether you are part of a large business optimizing crop yields or a small institution estimating deforestation, UP42 is for you. By lowering the barrier to entry, geospatial data is no longer restricted to governments and large businesses. Our scalable infrastructure means that people no longer need to worry about building the architecture needed to support geospatial analysis. This is usually the next hurdle that smaller businesses or individuals face.

UP42 has a unique open ecosystem-based approach that can openly invite small and medium businesses and freelancers to develop and mature geospatial solutions

Which are the primary sources of data that UP42 will handle; what is the source of drone imagery?

ET: Yes, we integrate other sources too. Currently, our portfolio includes data from Airbus, as well as others. We have imagery from Sentinel-1, Sentinel-2, Pléiades, Landsat-8, as well as SPOT 6/7. We also have public transit data from Ito Word. Our growing marketplace of data providers aims to bring a variety of geospatial perspectives to our customers. This means that we will one day have drone imagery on the platform too.

UP42 is offering 'ready-to-use' algorithms that can do everything from detecting clouds to revealing changes like new buildings and shrinking forests. How are you using emerging technologies like AI and ML for change detection?

ET: Many of the Machine Learning (ML) and Artificial Intelligence (AI) algorithms are pretty sophisticated. They require a different kind of computer processor called a GPU. We are on the verge of offering those resources on our platform so that our partners can take advantage. In the next three months, we will have five new algorithms on UP42, which will feature object detection.

Do you think the EO industry has fully exploited the true potential of AI and ML?

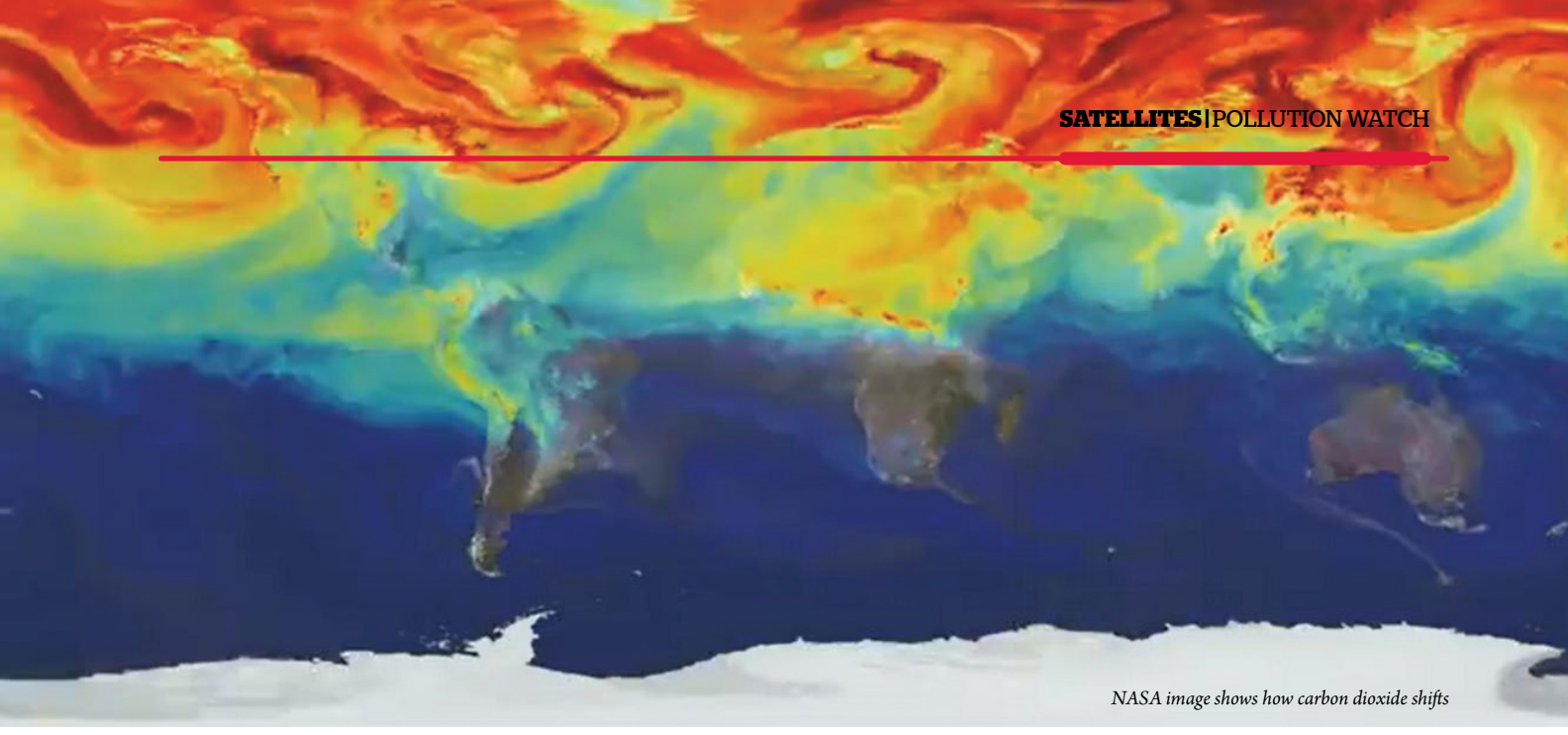
FL: AI is moving out of the abstract world of data and information into the real world, and we are part of that trend either by ourselves or with our partners. Machine Learning is already used in our industry replacing more traditional rule-based automation processes. It is the case, for example, for our Starling or Ocean Finder services. The challenge we are currently working on is to fully exploit such techniques. We need to scale up the use cases, prove concepts and get embedded into business processes.

ET: The industry needs to experiment with more use cases before ML and AI are fully utilized. The EO field generates huge datasets, so there is no doubt that we need computers to help analyze that. The more customers are able to use geospatial data in their products, the more need for ML and AI will arise.

How do you think technology integration will change the face of the industry?

FL: I think that it is true that the ecosystem we live in is becoming more complex, blurred, and that integration is one of the drivers. Collaboration is a key trend driven in part to share development costs and realize benefits by players across the value chain. The trend is here to stay, but we continue to operate in a highly competitive environment. Yes, there is a role for all players, including the smaller ones. They are able to leverage data streams and platforms that take significant investment to set up and create scale.

ET: The geospatial industry is transforming by leveraging software. Players in the space are becoming more interoperable with each other. There is a lot of synergy to be captured by these integrations.



NASA image shows how carbon dioxide shifts

STATE OF THE EARTH

Technological advancements like miniaturization of sensors, high-speed data transfer and enhanced storage capabilities have led to a new wave of satellites specially built for tracking pollution and pinpointing sources of emissions. **By Aditya Chaturvedi**

The impact of global warming would be much more severe than the Great Depression; it would be ten times as deep as the more recent Great Recession, which still so rattles us. And it would not be temporary. It is hard to imagine any system surviving that kind of decline intact, no matter how big.

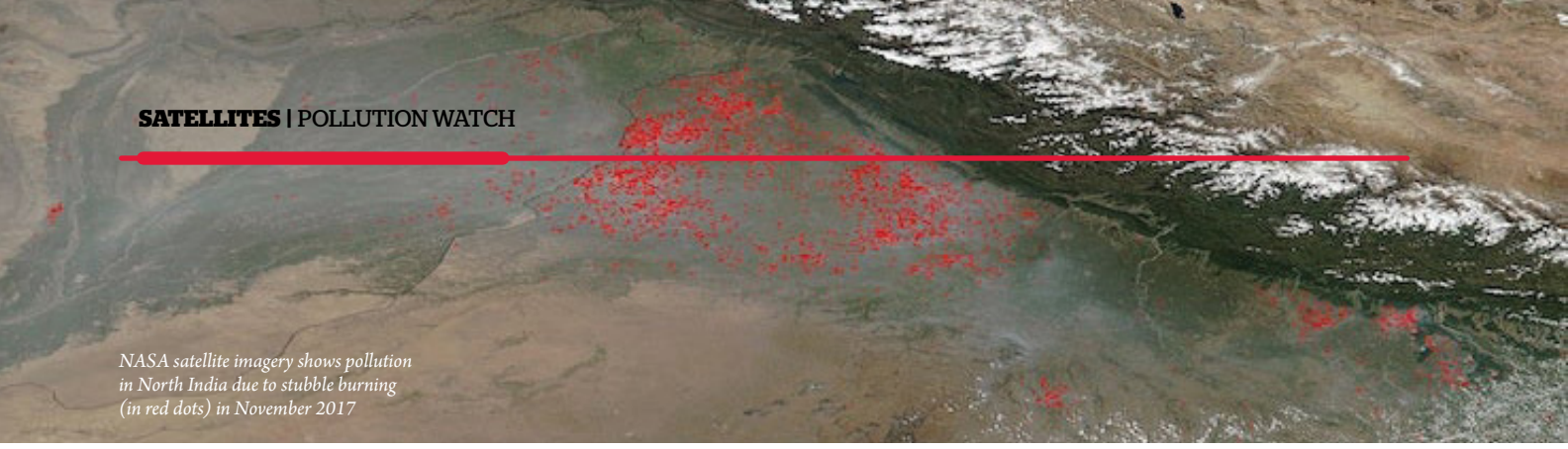
— David Wallace-Wells, The Uninhabitable Earth: Life After Warming —

Calling Climate Change an impending catastrophe would amount to a fatalistic resignation — deeming it inevitable and shirking from what ought to be done. As we build our future on unprecedented technological progress, we undermine the climate at our own peril. Greenhouse gases such as CO2, NO2 and methane are the main causes of global warming, leading to Climate Change and extreme weather conditions. And the fight against pollution is an essential part of mitigating Climate Change.

Amidst this bleak view, satellites have come to our rescue. Technological advancements like miniaturization of sensors, high-speed data transfer and enhanced storage capabilities have led to a new wave of satellites specially built for monitoring pollution and tracking the sources of emissions. This has enabled organizations to gain actual insights into the nature of pollution and formulate strategies to tackle it.

"The advent of smaller, more affordable satellite platforms, combined with technological breakthroughs in the miniaturization of instruments, is opening a new world of possibilities to gather even more critical data [in this field]," says **Jean-Francois Gauthier, Director, Business Development, GHGSat,** a NewSpace startup based in Montreal, Canada.

Around a dozen governments and private companies are planning to launch satellites that can pinpoint the source of pollutants and



NASA satellite imagery shows pollution in North India due to stubble burning (in red dots) in November 2017

greenhouse emissions. Availability of satellite data on emissions has also contributed in increasing awareness about the scourge of air pollution and has led to the formation of public action groups.

"Low-cost monitoring and real-time data have vastly improved awareness about air pollution around the world and empowered people to speak out," points out **Lauri Myllyvirta, Lead Analyst, Greenpeace Global Air Pollution Unit.**

Sentinel-5P — 'world's most advanced'

Copernicus Sentinel-5P, launched by ESA (European Space Agency) in October 2017, is said to be the most advanced pollution monitoring satellite in the world. It tracks carbon monoxide, nitrogen dioxide and ozone, along with aerosol. It also monitors formaldehyde, which is one of the sources of carbon monoxide. Insights gained from Sentinel-5P data has shown that most of the air pollution globally is anthropogenic, and has impelled policymakers to take adequate actions.

"Sentinel-5P can clearly show the sources of air pollution at the global level. In Europe, there are EU Directives (2008 & 2016) that aim to reduce the exposure of European citizens to air pollution to reduce emissions," explains **Dr Claus Zehner, ESA/ESRIN, Sentinel-5 Precursor, Sentinel-4, and Sentinel-5 Missions Manager.**

ESA has been a pioneer in pollution monitoring. In 2002, it launched ENVISAT, the world's largest satellite for environmental monitoring. "With the new mission Sentinel-5 Precursor, we have daily global coverage and a spatial resolution of 7km x 3.5km, which is really a game-changer in pollution monitoring," adds Dr Zehner.

What gives Sentinel-5P an edge over previous ESA satellites (GOME, GOME-2, SCIAMACHY and OMI) is that it measures down to the surface in case of clouds, generating accurate information on air pollution. Sentinel-5P fills the gap in air quality measurement between ENVISAT and Sentinel-4 (geostationary) missions. For this reason, its instruments will be hosted on EUMETSAT satellites, which are scheduled to be launched from 2023.

PULSE OF THE PLANET

CO2 LEVELS IN 2019 ARE ALL TIME HIGH IN **3 MN** YEARS
National Oceanic and Atmospheric Administration, US

JUNE 2019 **HOTTEST IN EARTH'S** RECORDED HISTORY
Copernicus Climate Change Service

JUST 100 CITIES IN THE WORLD ARE RESPONSIBLE FOR **18%** OF ALL GLOBAL CARBON EMISSIONS
World Resources Institute (WRI)

90% OF THE WORLD'S POPULATION INHALES ALARMINGLY HIGH LEVELS OF TOXIC POLLUTANTS
World Health Organization (WHO)

7 MN PEOPLE SUCCUMB TO AIR POLLUTION-BORNE DISEASES EVERY YEAR
World Health Organization (WHO)

LARGE PARTS OF THE WORLD WILL BECOME TOO HOT FOR HUMAN SURVIVAL BY 2100
MIT study

Startups in the fray

Realizing the potential in this segment, a plethora of startups have jumped into the fray. Identifying the exact sources of emissions and taking desirable actions to curtail them can check global warming.

"Methane, a greenhouse gas, is responsible for 25% of global warming. By identifying where exactly it's being emitted and then monitoring it, we can track it and see the effect," says **Yotam Ariel, CEO, Bluefield**, a startup based in San Francisco, US. Bluefield is funded in part by Village Global LP, a venture capital firm backed by technology moguls such as Bill Gates, Jeff Bezos and Mark Zuckerberg.

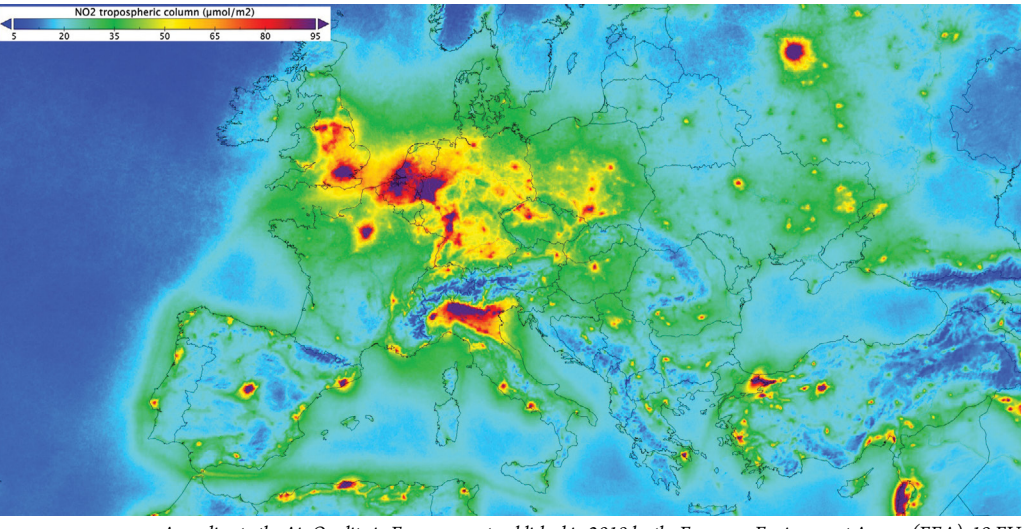
Ariel founded Bluefield with the vision for it to be the 'Breathing Monitor' of the planet by using satellites to track greenhouse emissions and other pollutants. The company will deploy its first microsatellite by the end of 2020 or early 2021, and eight other such satellites by 2023.

"Methane has a Global Warming Potential (GWP) 28 to 36 times greater than CO2 over 100 years. This means that stopping methane leaking to the atmosphere has a very large positive impact," says Gauthier of GHGSat.

The company aims to become the global reference for remote sensing of greenhouse gas (GHG), air quality gas, and other trace gas emissions from any source in the world. Its demonstration satellite was successfully launched in June 2016. GHGSat C-1 satellite is expected to be launched this year.

Most of the methane emissions are from

oil and gas industry, and current satellite monitoring lacks the precision to pinpoint the exact source. The existing methane monitoring satellites have 1km or more resolution, which means they can only see a region or an area, but cannot identify the exact source like a specific storage tank or an oil and gas well. "We can pinpoint the meeting source within 20 meters," says Ariel.



According to the Air Quality in Europe report published in 2018 by the European Environment Agency (EEA), 19 EU Member States recorded nitrogen dioxide concentration above the annual permissible limit. Imagery from Sentinel-5P

Tracking methane is quite expensive currently, but the cost is expected to go down substantially in the coming years. "It costs several hundreds of dollars for one measurement, for one site on location. Globally, there are $3 million such sites. So, to measure all the sites in the world just once would cost a whopping $1.5 billion," he explains.

WattTime, a non-profit Artificial Intelligence startup founded in 2017, plans to use satellite imagery for tracking pollution from every single power plant in the world. The company intends to use data from a number of sensor operating at different wavelenghts. Infrared imaging would be used to detect heat. WatTime would use satellite imagery from government programs as well as private companies. Its data would be available publicly.

Government programs

Monitoring pollution and greenhouse gas emissions from space is not new. In January 2009, Japan launched the world's first satellite dedicated to greenhouse monitoring — Greenhouse Gases Observing Satellite (GOSAT). It measures CO2 and methane densities from 56,000 locations around the world. In October last year, the Japan Aerospace Exploration Agency (JAXA) launched GOSAT-2 to generate even more precise data.

After a failed attempt to launch its first spacecraft dedicated to studying atmospheric carbon dioxide (Orbiting Carbon Observatory — OCO) back in 2009, NASA was successful in launching OCO-2 in 2014. OCO-2 is the second successful high-precision (better than 0.3%) CO2 observing satellite after Japan's GOSAT. The American space agency is now working on OCO-3, which will be developed and assembled by using spare materials from OCO-2. The instrument will be hosted on the International Space Station.

By early 2020, US is scheduled to launch the Geostationary Carbon Observatory (GeoCarb) to track global carbon cycle from a geostationary orbit, making it the first NASA satellite to measure methane near Earth's surface. GeoCarb will gather 10 million daily observations of the concentrations of carbon dioxide, methane, and carbon monoxide.

In November 2018, the Indian Space Research Organisation (ISRO) launched HySIS, a hyperspectral imaging observation satellite with a mission span of five years. Its main aim is to study the Earth's surface in visible, near-infrared and shortwave-infrared regions. The satellite monitors pollution from industrial sources. French space agency CNES plans to launch MicroCarb mission in 2021 to monitor and characterize CO2 surface fluxes.

The Chinese story

Air pollution is a grave issue in China, particularly in the bustling megacity of Beijing. China is among the few countries that have launched their own satellites for monitoring pollution. Satellite data has assisted the government authorities in reducing pollution considerably. "Monitoring air quality by satellite remote sensing technology is a new method that is fast growing. But it has only started developing recently," emphasizes **Lily Xu, CEO, SpaceWill,** a holding subsidiary of ChinaSiwei, which is part of China Aerospace Science and Technology Corporation (CASC).

Through flexible resource management of multi-sensor satellites, including SuperView-1, WorldView and over 40 other high-resolution remote sensing satellites, SpaceWill has been playing an important role in the field of air quality monitoring with high-resolution remote sensing images.

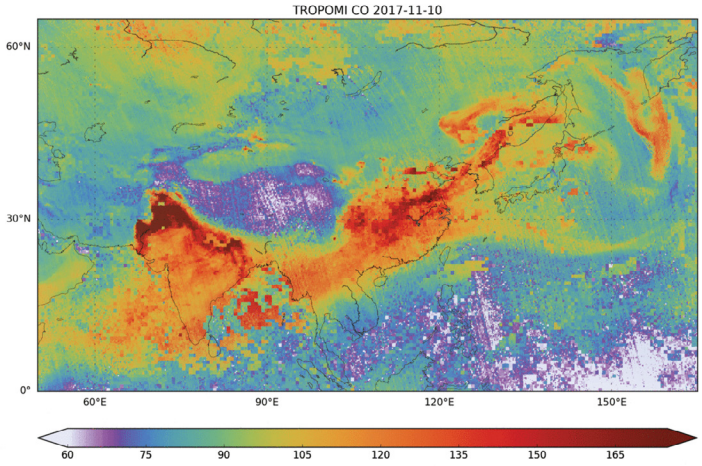
TanSat is a Chinese satellite that tracks CO2 in the atmosphere. By monitoring concentration and flow of CO2 levels every 16 days, the satellite helps understand Climate Change by analyzing the source of carbon emissions.

Last year, China launched Gaofen-5 that can obtain spectral information from ultraviolet to long-wave infrared radiation. It is the world's first full-spectrum hyperspectral satellite for comprehensive observation of the atmosphere and land.

"By analyzing the images, we are able to detect diffused pollution sources of construction site, bare land and sand area in Beijing. It provides useful information which can benefit government agencies in managing remedial measures to improve air quality and environment," adds Lily Xu.

Collaborative approach

Monitoring greenhouse emissions and then analyzing the data to mitigate Climate



Copernicus Sentinel-5P carbon monoxide measurements in November 2017 show long-range transboundary air pollution transport from India to China. The mission has a swath width of 2,600 km, which allows the whole planet to be mapped every 24 hours

Change requires a collaborative approach. "Greenhouse gas measurements are very difficult and no single country can make all the necessary measurements alone," underlines **Harry Cikanek, Director of NOAA's Center for Satellite Applications and Research**.

For instance, the Japanese Ministry of Environment and the National Institute for Environmental Studies (NIES) shares the GOSAT 1 and 2 data with NASA and other international scientific organizations. OCO data is open sourced and freely available to the public.

NASA, NOAA and the EPA have together launched project 'IDEA', which combines NASA and NOAA satellite data with the EPA's air quality index, thus improving the accuracy of air quality forecasts. An interesting private-public partnership emerged following the massive natural gas leak in California in October 2015 — the biggest in American history — when a broken oil well released 100,000 tonnes of methane. Soon after this, California firmed up plans to launch its own pollution monitoring satellite in partnership with Planet.

Planet, which provides near-real-time imagery of any location on Earth, will build and operate the satellite, which will be fitted with high-quality sensors that can point to the exact source of emission.

"The partnership aims to achieve a long-term, sustainable model for developing satellite technologies that would enable us to collect certain climate data to encourage better decision-making. With accurate measurement of and greater transparency on climate data, governments, businesses, scientists and citizens around the world can develop more targeted and effective mitigation strategies," explains **Robbie Schingler, Co-Founder and Chief Strategy Officer at Planet.**

Copernicus is an open platform with a collaborative approach, and on similar lines, open data needs to be prioritized at the global level for reducing pollution. "An open data policy is the key to making people aware about air pollution and its possible impact on their daily lives," says Dr Zehner.

"We use state-of-the-art atmospheric models, data analysis techniques and global databases to provide analysis that supports and empowers campaigns for clean air and clean energy. This includes projecting the air quality and health impacts of polluting projects such as coal-fired power plants, detecting emission sources using remote sensing and quantifying the effects of air quality policies using ground monitoring and satellite data, among other things," says Myllyvirta.

Ongoing challenges

Highly accurate analysis tailored for the requirements of campaigners and policymakers at various levels is needed. There is also the need to bridge the gap between availability and analytics capability. "There is an unlimited need for such analysis and very little capacity for doing it in a way that is responsive to the needs of campaigners, lawyers and policymakers," stresses Myllyvirta.

Ruing the mismatch between the profusion of satellite data and expert analytics, she feels that the biggest bottleneck is in analysis. There are tens of thousands of air quality monitors generating real-time air quality data that is available publicly, and satellites capture every square kilometer of Earth's surface multiple times every day. However, the number of people working to translate this into actionable insights can fit into an auditorium," she says. Also, since pollution monitoring is not widespread so there is still much scope left for technological convergence and interoperability.

"Most existing air qualities monitoring technologies are empirical. They can't be used in other areas, as they are less systematic and practical. There are still many key technologies for satellite data processing, parameter retrieval, application model development, thematic data production and business application system that have not been solved yet," says Lily Xu.

Fusion with AI and future trajectory

AI-based algorithms would boost pollution monitoring capabilities. AI and Machine Learning are critical to GHGSat. "By combining our unique data with other sources of relevant information (flaring, production data, other satellites, etc), we derive very specialized and actionable insight our customers can use right away. We are also able to optimize the efficiency of our system by using these tools," emphasizes Gauthier.

"AI can be used specially to speed up processing time and might therefore play a huge role in future planned space missions to provide fast information to end users," says Dr Zehner. Lily Xu agrees with Dr Zehner on the tremendous potential of AI, adding that new innovations in AI, Machine Learning and Data Science would open up opportunities and lead to more advancements in pollution monitoring.

"Geostationary satellites will be a major step once they become available — going from one frame per day to almost continuous imagery. This will make a huge difference," emphasizes Myllyvirta.

Aditya Chaturvedi, Assistant Editor
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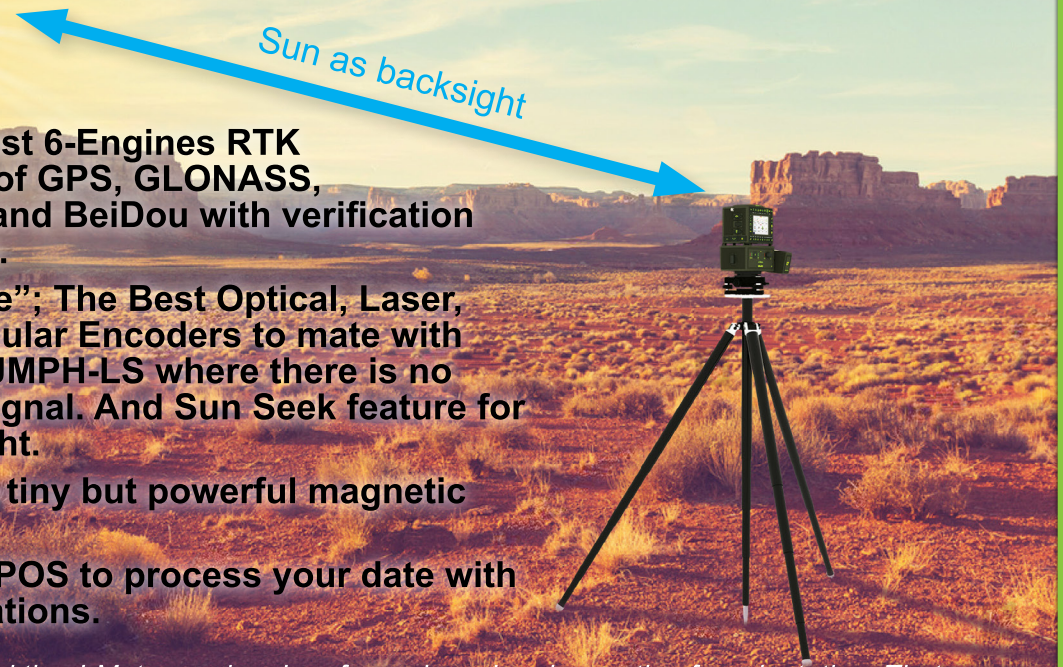
Total solution



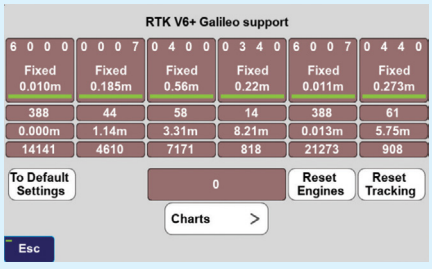
- **The Best 6-Engines RTK system of GPS, GLONASS, Galileo and BeiDou with verification features.**
- **"J-Mate"; The Best Optical, Laser, and Angular Encoders to mate with the TRIUMPH-LS where there is no GNSS signal. And Sun Seek feature for Backsight.**
- **J-Tip a tiny but powerful magnetic locator.**
- **Free DPOS to process your date with COR Stations.**

"While I had the J-Mate running, I performed a solar observation for orientation. That was about the sweetest execution I could imagine. I see so much potential here."

John Evers, PLS

Auto Verify...
Auto Validate...

RTK V6+
GPS, GLONASS, Galileo, BeiDou



six engines plus one support

"I don't know how the other surveyors do it without Javad ! I'll back my data up all day long with the confidence of the Javad system."

see full letter in the last page

JAVAD

www.javad.com

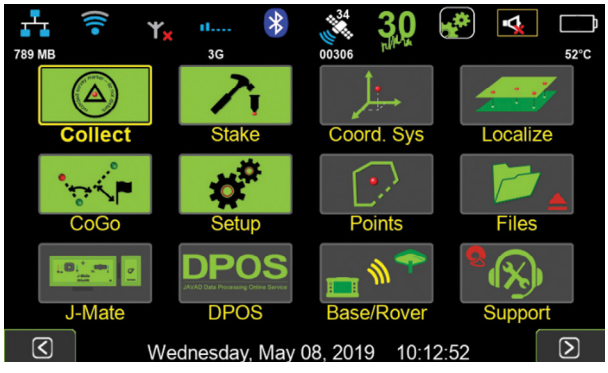
Introduction to J-Mate

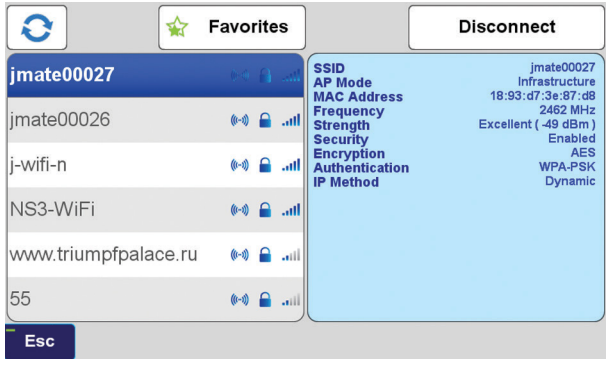
Let's set the record straight: J-Mate is not a total-station. **J-Mate and TRIUMPH-LS together** make the **"Total Solution"** which is a combination of GNSS, encoder and laser range measurements that **together do a lot more than a total station**. For long distances you use GNSS and for short distances (maximum of 100 meters) you use the J-Mate along with the TRIUMPH-LS. Together they provide RTK level accuracy (few centimeters) in ranges **from zero to infinity**.

As with the TRIUMPH-LS, with the J-Mate we also provide software improvement updates regularly and free of charge. Download the J-Mate update in your TRIUMPH-LS and then inject it to the J-Mate. The J-Mate SSID will be in this format JMatexxx, where xxx is your J-Mate's serial number. After a Wi-Fi connection is established, click the J-Mate icon and then click Setup. When you are prompted to connect to the J-Mate, click yes and then follow the remaining prompts.

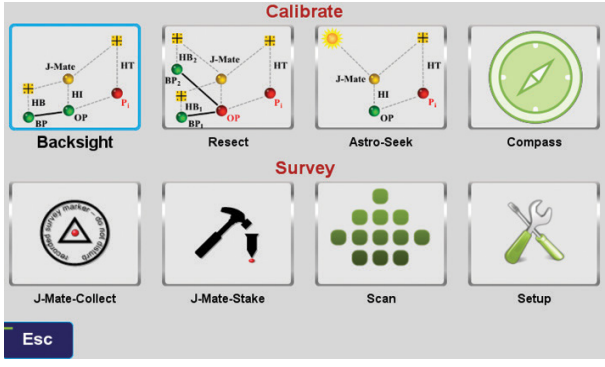
Connecting the TRIUMPH-LS to the J-Mate

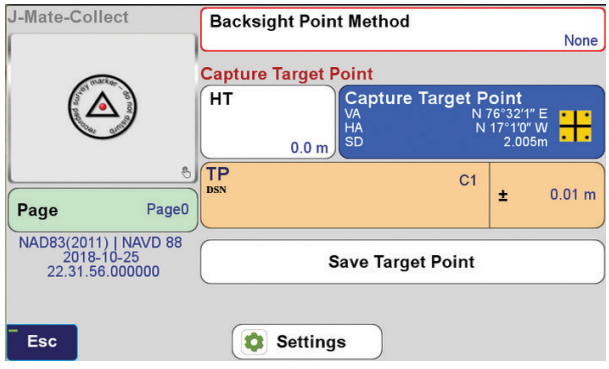
TRIUMPH-LS communicates with the J-Mate through Wi-Fi. Turn on both the TRIUMPH-LS and the J-Mate. Click the Wi-Fi icon on the TRIUMPH-LS Home screen to connect to the J-Mate, much the same way as you connect TRIUMPH-LS to your Wi-Fi access point.





After connection, click the J-Mate icon on the TRIUMPH-LS Home screen and then J-Mate/ J-Mate Collect/Capture Target Point to get familiar with the Main J-Mate screen.





VB-RTK

Get on the Grid with VB-RTK. For over a decade American surveyors have been using the National Geodetic Survey's Online Positioning User Service. Surveyors employing RTK have been a significant share of the user segment of OPUS.

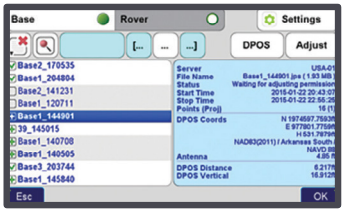
A significant share of OPUS users are surveyors using RTK. Often a surveyor will set up his base on a new, unknown position and allow an autonomous (or standalone) position to be used for the base coordinates. While he is performing his RTK work with fixed vectors between his base and rover, he stores data at the base to be submitted at a later time to OPUS. Once he is finished with his work, he downloads this file to his computer, converts the file if necessary, and submits it to OPUS. He then receives an email response back with a precisely determined coordinate for his base station. He then must take this coordinate, relate the coordinate to his project coordinate system, and then translate the work from the autonomous (or standalone) position he used in the field to this new coordinate. This procedure can produce excellent results and anchors the survey to the NSRS. The down side to this is that there are several steps that must be carefully observed and each of these error prone steps costs time.

With J-Field data collection software, JAVAD has been automating many tasks that surveyors have been doing for years, making the tasks more efficient and reducing sources of potential error. One example, **"Verify RTK with V6 Resets"**, is being recognized by surveyors across the country as the most accurate and efficient way to confidently determine RTK positions. Rather than taking a shot, manually resetting (or dumping) the receiver and taking a second shot for comparison, Verify RTK does this automatically with a user defined number of reset iterations.

JAVAD has continued this automation philosophy by dramatically simplifying the process of translating a survey from an autonomous base position to precise geodetic coordinates with **VB-RTK (Verify Base – RTK)**. Using the JAVAD GNSS, Data Processing Online Service (DPOS), which is powered by the proven JAVAD GNSS Justin processing engine. **This multi-level process is done in J-Field completely automatically.**

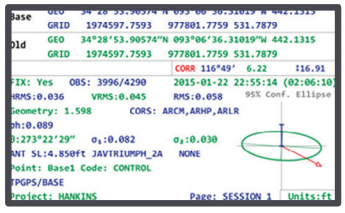
Once an RTK session has been completed, the user returns to his JAVAD base receiver and presses "Stop Base" on the TRIUMPH-LS. **At this point, the raw data file that has been recording at the base during the session, is wirelessly downloaded from the base to the TRIUMPH-LS. When the download is complete, the user returns to his office and connects the TRIUMPH-LS to the internet.**

When internet connection is made, the file is automatically transmitted to one of the JAVAD GNSS servers for post processing. Once data and ephemerides are available for the session, **DPOS** processes the file and returns results to the waiting TRIUMPH-LS. This all takes place within minutes.



Once results are returned, the new coordinates for the base are shown related to your coordinate system (including localization systems).

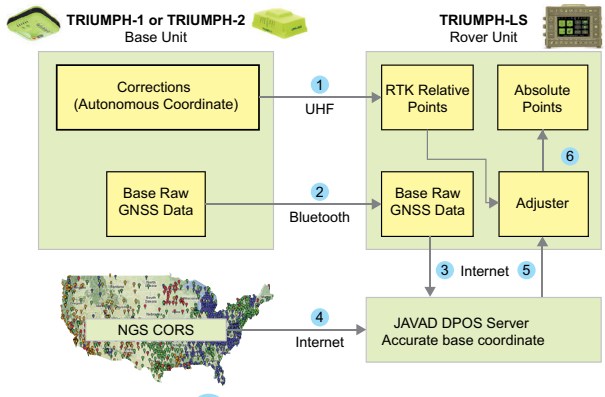
The horizontal and vertical differences between the base coordinates used and the DPOS determined coordinates are shown. **This provides for an instant check of the base coordinates and instrument height** if the base were set up on a known position.



All rover points associated with that base session translate automatically in seconds. Only those rover points associated with that base session translate.

If the user is not satisfied with the results of the DPOS solution and wants to revert back to the original RTK positions, he simply clicks **"Undo"**.This process is immune to base instrument height errors because the internal vectors between base to rover are related to the antenna, not the ground point. So, an accidental entry for the base height of 543' instead of 5.43' can be resolved by VB-RTK.

In addition to the advantages of having your RTK base station near your work area, which gives you much more accurate and faster fixes, especially in difficult areas, and saving you the RTN fees; perhaps most important of all, your work is now precisely related to one of the most accurate geodetic control networks in history – the NGS CORS. Every rover point is only two vectors removed from the CORS (CORS to base, base to rover). This means that you can return again someday to find your monuments easily and accurately. This makes your records incredibly more valuable to both you and future surveyors. J-Field also has the unique ability to load and view every point you have ever surveyed from all the projects in its system. By combining this feature with a **distance filter** in its advanced set of filters, you can easily view all the points you have previously surveyed within a given distance of a point in your current project. Having an easily accessible record of nearby georeferenced coordinates is very beneficial as you may have previously located monuments in past surveys that are beneficial in your current project. J-Field allows you to easily copy these selected points into your current project, eliminating the need for you to resurvey them. All of this is available automatically on the world's most advanced RTK rover – **the TRIUMPH-LS**.



You do 1, the rest is automatic

Concepts Behind RTK Verification

Fundamental in the determination of GNSS solutions is calculating the correct number of full wavelengths (so-called ***fixing ambiguities***) in order to figure out the distances from the satellites to the receiver. In doing Real Time Kinematic (RTK) surveying, we need it fast and we need it to be correct.

Multipath, the reflections of GNSS signals from ground and nearby objects and structures create their own indirect measurements from the satellites to the GNSS receiver. It's as if your measuring tape is bent around an obstacle such as a tree instead of a free and clear line of sight between two points. No calculator is going to improve this result.

TRIUMPH-LS has sophisticated hardware to distinguish between the direct and indirect signals and remove most of the indirect signals. It also reports the amount of indirect signal that has been removed. The worst case is when the receiver doesn't see the direct signal at all; e.g., the satellite is behind a building, but it's still receiving the signal reflected off of the nearby structure. It is the task of the RTK engines to isolate such indirect signals and then exclude them from the calculations.

If too many of the signals are affected by severe multipath or indirect signals, no solution may be found. Remember, indirect signals are analogous to the bent measuring tape! When you're preforming RTK surveying, observe your environment and come to recognize that the structures around you are like mirrors for GNSS signals.

The other aspect impacting the veracity of a fixed solution is when there are weak GNSS signals. Frequently, weak signals are due to their penetration directly through tree canopy.

While the **TRIUMPH-LS** can't move the obstacles that are creating multipath out of the way, its sophisticated hardware has advanced multipath reduction sub-system, its tracking software is designed to handle even the weakest signals, and its **J-Field** software provides reliable RTK solutions like no other system with its **Automatic RTK Verification System**. J-Field also has ample tools to demonstrate the reliability of the solution or warn against questionable results. You can readily see that without such tools other systems can provide you wrong and misleading solutions.

J-Field uses six RTK engines (Figure 1) running in parallel plus a support engine to monitor and aid the six engines. Each engine uses a different criteria and mathematical method tailored to resolve ambiguities in different conditions. These six parallel engines not only verify robust solutions but also maximize the possibility of providing solutions in all conditions.

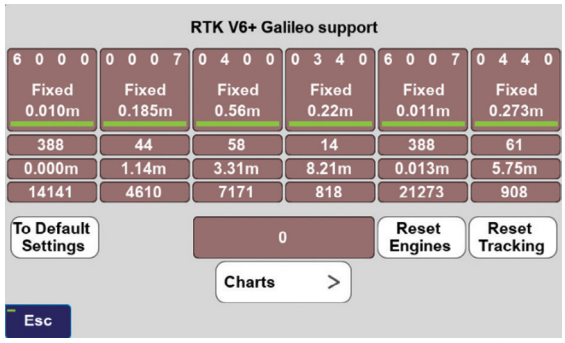


Figure 1 *V6+ six RTK Engines*

User Defined Verification Tools

J-Field provides the option for you to specify the **Minimum Number of Fixed RTK Engines** in verifying solutions **N** times before a position is automatically accepted where **N** is a user defined value.

J-Field employs two metrics to evaluate the performance of its RTK system of six engines: **1) Confidence Counter, and 2) Consistency Counter.** (Figure 2)

Confidence Counter

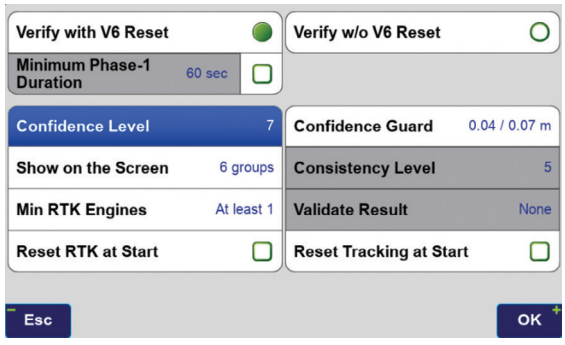


Figure 2 *Verify Settings*

This metric is incremented each time an engine is reset, ambiguities are recalculated, and the solution is in agreement with the previous ones (as defined by the **Confidence Guard (CG)**, default value 5 cm) is achieved. The Confidence Counter increments by 1, 1.25, 1.5, 1.75, 2.0, and 2.5 depending on the number of reset engines that fix in that epoch.

Consistency Counter

The Consistency Counter is incremented each time a solution is in agreement with the previous ones (as defined by the Confidence Guard) irrespective of engines being reset or not. The Consistency Counter is incremented by 0.0, 0.1, 0.25, 0.5, 1.0 and 1.5 depending on the number of fixed engines used in that epoch. Note that one fixed engine gets no credit and 6 fixed engines gets a **Consistency Credit** of 1.5.

Using these Confidence and Consistency verification tools, J-Field has two options to achieve reliable RTK solutions: **1) Verify With Automatic RTK Engines Resets** and **2) Verify Without Automatic RTK Engines Resets.**

Verify with Automatic RTK Engines Resets

This method has two steps: **1) Confidence Building** and **2) Smoothing and verifying**.

• **Step One.** In Step One, fixed engines are reset and solutions are collected into groups. Each group contains all the epochs located within a specified radius (the CG value) from its center and new groups are created as necessary so that all epochs fall into at least one group. Each group has its own Epoch Counter, Confidence Level and Elapsed Time. A point may fall into more than one group. The groups are sorted from best to last by the sum of their Time and Confidence with the current best group being shown within [ ] and others within ( ). Step One continues until a group reaches the Confidence Level. (Figure 3)

• **Step Two.** During Step Two the engines are

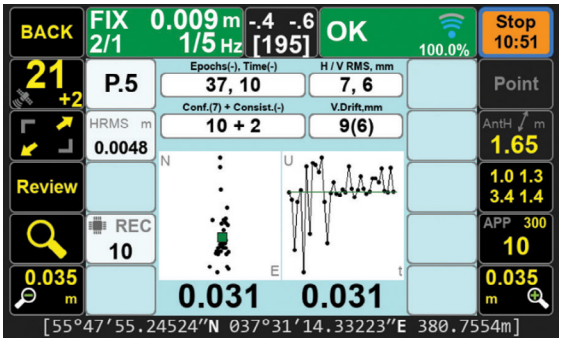


Figure 3 *End of Step one*

not reset and solutions which are located inside the CG of the selected Group are added to that Group for the remaining number of epochs that user has requested (Epoch Number, EN) in the How to Stop screen. Epochs which are outside the CG of the selected Group will be stored in a new (or previously created) group; the RTK engines are reset if the epoch falls outside a sphere with a radius twice that of the CG and the process will then revert back to Step One and the Confidence Level of the current group will be reset to 0.

If the number of epochs falling outside of the current group (but less than 2X outside it) reaches 33% of epochs collected so far, the process will revert back to Step One. Previously created groups will remain intact and once an existing or previously created group meets the Step One criteria, it will pass to Step Two. (Figure 4)

In both steps the Consistency Counter is also incremented as mentioned earlier.

You can manually reset all RTK engines via the V6-RTK engines screen (Figure 1), or assign this

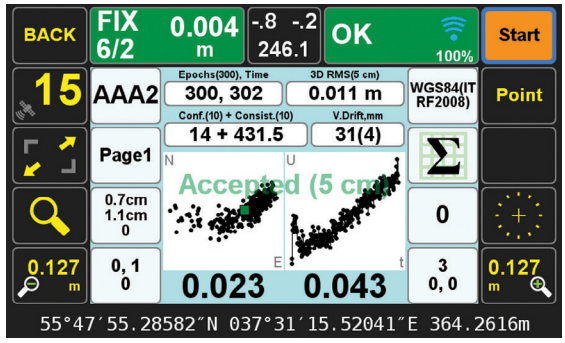


Figure 4 *End of Step 2*

reset function to any one of the U1 to U4 hardware buttons in front of the TRIUMPH-LS for easy access.

Verify without Automatic RTK Engines Resets:

In this method we don't force the RTK engines to reset but rely mostly on the Consistency Counter. There will be only one group as selected by the first epoch. Solutions that are not within the Guard band of the current average will be thrown out. If more than 30% of solutions are thrown out, the process will restart.

The horizontal and vertical graphs presented in both approaches also help the surveyor to evaluate the final solution. The linear drift of the vertical solution and its drift RMS are also shown above the vertical graph. A high linear drift (more than few centimeters) reveals severe multipath or, in rare cases, a wrong ambiguity fix. Pay close attention to the vertical drift and the horizontal and vertical scatter plots of epochs. Consider the scatter plots as doctors examine X-rays to determine anomalies.

The desired **Confidence Level** and **Consistency Level** are user selectable. Default values are 10. These parameters along with the desired number of epochs must be reached before a solution is provided.

In either case there is also a **Validate** option which, when selected, will reset all engines at the end of the collection and continues with 10 more epochs to validate if the solution is within the desired boundary of the Confidence Guard. (Figure 2) Minimum number of engines for the Validation Phase is user selectable.

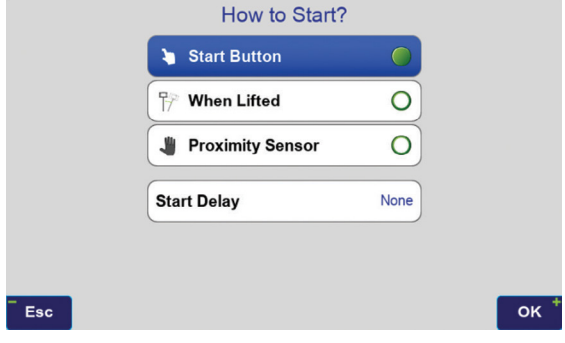


Figure 5 *How to Start*

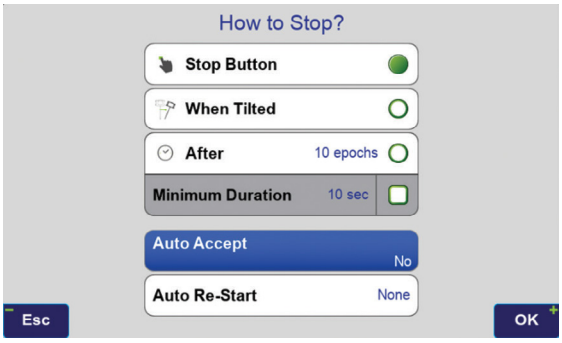


Figure 6 *How to Stop*

In either case, if Auto-Accept is activated, the position will be automatically accepted if the RMS of the final solution is less than what user has selected in the Auto-Accept screen. (Figure 6)

You can also use **Auto-Restart** if you want to monitor structures or test the RTK system unattended. (Figure 6)

Screen Shots of Action Screen

Action Screen shows detailed information about each point collected. Screen shots can automatically be attached to each point and saved at the end of each collection (Figure 7). In **Verify with Automatic RTK Engines Resets** screen shots at the end of both Step One and Step Two are saved (Figures 3 and 4). In Action screen there are 8 white boxes that selected items can be viewed on them.

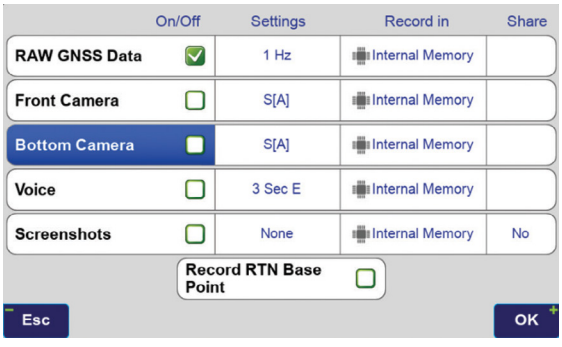


Figure 7 *What to record screen*

Review Screen

View cluster of all points. Select the desired point to see its point cluster (Figure 8). Click the icons to see additional details about that point (Figure 9) including the distance and direction to the current point (Figure 10).

The effects of multipath, ionosphere, orbit, and other sources of problems somewhat exponentially increase as the baseline length increases. In a VRS/RTN scheme your **actual** baseline length is the actual distance to the nearest base station. The **virtual** base station that is mathematically created is not the actual length. We strongly recommend using your own base station near your job site in a Verified-Base RTK (VB-RTK) scheme.

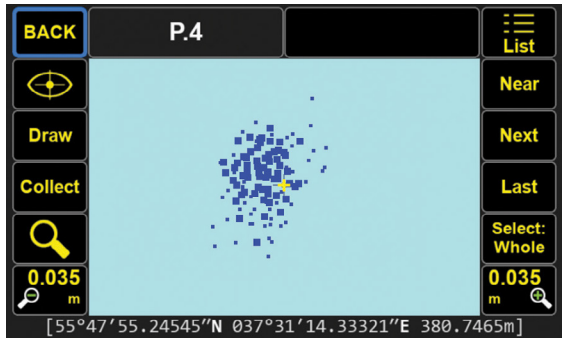


Figure 8 *Review screen shows cluster of 386 points*

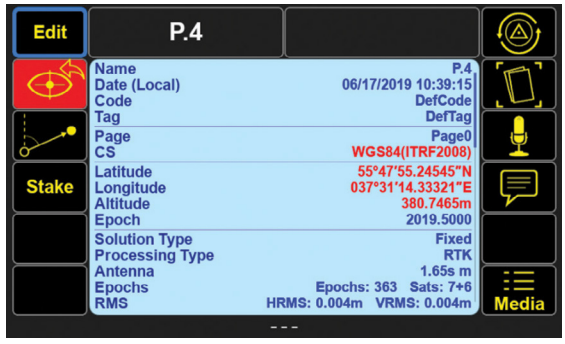


Figure 9 *Detailed information on selected point (scroll to see all information)*

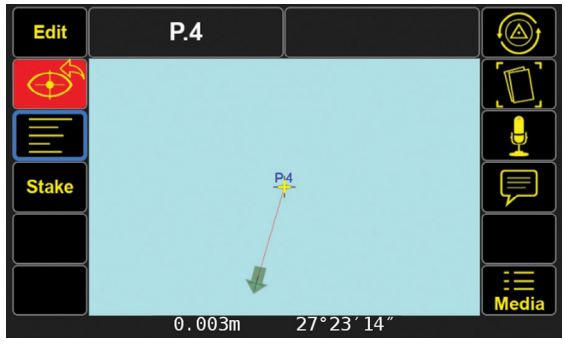


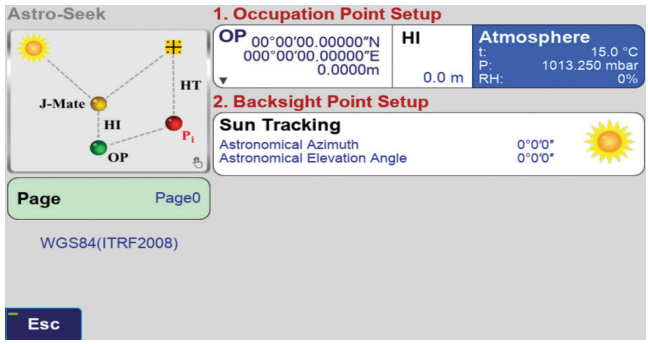
Figure 10 *Distance and direction from the current point to the selected point*

In addition to providing you with the most reliable RTK solutions (especially true in remote areas where cell coverage is hit or miss), using your own base receiver allows you to easily tie your solutions to well-established IGS/NGS spatial reference systems through Javad's exclusive Data Processing Online Service (DPOS) and J-Field's user-friendly Base/Rover Setup. Note that post-processed results returned to the TRIUMPH-LS using DPOS are dependent on the availability of orbital data from NGS and may require several hours. Alternatively, if you don't have access to IGS-type stations to use DPOS, you can select an open area near your job site and use TRIUMPH-LS to obtain its position via RTN networks for about 5 minutes.

Backsight point and the Sun

Similar to using conventional total station, to use the J-Mate you need to first establish its accurate position and calibrate its vertical and horizontal encoders. Then proceed to shoot the unknown points. This is similar to using any total station, but we have improved and automated the process.

With J-Mate you can do these in three different ways as shown in the J-Mate screen of the TRIUMPH-LS. Via the J-Mate-Backsight; J-Mate-Resect and J-Mate-Astro-Seek icons.



If GNSS signals are available at the site, click the J-Mate-Backsight icon.

This screen appears which guides you to determine the accurate positions of the Occupation Point and a Backsight Point to establish an azimuth and calibrate the J-Mate angular encoders.

The tripod is setup at the “Occupation Point” (OP). The J-Mate is secured on top of the tripod.

Next, TRIUMPH-LS is put on top of the J-Mate with its legs registered to the matching features on the J-Mate.

Next Use the RTK Survey feature of the TRIUMPH-LS to quickly determine the accurate location of the Occupation Point. You can use your own base station or any public RTN.

Next, slide the J-Target on top of the TRIUMPH-LS, lift it from the J-Mate and move to the “Backsight Point” (BP). The camera of the J-Mate will search the J-Target. The camera’s view is visible from the TRIUMPH-LS screen, which mostly focuses on this J-Target. When at the Backsight Point, its accurate position is determined by the TRIUMPH-LS, and the Azimuth from the Operation Point to the Backsight Point is determined, and the J-Mate is calibrated and ready for use.

After this calibration is complete, if the tripod is disturbed, the red LED on the front of the J-Mate will blink to show that re-calibration is required.

We can now replace the TRIUMPH-LS on top of the J-Mate at the Occupation Point and proceed to shooting as many “Target Points” as the job requires. From now on TRIUMPH-LS is used as a controller and you can hold in your hand too, but it is more convenient to put it on its place to have free hands.

If GNSS signals are not available at the Occupation Point, click the “J-Mate-Resect” icon to shoot two known points to establish its accurate position and calibrate its encoders. Then continue to shoot the unknown points.

Astro-Seek feature: Sun as the Backsight point!

We have added a new innovative feature to the J-Mate that it can automatically calibrate itself via its automatic Sun Seeking feature.

Attach the Sun filter to the camera of the J-Mate, click the “J-Mate-Astro-Seek” icon and click the “Sun” icon in the screen which appears and J-Mate will automatically find the Sun, and use its position to calibrate the angular encoders automatically.

J-Tip

TRIUMPH-LS tags coordinates with magnetic values, It also guides you to top of the item to survey it.

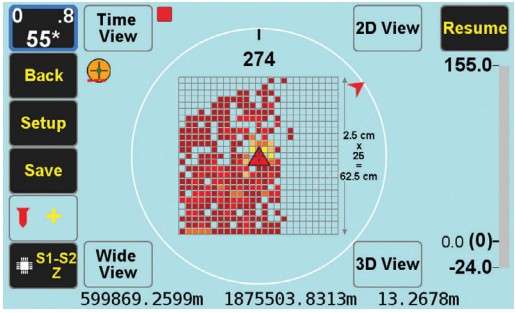
The Mag View focuses only on the mag object with the highest mag value.

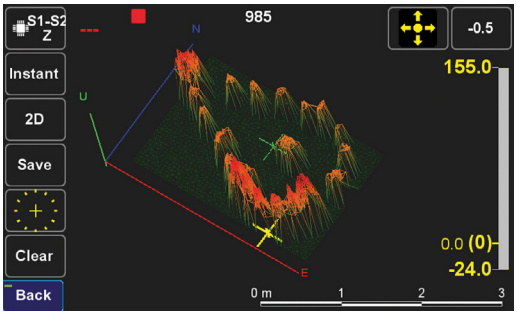
The audio and graphical bar show the magnitude of the magnetic object.

In “Setup” you can select the cell size and the size of the field you want to scan.

2D and 3D views of the field show the magnetic objects that have been scanned.

Zooming the 2D and 3D screens can show the shape of the magnetic objects under the ground.





For many sophisticated features of the J-Tip see its Users Manual in www.javad.com

What a great little system! I’ve been using it a good bit in the last few months since purchased controller back in November. Really appreciate all that I’ve learned here on the forum from folks like Nate the Surveyor, Shawn Billings, Matthew Sibole, others and all the developers on the Javad Team. Although this system has only a quarter of the channels as the Triumph-LS, it still amazes me in high multi-path areas using the RTN. Once you read the manual several times, especially on RTK Verification, everything falls into place. There is so many ways to verify your position if there’s any doubt; i.e., distance to last point, confidence and consistency levels, verification with selected # engines, saving of raw data to post process, etc.

Last project was cutting out 33 acres, part of the boundary was at the corner of a 150 acre tract. Located all the existing corners and the proposed corners with the owner (1 day field work). Computed the acreage (1/2 day office) and then staked out the corners and staked a few lines using my brothers Triumph-LS with radio RTK (1 day field work). This site was very bad with multi-path (pine forests and hardwood lands). I don’t think I could have used the Victor-LS/Triumph-2 in these conditions for stake out (I didn’t try). The Triumph-LS ruled in these conditions and minimal time was spent on station, staking out the actual new corners. Verification of my original locations performed with the Victor-LS/Triumph-2 checked < 0.1’ both horizontal and vertically. Also re-measured all staked points for verification while on station. Surveying is so much fun again when I can get out of the office!!!

I don’t know how the other surveyors do it without Javad! I’ll back my data up all day long with the confidence of the Javad system.

Bryan Enfinger

Thanks a lot Bryan. If you don’t mind, I would like to share your experience in our publications.

Javad Ashjaee

I just get excited using the equipment, it’s light years beyond anything available! I really enjoy finding time to keep learning on this machine, I’ve always enjoyed learning new things and this is the greatest yet. We were part of the trial team originally, my brother Buck really loves the Triumph-LS/Triumph-2 system.

Here’s an attached pic from the collect screen. I was verifying PT23 with two additional shots with the EPOCH count set at 10, time set at 180 secs and the APP set at 3600 secs (1 hour) for raw data logging if I didn’t get any fixed positions. This was in a wooded area with 25 year old pines and hardwoods with many leaves. I was amazed I got a fix with 5 engines within approx 1 minute and met the confidence and consistency levels set. Notice the “distance to last” measurement, all this with the Victor-LS/Triumph-2 system. While I know this won’t occur in all situations in the time frame shown here, even if it didn’t get a fix I had the raw data to post process using short baselines (i.e., another base <1.0 mile away).

Bryan Enfinger ENFINGER & ASSOCIATES PROFESSIONAL LAND SURVEYORS

THE BIG PICTURE

Satellite earth observation is a global enterprise right from the days of Landsat. However, with rapid privatization of the industry, there are conflicts between the data policy dictated by commercial requirements and national laws. Initiatives at national, sub-national and regional levels and their due alignment with each other is imperative to understand the impact on the industry. **By Prof Arup Dasgupta**

The 2019 edition of the Global Geospatial Industry Outlook and Readiness Index (published by Geospatial Media and Communications in GeoBuiz report) shows that the geospatial industry was worth around $339 billion in 2018. The industry is projected to be worth $439.2 billion by 2020, growing at a CAGR (compound annual growth rate) of 13.8%. This growth acceleration can be attributed to continuous technology advancements in the industry, democratization of geospatial information riding on integration with advances in digital technologies and resulting innovative business models. The earth observation industry alone is estimated to grow at a CAGR of 9.1% during 2018-23, according to Reportlinker, and is anticipated to be worth $11.8 billion by 2023. These numbers give an idea of the globally expanding geospatial market.

A closer look at the breakup of these numbers shows that the lion's share of $439.2 billion belongs to the GNSS and positioning market ($260.8 billion), followed by GIS and Analytics ($88.3 billion) and earth observations ($79 billion). "This is mainly due to the growing demand for location-based information, proliferation of mobile devices and the growing need for GNSS devices in various industry segments such as agriculture, aviation and intelligent transportation systems (ITS)," says the Geospatial Industry report. GIS and Spatial Analytics segment is fostered by "growing adoption of Spatial Analytics in city planning, utilities management, e-governance, applications, retail and logistics, disaster management and various other applications". Small satellites, nano satellites, near-real-time data acquisition and the growing value added industry using high resolution data are feeling the EO industry.

THE LANDSAT STORY

Landsat imageries are being used by researchers, scientists and policy-makers all over the world to monitor land use, deforestation rates, water quality and coral reef health. Until 2008, 53 Landsat scenes per day were being downloaded at a cost of approximately $500 per scene. In 2007, the US government decided to make it freely available. The economic value created by the open earth observation data has been significant since then as the demand for the Landsat data rose over 100 fold in just three years! Since the open data policy, approximately 5,600 scenes have been downloaded per day and 40 million Landsat downloads have taken place till 2016. Additionally, developed on the available open earth observation data from Landsat, 16 applications (across various user segments) have produced savings of $350 million to $436 million per year for the federal and state government. With federal investments up to $3.5 billion annually in civil earth observation programs and data, open earth observation data is set to conservatively add $30 billion to the United States economy.

However, there is a twist in the tale. A year ago, the article in *Geospatial World*, *"Who's Buying all that Satellite Imagery?"*, found that the big customers are the government departments, with defense being right at the top. Industry experts anticipate that by 2020, the market will be equally divided between government and industry, and by 2025, industry will overtake the government and a new segment of citizen consumers will emerge. In such a scenario, how should the governments respond in terms of policies and regulations?

Private-public partnership

At the 2019 Geospatial World Forum, a panel on National Policies and Strategies for EO Industry Development discussed many of these issues. One of the approaches that emerged was for the government and industry to work together in key areas such as disaster management, weather information, border surveillance and natural resources management. Massimo Camparini, CEO, e-GEOS, states the experience of the Italian Space Agency working with Telespazio for the company's platforms for maritime surveillance, defense and intelligence, agriculture, asset management and cloud computing. This marks a paradigm shift from data sales to subscription-based solution platforms.

Max Craglia, Team Leader (Digital Economy) at the Joint Research Centre of European Commission, says, "It is not just space, but the whole geographic information domain that contributes not just to the policies of the union, but also to economic and social development, which also are the policies of the European Union." It is interesting to note that the JRC is conducting a study on the impact of EO industry on geospatial policies. One would have expected it to be the other way around, but it highlights the point that technology outpaces policy and the latter is always trying to catch up.

Geoff Sawyer, Secretary General, EARSC- Belgium, asserts that the composition of geospatial industry in Europe has changed. "In the findings two years ago, we discovered nearly 8000 employees in 500 companies in the EO services sector in Europe with 4.2 billion revenue. Of these companies, 96% were SMEs, with 66% of them with less than 10 employees," he says. In an ongoing review, it emerges that in this sector, 46% are startups. It is also clear that the free and open data policy around Copernicus is a great help to these companies.

The view from the industry is well enunciated by **Agnieszka Lukaszczyk, Senior Director for EU Affairs, Planet.** She says, "It sounds like something idealistic, but we need to keep public good at the very top. Why do we do what we do? What is the big picture? And this is what's interesting and why I joined Planet — because we are a company divided in two parts. One is the commercial part where we have to do business and make money, but we do that to take the second company's initiatives ahead, which is doing the humanitarian efforts with a lot of free data for natural disasters and issues for environment, or for African countries to monitor poachers."

"We also blend governments and companies, but it's really people, and their expectations are different. In the public sector, it is taxpayers. Money comes in potentially from taxpayers, but the risks that the public sector

THE COPERNICUS VALUE

The Copernicus program too has adopted a free and open data policy. This means that the data available from the Sentinel satellites will be available at no charge to the users, thus helping the industry to develop. According to a study by the European Association of Remote Sensing Companies (EARSC), the Copernicus open data policy continues to deliver value to the public and the private sector alike, increasing return on investments through the creation of new enterprises, jobs, data-driven applications, etc. The exploitation of the open earth observation data from the Copernicus is poised to bring sound economic benefits. While the total investments in the Copernicus program are expected to reach EUR 7.5 billion, the expected rate of return on these investments is set to double to EUR 13.5 billion.

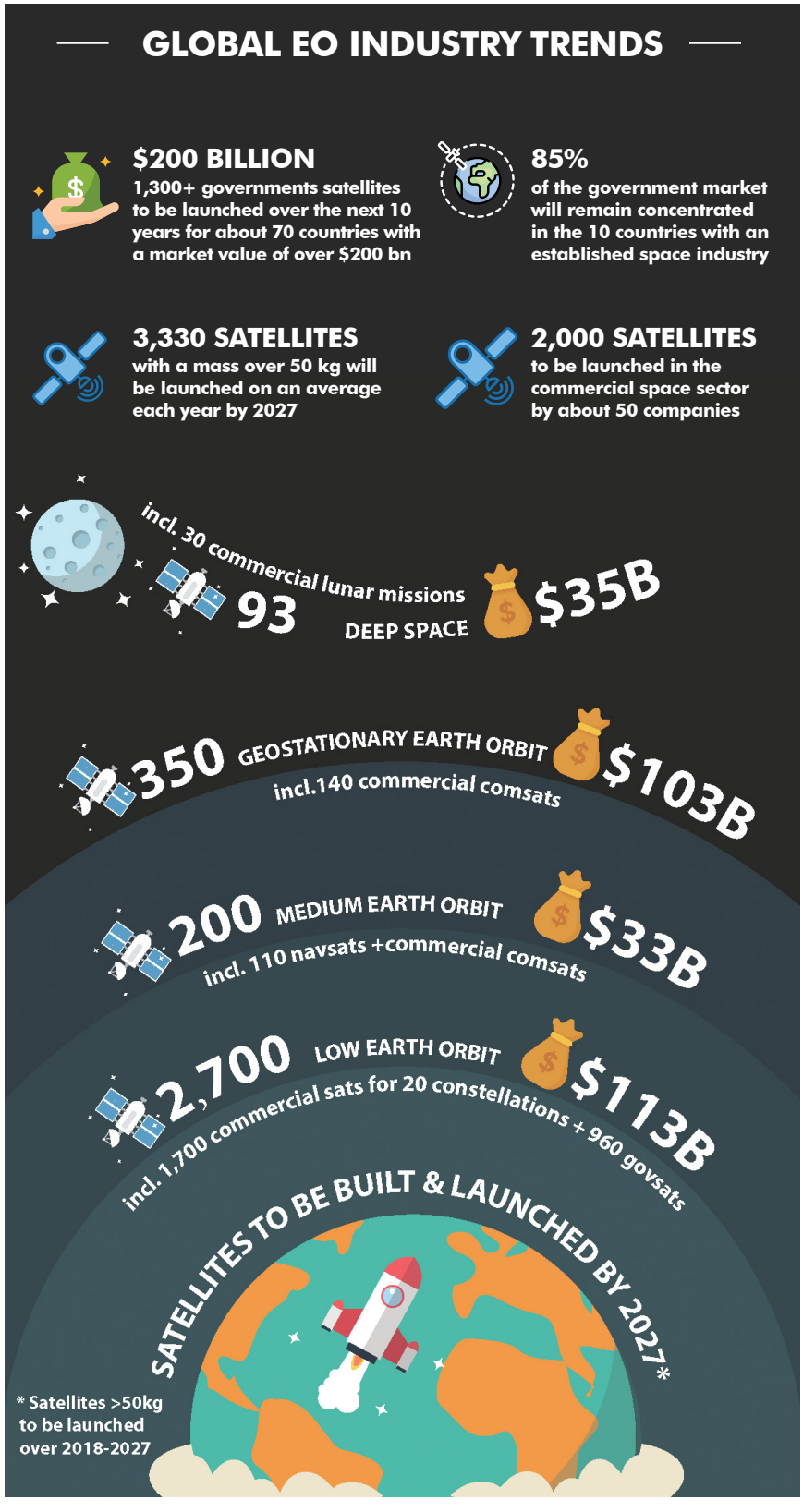
is going to take are very low because they have to respond to taxpayers. Whereas in the private sector, it's the opposite: you have few investors and they are willing to take risk. So the priorities that the two operate on are totally different," Agnieszka adds.

She stresses that therefore it is important for the two to talk. "Public private partnerships are the key. More and more industries are doing a lot of work in space. It is important that we work together and the industry should have a voice in the policy, particularly in space. Without industry, space would not be what it is today. A lot of people in the industry feel bad about regulations. So we need to put in smart policies that actually foster innovation and growth and allow the industry to grow and upgrade. And we need to find this balance between what is public good and what market is offering," Agnieszka explains.

An example of such a partnership is the servicing of the International Space Station, an international governmental effort, through the Dragon spaceship built by SpaceX, a private company in the US, and launched by Falcon 9, developed by SpaceX from the launch infrastructure which belongs to NASA, a government entity of the US. There are no subsidies, no grants, but a business contract that shows the importance of government contracts in raising small companies to great heights. In general, the government is the biggest customer of services, hence procurement policies must become innovative, according to Geoff. Agnieszka adds that the government should include earth observation in policies for other sectors as a viable tool in order to increase the market size for industry.

National policies

The earth observation policies are essentially national in nature because each country has its own perception about data and applications relevant to its needs. Policies in turn define the regulatory framework and industries have to work within this framework. With respect of policies, it is necessary to cover both geospatial specific and general Information Technology policies because geospatial can be considered to be a



Courtesy: Euroconsult

special case of IT. Most IT innovations like the Cloud, Big Data Analytics, AI and Deep Learning find their way into geospatial applications. Some other technologies like Internet of Things gain value with geospatial inputs.

At the core of this is the National Mapping Policy, usually administered by the National Mapping Agency (NMA). The NMA is charged with the maintenance of a geodetic frame of reference and a series of authenticated maps of the country with official feature names. It has to serve the civil and military needs of the country with various products for different sections of society. Given this mandate, the NMA must recognize the needs of industry and society and create an enabling environment so that the benefits of public-private partnership can be realized. While NMAs are perhaps the oldest spatial organizations in any country, they therefore carry a baggage of tradition, which they have to overcome through recognition and adoption of modern technologies. Private entities can play a major role in the PPP mode.

NMA and other agencies, both government and private, need to jointly evolve a National Geospatial Policy that addresses earth observation from space, piloted and remotely operated aircraft, sensor networks and GNSS. An Open Data Policy is needed specially when the data is collected at taxpayers' cost. While private agencies are justified in costing their data because they have to satisfy their shareholders, public agencies cannot re-tax the already taxed. Often, an excuse is made by government agencies that the cost is just recovery of the direct cost of data publishing and dispatch. Be that as it may, the case for open data is more than proven by Landsat and Copernicus. Many innovative applications using these datasets are the dividends that benefit the taxpayer.

Other policies that impact geospatial systems are those concerning science and technology, innovation and information & communication technology. These include strategies for Cloud infrastructure, network infrastructure, IoT infrastructure and digital empowerment. In parallel user departments, there is need for strong policies and strategies like adoption of BIM, engineering design and IoT. The value added industry, particularly in geospatial applications, needs to invest in Data Analytics, AI and Deep Learning and use them in solutions for user departments.

Volunteered information and crowd sourcing are neglected data sources. There has to be a clear policy on the way such data can be curated and used in geospatial solutions, particularly in real-time and near-real-time situations.

Global or glocal?

Satellite earth observation is a global enterprise right from the days of Landsat. However, with the rapid privatization of this industry, there are conflicts between the data policy dictated by commercial requirements and national laws. Therefore, such industries have to be sensitive and abide by national laws of the countries in which they operate. As far as space is concerned, it is governed by the Outer Space Treaty of the United Nations, but geopolitics is tempered by national goals. A case in point is the Long Term Sustainability (LTS) norms under discussion in the S&T Committee of the UNCOPUOS. Formulated in 2016, these norms could find approval for being presented at the General Assembly only in mid 2018, and that too only for 21 of the 28 clauses, after opposition from Russia finally ended.

Both national and private agencies need to jointly evolve a National Geospatial Policy that addresses earth observation from space, piloted and remotely operated aircraft, sensor networks and GNSS

LTS is essential because of the proliferation of small satellite constellations for earth observations as well as global communications are endangering the space environment and might lead to the Kessler syndrome where there might be a chain reaction of satellites crashing into each other. It is interesting to note here that the World Economic Forum is working on a Space Sustainability rating system that will rate industry and governments on how 'cleanly' they use space. The European Space Agency and the Space Enabled Research Group of MIT Media Lab are working on this rating system, and recently, Lockheed Martin Space has agreed to be a 'guinea pig' for evaluating the effectiveness of the system.

Agnieszka had mentioned about the role of the UN treaties in international cooperation and the need for industries to become active participants in the formulation of these international rules, principles and treaties to advance their international reach for business. The LTS and Space Sustainability rating system are steps in this direction.

The 2019 GeoBuiz report has a section on Geospatial Readiness Index, which is revealing. While a few developed countries rate high on this in terms of enabling policies, the developing nations do not fare that well. Even a country like India, which has a vibrant space activity and a growing geospatial industry, falls behind in enabling policies. There is a hangover from the colonial past and very real dangers in the geopolitical present that act as brakes. This is an area where more attention needs to be given by each country in framing policies to advance applications of geospatial systems.

Prof. Arup Dasgupta, Managing Editor
arup@geospatialmedia.net

THE GEOSS EFFECT

The GEO communities' GEOSS (Global Earth Observation System of Systems) has more than 400 million open data resources from more than 150 national and regional providers such as NASA and ESA, international organizations and the commercial sector. The data available helps countries create high social, economic and environmental impact. In addition, Radiant Earth Foundation started in 2016, is an earth imagery platform providing open earth observation data for positive global impact by fostering entrepreneurship worldwide.

Change Detection for Better Insights

One of the main goals set by the EOS team was to make the complex process of change detection in remote sensing data equally accessible and easy for non-expert users coming from non-GIS industries.

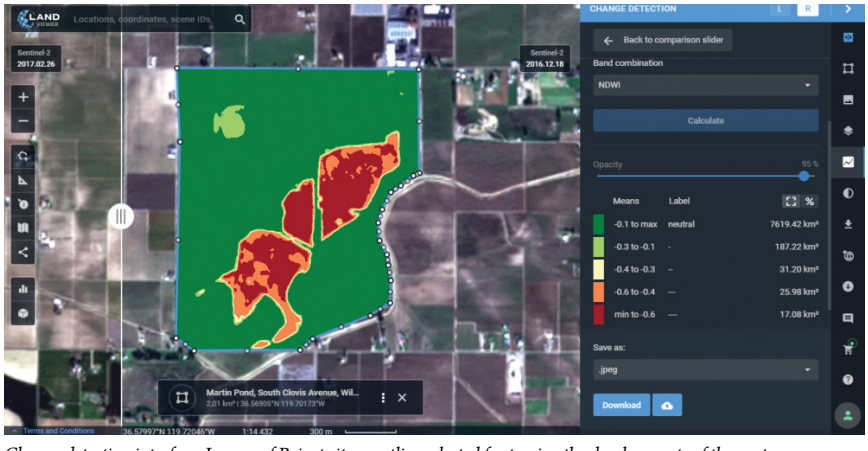
Remote sensing data has been majorly used to compare images of an area taken at different times to identify the changes it has undergone. With a wealth of long-term satellite imagery currently in open use, detecting such changes manually would be time-consuming and inaccurate. EOS Data Analytics stepped in by introducing the automated change detection tool to its flagship product LandViewer, which ranks among the most capable Cloud tools for satellite imagery search and analysis in today's market.

Unlike the methods involving neural networks that identify changes in the previously extracted features, the change detection algorithm implemented by EOS is using a pixel-based strategy, which means that changes between two raster multi-band images are mathematically calculated by subtracting the pixel values for one date from the pixel values of the same coordinates for another date. This new signature feature is designed to automate the change detection task and deliver accurate results in fewer steps and in a fraction of the time needed for change detection with ArcGIS, QGIS or any other image-processing GIS software.

Unlimited scope of applications

One of the main goals set by the EOS team was to make the complex process of change detection in remote sensing data equally accessible and easy for non-expert users coming from non-GIS industries.

With LandViewer's change detection tool, farmers can quickly identify the areas on their fields that were damaged by hail, storm or flooding. In forest management, satellite image detection of changes will come in handy for estimation of the burned areas following the wildfire and spotting the illegal logging or encroachment on forest lands. Observing the rate and extent of Climate Changes occurring to the planet (such as polar ice melt, air and water pollution, natural habitat loss due to urban expansion) is an ongoing task of environmental scientists, who may now have it done online in a matter of minutes. By studying the differences between the past and present using the change detection tool and years of satellite data in LandViewer, all these industries can also forecast future changes.



Change detection interface. Images of Beirut city coastline selected for tracing the developments of the past years.

Use cases

A picture is worth a thousand words, and the capabilities of satellite image change detection in LandViewer can be best demonstrated on real-life examples. Forests that still cover around a third of the world's area are disappearing at an alarming rate, mostly due to human activities such as farming, mining, grazing of livestock, logging, and also natural factors like wildfires. Instead of massive ground surveying of thousands of forest acres, a forestry technician can regularly monitor forest safety with a pair of satellite images and the automated change detection based on NDVI (Normalized Difference Vegetation Index).

How does it work?

NDVI is a known means of determining vegetation health. By comparing the satellite image of the intact forest with the recent one acquired after the trees were cut down, LandViewer will detect the changes and generate a difference image highlighting the deforestation spots, which can further be downloaded by users in jpg, png or tiff format. The surviving forest cover will have positive values, while the cleared areas will have negative ones and be shown in red hues.

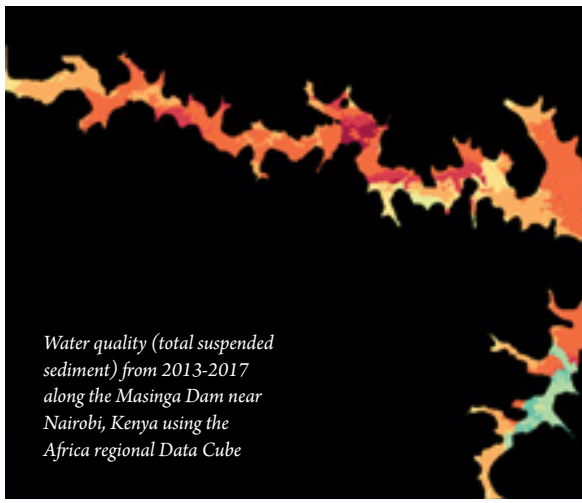
Another widespread use case for change detection would be agricultural flood damage, which can be quickly mapped and measured with the help of NDWI-based change detection algorithms.

Change detection in LandViewer

There are two ways to launch the tool and start finding differences on multi-temporal satellite images: by clicking the right menu icon "Analysis tools" or from the Comparison slider — whichever is more convenient. Currently, change detection is performed on optical (passive) satellite data only; addition of the algorithms for active remote sensing data is scheduled for future updates.

Explore the latest capabilities of LandViewer on your own: https://eos.com/landviewer

IT'S TIME FOR AFRICA



Water quality (total suspended sediment) from 2013-2017 along the Masinga Dam near Nairobi, Kenya using the Africa regional Data Cube

Earth observation has immense potential to support decision-making across the vast continent of Africa and to improve the life of every African. Digital Earth Africa (DE Africa) will be a continental-scale operational Data Cube for Africa. Taking freely available, analysis-ready satellite imagery as an input, the Data Cube will produce full-resolution decision-ready products available to one and all.

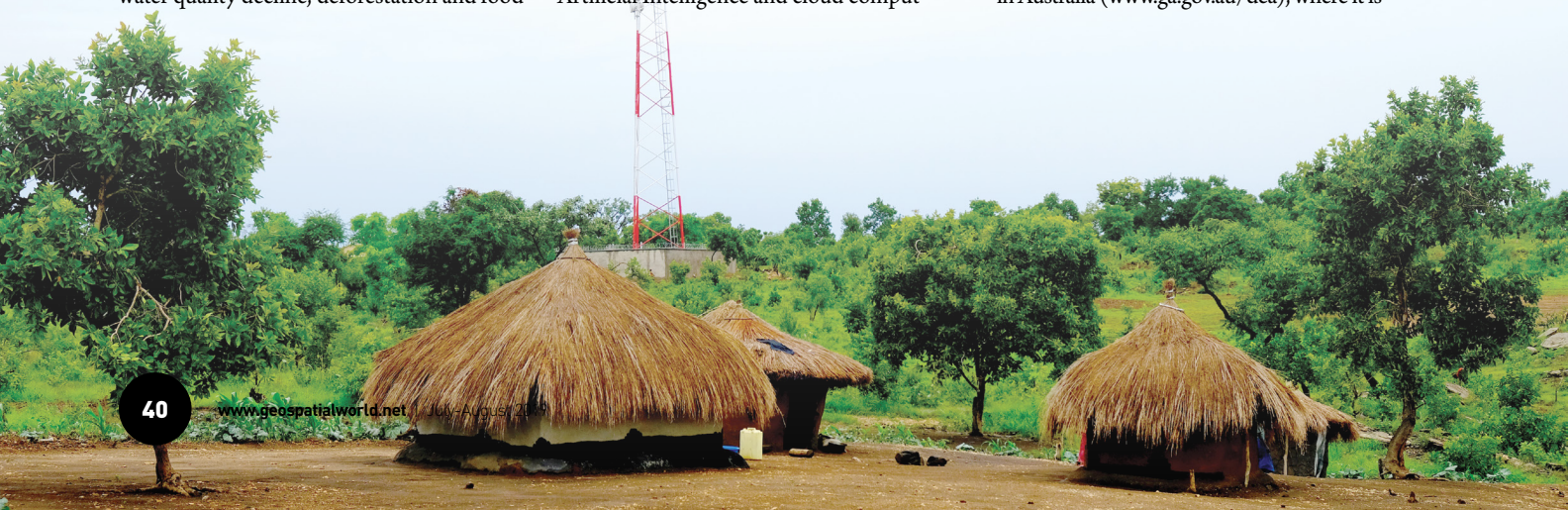
By Adam Lewis, Aditya Agrawal & Steven Ramage

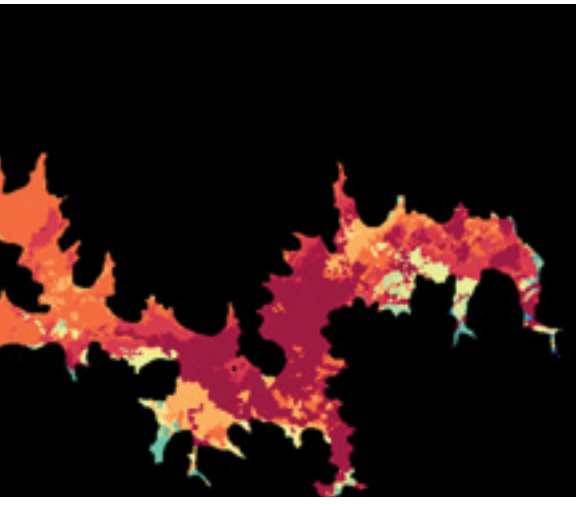
The United Nations Sustainable Development Goals (SDGs) are a global effort to address social, economic and environmental challenges across all countries by 2030. These ambitious goals require new approaches in using data, creating challenges and opportunities for earth observation. A massive continent with rich and diverse environments, Africa is under constant threat from Climate Change and environmental degradation, illegal mining, land degradation, water quality decline, deforestation and food insecurity. These challenges are taking their toll on communities and ecosystems.

Changes in the way we access and use data — a key transition of the Fourth Industrial Revolution — are enabling a fusion of technologies that support implementation of the SDGs. New possibilities for data analytics and visualization are emerging through the combination of human capability and advances in science and technology — including global observing systems, computer processing power, storage capacity, Artificial Intelligence and cloud computing. However, despite these advances there remain major barriers to earth observation delivering its full potential to improve decisions. Finding, accessing and processing earth observation data to produce decision-ready information remains a struggle for many countries.

Earth observation data and services have untapped potential to help address environmental challenges and development priorities, and to progress national and continental policy frameworks, including the Paris Agreement, the Sendai Framework for Disaster Risk Reduction, SDGs and Agenda 2063 — Africa's master plan for transforming the continent into the global powerhouse of the future. Furthermore, with the increased quality, detail and availability of satellite imagery, earth observation now has the potential to benefit businesses, NGOs and individuals in their day-to-day decision-making.

The Data Cube (www.opendatacube.org) was first developed and operationalized in Australia (www.ga.gov.au/dea), where it is





Target (Contribute to progress on the Target, not necessarily the Indicator)									Goal	Indicator (Direct measure or indirect support to the Indicator)				
							1.4	1.5	1 No poverty	1.4.2				
						2.3	2.4	2.c	2 Zero hunger	2.4.1				
					3.3	3.4	3.9	3.d	3 Good health and well-being	3.9.1				
									4 Quality education					
								5.a	5 Gender equality	5.a.1				
		6.1	6.3	6.4	6.5	6.6	6.a	6.b	6 Clean water and sanitation	6.3.1	6.3.2	6.4.2	6.5.1	6.6.1
					7.2	7.3	7.a	7.b	7 Affordable and clean energy	7.1.1				
								8.4	8 Decent work and economic growth					
					9.1	9.4	9.5	9.a	9 Industry, innovation and infrastructure	9.1.1	9.4.1			
						10.6	10.7	10.a	10 Reduced inequalities					
	11.1	11.3	11.4	11.5	11.6	11.7	11.b	11.c	11 Sustainable cities and communities	11.1.1	11.2.1	11.3.1	11.6.2	11.7.1
				12.2	12.4	12.8	12.a	12.b	12 Responsible consumption and production	12.a.1				
					13.1	13.2	13.3	13.b	13 Climate action	13.1.1				
		14.1	14.2	14.3	14.4	14.6	14.7	14.a	14 Life below water	14.3.1	14.4.1	14.5.1		
	15.1	15.2	15.3	15.4	15.5	15.7	15.8	15.9	15 Life on land	15.1.1	15.2.1	15.3.1	15.4.1	15.4.2
								16.8	16 Peace, justice and strong institutions					
17.2	17.3	17.6	17.7	17.8	17.9	17.16	17.17	17.18	17 Partnerships for the goals	17.6.1	17.18.1			

Linkages to where earth observation and geospatial data can directly support SDG goals, targets and indicators (Group on Earth Observations).

transforming the use of earth observations in government decision-making and private sector innovation. The Committee on Earth Observation Satellites (CEOS) promoted its use to other countries as a Cloud-based, open-source, data processing earth observation analytics platform. Earth observation Data Cubes are now being used worldwide to unlock vast archives of satellite data, allowing users to extract insights and information from these observations. Data Cubes provide an environment in which algorithms can be rapidly developed and applied to generate information products from the full earth observation time-series at continental scales. For example, trends can be detected, visualized and acted upon.

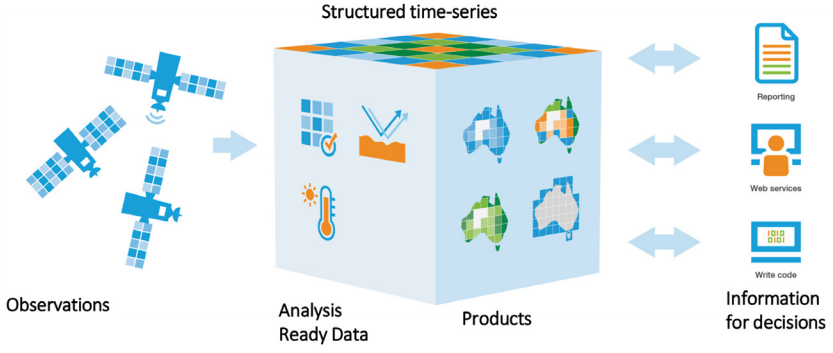
Much of the data used in Data Cubes is freely available, but Data Cubes reduce the data preparation and processing burden by at least 80%, allowing remote sensing experts to focus their attention on solving problems, rather than wrangling data. The Data Cube allows routine processing at continental scales with full resolution, moving earth observation into an operational role. Full time-series of images are accessed, producing more accurate and detailed information, and allowing processes to be visualized and understood. However, so far, Australia's is the only continental-scale Data Cube.

Earth observation Data Cube for Africa

In March this year, in Addis Ababa, Ethiopia, the Australian government and The Leona M. and Harry B. Helmsley Charitable Trust together announced funding to establish a Data Cube for Africa. The Digital Earth Africa Program (DE Africa) will develop a continental-scale Data Cube providing a routine, reliable and operational service enabling African nations to track changes across countries in unprecedented detail. With a land area of over 30 million square kilometers, four times as large as Australia, DE Africa will be the world's largest continental Data Cube.

Funders are investing in DE Africa because of its potential for broad-scale transformation, across sectors and scales, from continental reporting to the lives of individuals.

"We invested in Digital Earth Africa because we believe it will be transformative for every country across Africa and for every person in Africa," says Walter Panzirer from Helmsley Trust.



A high-level illustration of what a Data Cube offers: taking earth observations, putting them into an analysis-ready format across a time-series from which decision-ready products can then be developed. DE Africa will apply this model — of continental observation and information — to Africa

YEAR ONE
Setting the Foundation

- Developing the strategy and vision
- Implementing against the governance framework
- Establishing institutional hosting arrangements and office
- Recruitment of DE Africa staff
- Building the DE Africa data and ODC infrastructure
- Delivery of 1 continent-wide beta data product
- Developing a Communications and Outreach strategy inclusive of an Africa-wide launch event
- Stakeholder engagement strategy
- Establish key partnerships with in-country enablers and others
- Alignment strategy
- DFAT Investment Design

YEAR TWO
Building Capacity & Uptake

- First DE Africa Annual Users Meeting
- Product roadmap
- 3 continent-wide data products
- DE Africa Office fully staffed
- Regular training and capacity building program in place
- Engagement at the country level on uptake of developed data products
- An increased ability at the country level to exploit DE Africa data and tools
- Study outlining the economic value of EO data for Africa
- Increased high-level political engagement
- Co-investment from additional philanthropic / aid agencies including in complimentary activities including on-ground

YEAR THREE
A Developing Ecosystem

- 5 continent-wide data products
- Case studies on the impact of EO data on policy and coordination mechanisms at the country level
- A developing business case for direct country-level investment based on delivered value
- Data from DE Africa is independently ingested into new, innovative applications
- Sustainability plan for continued operations of DE Africa

International satellite programs including Landsat (United States), Sentinel-1 and Sentinel-2 (Europe), and ALOS (Japan) will provide the analysis - ready Data needed by DE Africa. The Data Cube itself will use the Open Data Cube software, allowing African countries full control over the products that are generated by the system. DE Africa will also have access to skills, knowledge and open algorithms developed by the broader Open Data Cube community and will be able to leverage that international work to rapidly build capacity and adapt products for Africa. Once established, DE Africa will produce routine data products and services for the African continent that are freely available to all users, analogous to the operation of a weather service.

DE Africa will build on the achievements and lessons from the Africa Regional Data Cube (ARDC), an initiative spearheaded by the Global Partnership for Sustainable Development Data (GPSDD) and the Committee for Earth Observing Satellites (CEOS). ARDC developed Data Cubes for Sierra Leone, Senegal, Ghana, Kenya and Tanzania and demonstrated their value through a series of applications, including flood and drought hazard, land cover and urban expansion, agricultural responses to Climate Change, detection of illegal mining, and coastal change. ARDC demonstrated also that algorithms developed in other countries such as Australia can be rapidly ported to Africa and build capacity there.

As a Community Activity of the Group on Earth Observations (GEO), DE Africa will also benefit from global input and support, including from AfriGEO — GEO's regional initiative in Africa. DE Africa will also align and work with other activities in Africa, such as the plan for Geospatial Information for Sustainable Development in Africa (2016-2030) and GMES in Africa.

Three-year plan

Digital Earth Africa is in the first year of an ambitious three-year plan to lay the foundations for an ongoing service. Over the course of 2019, it will establish institutional arrangements, build partnerships, recruit staff, engage governments, develop a product roadmap, deploy version 1 of the DE Africa infrastructure and produce its first continental data product. Governance structures including an independent Board and a Technical Advisory Committee will ensure that priorities are set within Africa, and that DE Africa delivers information products that are needed and sought after to help address real issues.

Subsequent years will see countries directly benefiting from DE Africa's tools and resources and developing a better understanding of how DE Africa's continental data and information products can be targeted toward and used to address key national priorities. DE Africa is expected to mature into a continental infrastructure that will be utilized across all sectors, with new applications and innovations being developed by an engaged and active African Data Cube community.

Ecosystem of innovation?

For Dr. Adam Lewis, who is heading the DE Africa Establishment Team, the ultimate success indicator for DE Africa will be the emergence of an ecosystem of innovations, each taking the operational products from DE Africa and putting them to new and unforeseen uses. "Incremental progress is not enough — the visible benefits of Earth observations should be growing exponentially; if we as the international Earth observations community can remove the final barriers to the use of these data, that can happen; perhaps more so in Africa than anywhere else," says Dr. Lewis.

We encourage you to find out more about this initiative by visiting: http://www.ga.gov.au/digitalearthafrica

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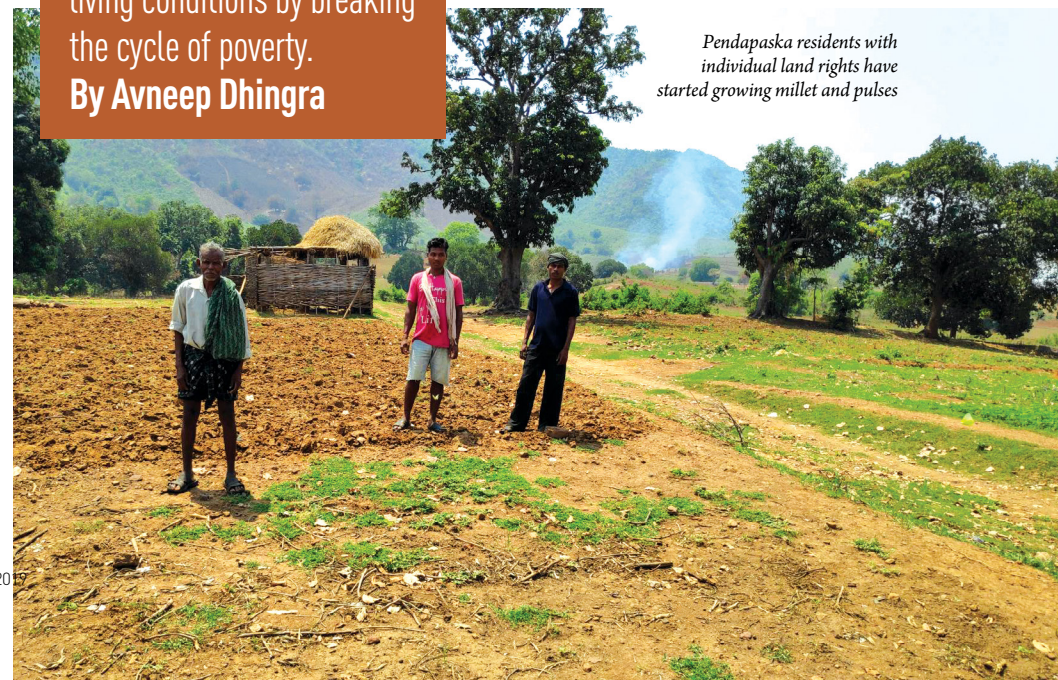
Ownership to Empower

Land rights have direct bearing on the incomes of marginalized individuals and communities, and the potential to transform their living conditions by breaking the cycle of poverty.

By Avneep Dhingra

Land is a symbol of identity, and often the only source of livelihood, for marginalized people and communities in developing and underdeveloped countries. Land ownership or tenure security, depending on the category or size of land, opens up new avenues for income generation, helping them emerge out of poverty. A classic example of this phenomenon is the remote villages in the Indian states of Odisha and Rajasthan, where people have progressed immensely, thanks to better earnings due to new opportunities and a sense of ownership and empowerment brought about by land rights.

As you set foot in Lamer, a small village in Odisha's Kalahandi district, your attention is instantly drawn to a handful of dish antennas mounted on the low-lying roofs of bamboo and brick houses. There are about 65 families or 300 people in the village, and nearly half



Pendapaska residents with individual land rights have started growing millet and pulses

of the households have TV sets. The locals' countenance conveys suspicion at first, but a few minutes of conversation — seated on a dusty tarpaulin in the complex of a newly constructed temple — puts them at ease.

"Almost every house here has a mobile phone. Some of them even have smartphones," says a proud Subhal Majhi, the gram sabha president. The turning point in the story of Lamer and its inhabitants came in 2012, when the locals learnt that they had been granted the ownership of nearly 1,000 acres of forestland surrounding the village under the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 (FRA). "The title was issued in 2010, but was gathering dust in the block office. We came to know about it two years later. It was the beginning of our transformation," adds Majhi.

Multiplier effect

In 2017, Lamer was granted transit permit by the state forest department to transport and sell bamboo commercially. "Most villagers are either involved in harvesting bamboo or work as daily wage labourers. Earlier, we used to illegally cut bamboo and sell it to a middleman for INR 3 ($1 = INR 68) per piece (measuring 20-25 feet). It was a risky job as villagers were often caught by forest officials, and had to offer a live chicken as bribe to avoid punishment. The ones employed as laborers were given INR 75 for eight hours of rigorous toil in temperatures hovering around 45-47 degrees Celsius," says 36-year-old Madan Biswal, a village resident.

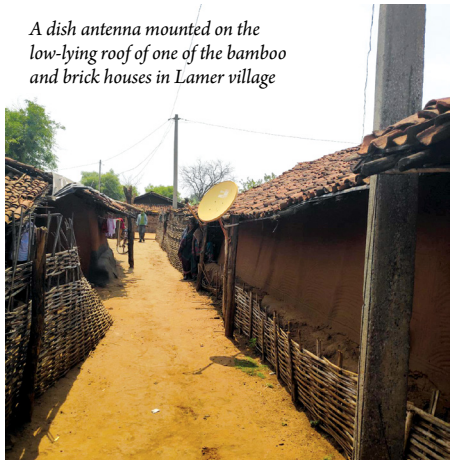
Women in Lamer village have started going to the nearest hospital for childbirth

Soon after getting the ownership, the gram sabha set up a forest management committee and appointed teams to guard the forest at night — to prevent 'outsiders' from cutting trees and extracting stone chips. "People had to earlier walk for 8km every day in search of fully grown bamboo. Things changed after we started protecting the forest. By the time we received the transit permit, the forest had expanded and bamboo was just 100 meters away," says Biswal.

After the village committee officially took over the transportation and sale of bamboo, the same piece that was earlier supplied for INR 3, was now sold at INR 60. "Of this, INR 25 goes directly to the harvester and INR 17.5 each goes to the gram sabha for development works and the management committee for forest protection," says Sushma Majhi, who at 61 is among the oldest women members of the gram sabha.

Social returns

Even though Lamer gram sabha existed long before the village got land rights, the body became assertive only after 2012. "We collectively took up the issue of low wages with contractors and complained to the administration about only a handful of families getting subsidized rice. For the past few years, the daily wage has been increased to INR 180 for women and INR 200 for men, and every family receives government subsidies," adds Majhi, who once worked as a low-wage laborer.



A dish antenna mounted on the low-lying roof of one of the bamboo and brick houses in Lamer village

The steady increase in income due to land rights has brought motorcycles, television sets and mobile phones in some of the the remotest villages of the Indian state of Odisha

The steady income led to the advent of TV sets, mobile phones and motorbikes in Lamer, and ensured that its children found their way into the school. "The gram sabha has appointed a tuition teacher for children at INR 1,000 per month. We also bear the cost of childbirths at the nearest hospital and provide interest-free loans up to INR 20,000 to households for wedding and cremation ceremonies. We fully sponsor the education of a child if he/she wants to step out of the village to study beyond Class V," says the gram sabha president.

Additional source of income

Not too far from Lamer, in the neighboring district of Rayagada, is Pendapaska, a village that is home to around 270 people of the Kondh tribe. Of the 56 families here, 24 were awarded land rights in 2016. "Before that we used to survive by selling non-timber forest products (NTFPs) such as seeds, leaves and flowers. Despite having a forest spread over 1,000 acre, our earnings were low. Things have changed for the better in the past three years," says Muki Pidiska, 45, displaying a copy of her land title.

While the collective rights under FRA in 2014 did bring respite to the residents, the sea change in their lives came two years later. "The villagers who received individual rights began planting millet and pulses, which provided additional income," says Pendapaska gram sabha president Paik Ziaka. A kilogram of millet and pulses fetches anything between INR 30 and 50. "Apart from sending children to school, people have started spending on healthcare," he adds.

By 2018, every fifth household had a motorcycle and every third family a mobile phone. Individual land rights also made villagers eligible for a host of government welfare schemes such as Pradhan Mantri Gramin Awaas Yojana. A number of pucca houses have been constructed since then. "The administration must speed up the process of granting

Individual land rights also made Pendapaska villagers eligible for a host of government welfare schemes such as Pradhan Mantri Gramin Awaas Yojana. A number of pucca houses have been constructed since then

In Rajasthan's Picholiya village, residents set up a cooperative after getting land rights, and have been growing fodder trees such as Indian Rosewood and Adulsa in 100 acres

individual land titles to the remaining families. Though a large part of our requirements such as firewood, fruits, leaves and seeds are met by the forest, we need an additional source of income to do as well as our neighbors," says Mahisana Praska, a village resident.

"Pendapaska and Lamer are classic examples of how land rights have direct bearing on income. Then there is ecological capital (forests getting dense and improvement in groundwater table) and social returns. All these put together can add a multiplier to earnings and transform living conditions," says Barna Baibhaba Panda, Senior Programme Manager (East), Foundation for Ecological Security (FES). The non-profit supports smaller local organizations in helping residents of remote villages in Odisha assert their basic rights.

In Kalahandi, nearly 11,000 individuals and 250 communities have been awarded land rights till date. "In fact, ours is the only district where the land title has the names and pictures of both the man and woman of the house. We have seen how individual and collective rights have pulled people out of poverty in some of the most backward areas, and that is why whenever an application comes to us, we look into it quickly and do the needful," says Budhadev Panda, district welfare officer, Kalahandi.

Mapping for better management

Mapping of common lands and preparing geo-referenced maps of

such areas are critical elements in securing tenure over common resources like forests, water bodies, grazing lands, orchards and other village commons. FES has developed an Android-based mobile application called Common Land Mapping(CLM) tool which enables village communities to map their common lands by using smartphones.

"Village youths are trained to assist forest rights committees constituted under the FRA for mapping of forest areas claimed under provisions of Community Forest Rights. This application works in offline mode and is compatible with most smartphone models available in India. Once the forest area is mapped with the consent of the gram sabha, it generates a map downloadable in PDF format with area and coordinates mentioned on it," adds Barna Baibhaba Panda. The technology has helped villages to legally secure common lands for benefit of communities.

Earnings through savings

Like in the villages of Odisha, the positive impact of land rights can also be seen in Picholiya village of Rajasthan's Ajmer district. In 1992, the administration granted the pastoral village access to the 300-acre revenue wasteland lying in the outskirts. That year, the village set up a cooperative and has been growing fodder trees such as Indian Rosewood and Adulsa in 100 acres.

"The villagers have stopped buying fodder from outside. We now have a system where we auction fodder among the residents. A kilogram of fodder from the market comes for Rs 10. We sell it for half the price. Sometimes when we have excess fodder, we sell it to shepherds and cattle-rearers in the neighboring village," says Nami Chand, president of the Tree Growers Cooperative Society.

The village has over 5,000 cows, buffaloes and sheep, and on an average, each animal consumes 5kg fodder daily. "Think of it like this: if a family has three animals, it would annually require around 5500kg of fodder, which would come for Rs 55,000 in the market. But if you have fodder trees in your village, you would have to spend no more than Rs 28,000 for it. The difference in the amount is your earning," says village resident Kuldip Sharma, who owns five animals.

Pendapaska residents proudly display there land titles

Today, the young shepherds in the village are getting quality education, women are going to private hospitals for childbirths and girls are no more forced to get married at an early age. "People have set up water tanks for their animals, donated computers to the local school and have collectively built a hospital. The sense of ownership has brought empowerment, changing the way residents approach life here," says Kumar Rupam, program manager with FES in Rajasthan.

GIS-based system for soil, water conservation

FES has also developed a Composite Landscape Assessment and Restoration Tool (CLART), a Geographic Information System (GIS) tool to plan soil and water conservation measures. "The tool was developed to address an observed gap in considering different, equally important parameters while planning for an area," adds Rupam. For a particular location, the user can input some basic measurements (length/width/height) into the tablet-based design-estimation tool. With these measurements, CLART generates technical estimates with an approximate cost, requirements for persons and days, and design of the structure in the field location.

The tablets with CLART are equipped with open-source android applications (QGIS and QField) and an inbuilt GPS device.

Through the android app QField, the color-coded CLART maps can be accessed without an Internet connection. The inbuilt GPS can trace a particular field location, which is overlaid on the particular color that allows the user to directly check the recommendation for that particular location and make informed plans as well as technical estimates.

Sense of ownership

A few hours drive from Picholiya takes you to Thana village in Bhilwara district. The 250 families residing here got nearly 200 acres of revenue wasteland on the village outskirts converted to pastureland in 2012, and began planting Neem, Babul, Chinese date and other varities of trees. "Soon, we set up a Pastureland Development Committee, which is recognized under the Rajasthan Panchayati Raj Act. Every family felt that it was our land and we need to take its proper care. People were really passionate about the plantation and their efforts worked," says Balvant Singh, the committee's president.

In the next few years, the villagers not only started saving money on fodder for their animals, but also started earing by selling fruits and herbs. "Today, more than half of the households have TV sets and almost every family has a mobile phone. Children are sent to school and women are taken to proper hospitals for childbirths. A lot has changed in our lives because of our land," says 38-year-old Phool Kavar, a village resident. The villagers have ensured proper fencing of the land, and have also appointed a watchman to guard the area at night.

As you leave Thana, your eyes are drawn to a few dish antennas hanging from the rooftops. The scene transports you straight to Lamer, making you wonder whether land rights will pave the way for such symbols of prosperity in all remote villages of the country.

Avneep Dhingray, Associate Editor
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Like Expression and Education, Connectivity Should be a Basic Right

In the absence of proper connectivity, you cannot think about empowering or developing marginalized communities, says NetHope CEO Lauren Woodman.

Please give us a brief overview of NetHope. Who are your international partners?

NetHope is a consortium of 56 leading humanitarian, development and conservation organizations in the world. We are a consortium within the technology sector. We work with more than 60-70 large technology providers, and collectively the group tries to figure out how technology can be used in dealing with the issues faced by these 56 organizations. The consortium is diverse, and the issues we address include emergency response, refugee support, child vaccination, maternal health, financial inclusion, species protection and Climate Change. Our members include World Vision, Mercy Corps and many more large NGOs working in different geographies. We also work with large technology providers such as Microsoft, Salesforce, Facebook and Google. In fact Cisco was our first partner and helped us found NetHope nearly 18 years ago. We also work with USAID, other large donor institutions and many UN agencies.

What role does geospatial and mapping communities play in this process?

Quite a lot. For example, Esri has been our partner for many years. There are so many applications of

geospatial data for our members. It is not just limited to mapping the land rights. When combined with other data, geospatial data becomes very rich. For instance, in the beginning of the Ebola virus crisis, 23 of our member organizations were working in Liberia and Sierra Leone. It was very difficult to get information about rural areas as there was no connectivity. Frontline health workers couldn't be paid because it would take four days to send a text message. We went in with our technology partners and donor organizations and provided connectivity to more than 400 organizations. When we started mapping, it emerged that infection rates were falling in areas with connectivity. Even then Ebola treatment units were being set up in such areas. However, in areas where the rates were high, there was no connectivity or Ebola treatment units. Had we not mapped these areas, we wouldn't have found that correlation. All the data was right there in spreadsheets and tools, but until it was given a spatial dimension, it wasn't possible to see the obvious. We have seen increased use of geospatial technology in emergency response, in coordination across multiple organizations and multiple driven agencies. We also need it to see whether we are covering all the communities that need our help.

Do you have any specific expectations from the geospatial industry?

I think the geospatial industry has done a very good job of trying to make tools available at price points that make sense in the non-profit sector. It has done a fairly good job of trying to make systems that can use a wide variety of data and bring together data streams so that we can get critical insights to make informed decisions. One of the big challenges that we continue to face in the members is lack of skills. It's not just geospatial data, it's more of data at large. We can immediately understand geospatial data and see its utility. So, there is a big push in the sector to use this type of data. But we have not cracked the code yet on how to do that with all our member organizations, and how to identify the right type of skills that we need to build to get the initial benefits.

You have said that digitized is not equal to digital. Can you share the context to this comment?

If I as a non-profit haven't kept up with technology investments over the years and think maybe I'll just leapfrog and jump right into digital, that's not going to happen. Neither digital nor digitized stands alone. You can do the one, and then the other one and ladder your way up, but you can't forget one. If you just do digital, you end up with a situation that we had in the sector for many years — lots of great ideas and individual projects that are completely disconnected, not replicable and not scaled. And they won't scale up because they are not built on a solid foundation. Digitized and digital are both necessary, but they are very different, yet deeply interconnected.

Can you cite examples of how technology can help in tackling the biggest humanitarian problems?

There are lots of good success stories in almost every sub-discipline of the development, humanitarian and conservation spaces. We talk a lot about the use of sensors in agricultural work, being able to monitor soil quality and having insight into that, and then being able to help small shareholder farmers based on what we know and not just what we think. If you can start looking at data and provide people information about when to plant, what to plant, how to plant and when to go to the market, it will empower them. Frankly, some of these technologies don't really require a tremendous amount of training. We think a lot about how it's hard to roll technology out, hard to train everyone, but that's not always the case. A well-designed technology is intuitive. We have seen a huge shift in the technology sector in the past 20 years in terms of solutions being designed from the users' perspectives.

You have talked about a very interesting and evolving environment in which there is interplay between technology and sociopolitical landscape. Why don't you tell us a little about that?

I have been in technology for a long time, so I look back at the world where we were just putting PCs on desks. Then we made the big jump to networks inside a building. It was a huge shift as we could connect all the offices in the same company. Today, we live in a platform-driven world. You think of any individual and that individual is a part of many different networks and platforms. Earlier, the first version of any new rollout had to be reworked. That has changed. Software gets updated everyday. You look at the updates on the app store, every app gets updated in a couple of days on the fly. That's because companies have access to the database and they know what's happening. You don't have to throw a product out there, wait for six months, see how consumers are using it, put them in focus group and pull that data back in. You can know that instantaneously. There has been a massive cultural shift in the technology sector. How do we solve problems related to water rights, child vaccination, education or economic environment? We can do all of this at the same time, but it requires coordination between agencies. This is where we lag behind in this sector.

In terms of projects and ideas, what can we expect from NetHope in the next five years?

We will continue to focus on connectivity. You will see us working across multiple organizations with our members engaged in collective impact programs to solve problems that affect us all. The area that we have been doubling down on over the last 18 months has been The Center for the Digital Nonprofit. We are examining this intersection between people, process and technology, which came out of the work we did in surveying our members and asking them about their shift to digital. You will see us continue to focus on providing resources, tools and guidance to help organizations address challenges and work with the donor and technology communities to bridge those gaps.

SURVEY OF INDIA

Department of Science and Technology

Survey of India Mandate

National Map Policy (NMP)-2005 mandates Survey of India (SoI) To:

- Provide, maintain and allow access and make available the NTDB (National Topographical Data Base)
- Promote the use of Geospatial knowledge and intelligence through partnerships and other mechanism

A. National Spatial Reference Frame

- National Ground Control points (GCPs) Library
- Precision Bench marks (BMs)
- Tidal observations and prediction of tides
- Field gravity observations across country
- Field Geo-magnetic observations across country

B. National Digital Elevation Model (DEM)

- National DEM of ± 10 metre accuracy
- High Resolution DEM of ± 3 metre accuracy
- Ultra high Resolution DEM of ± 50 cm accuracy

C. National Topographical Template

- Topographic maps on all scales
- Aeronautical charts
- Special surveys for Airports /Air fields of AAI/ Navy/ Coast guard.
- Special maps for Indian Air Force

D. Administrative Boundaries

- International, state, district, tehsil and Village boundaries
- International Boundary (IB) Survey
- Inter-state Boundary (ISB) Survey
- Administrative boundaries data up to district and village level

E. Toponymy (Place names)

Standardized Geographical names database

https://indiamaps.gov.in
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International Boundary of India

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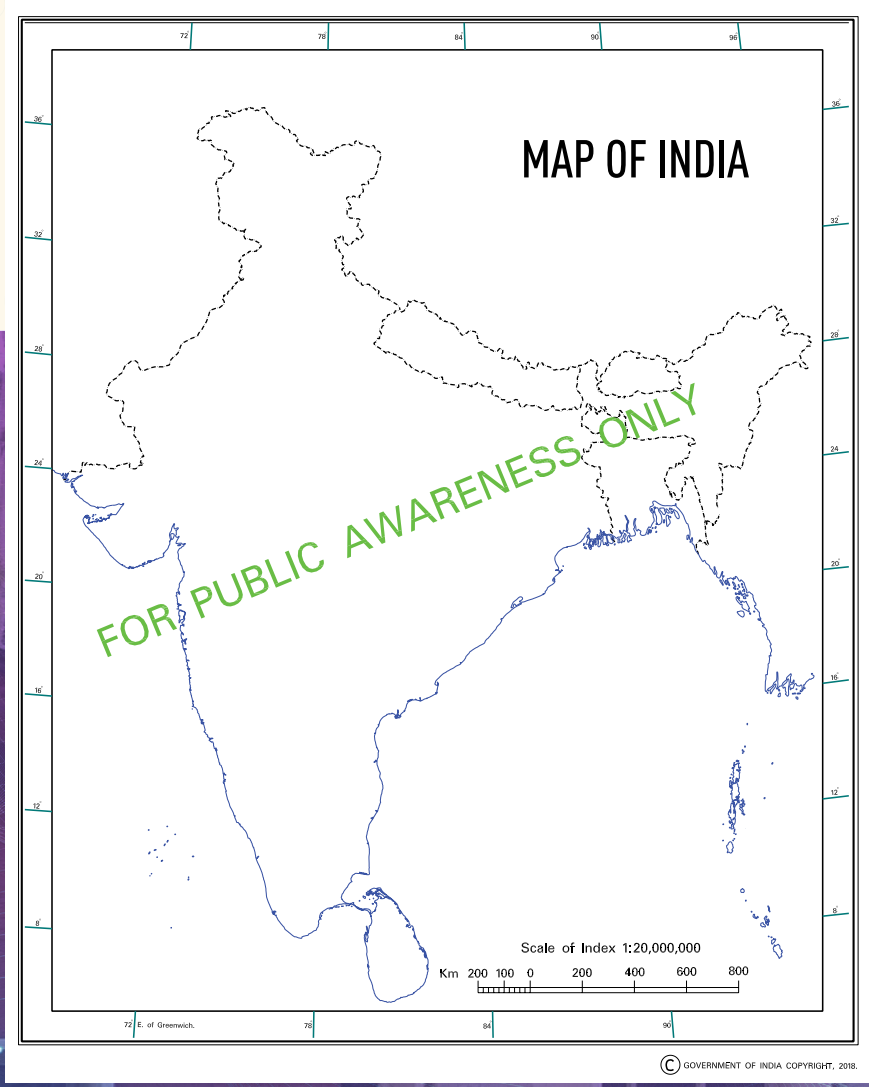
Incorrect depiction of the International Boundaries of India is a cognizable offence as under:

"Whoever publishes a map of India, which is not in conformity with the maps of India as published by the Survey of India, shall be punishable with imprisonment which may be extend to six months, or with fine, or with both"



Director, International Boundary Directorate (SoI), New Delhi is the nodal officer to deal with matter related to publishing the map of India with wrongly depicted International Boundaries

Email to – ibd.dli.soi@gov.in

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Vehicle-Mounted Scanning System for Tunnel Construction

FARO's Focus^{3D} increases overall efficiency and precision to 5mm tolerance for point cloud measurement.

A vehicle-mounted scanning system comprising the FARO Focus^{3D} is used to measure point cloud data at the excavation site in a mountain tunnel project.

In the construction of tunnels, surveying operations are deemed to be one of the most important operational tasks. A cross-section surveying operation is particularly significant for surface modeling, profiling, volume calculations and as-built control.

However, it is common assumption that tunnel surveying is a perilous task due to the unique working environment.

Ichikawa-based company, MAC Co., Ltd (MAC), which develops construction management systems for mountain tunnels, has worked with Nishimatsu Construction Co., Ltd. (Nishimatsu Construction) to co-develop a vehicle-mounted scanning system with the FARO Focus^{3D}.

This leading-edge scanning system measures and processes point cloud data of a mountain tunnel face within a5mm tolerance in just six minutes. The engineers selected the FARO Focus^{3D} for the system because of its superior automatic control function on computers, fast measuring speed and the overall convenience it offers.

These are some of the most critical factors for precision equipment when working in harsh construction environments such as tunnel sites.

Industry

- Construction & Civil Engineering
- Tunnel drilling

Applications

- Surveying

Benefits

- Delivers highly accurate measurements even in harsh environments
- Fast data transmission viaWi-Fi
- Point cloud measurement can be completed within a short time between various tasks of a tunnel construction project

The world's most precise construction management for mountain tunnels

"Recently, we have observed significant improvements in productivity for mountain tunnel construction projects," says Mr. Hirofumi Miyahara, President of MAC. "For example, drilling precision requires us to secure the design field and suppress surplus drilling (also known as over-digging) within 50mm. With precision construction control, we can reduce material cost, labor cost and project duration, as well as improve productivity levels. As 50mm tolerance cannot be determined visually, we need to rely on a surveying instrument. With the conventional total station, it takes too much time to obtain the large number of points and that affects the construction timeframe. Measurement using the 3D scanner also requires quite a bit of time — in setting up the equipment and reference balls, and for data processing."

The vehicle-mounted scanning system is actually a van with the FARO Focus^{3D}, a 3D laser scanner mounted on the roof. It enables fast point cloud measurement in a short time.

The key benefit of this system is that measurements can be taken very fast for multiple tasks such as blast hole drilling (where a hole is drilled and explosives rigged for blasting), muck discharging (where drilled rocks and excavated dirt are removed) and tunnel support erection (where temporary supporting structures are constructed to prevent rock mass from collapsing).

Detailed point cloud data at the touch of a button

In designing the scanning system, the team mounted the FARO Focus^{3D} on an automatic horizontal retention cradle supported by vibration-proof air cushion, such that it automatically keeps level once the vehicle stops at the measurement point.

A retractable enclosure covers and protects the Focus^{3D}. In addition, four marker spheres with built-in prisms provide positioning in relation to the total station. The markers allow point cloud data to be converted into coordinates. The system is built such that a host of processes — including horizontal retention, built-in prism reference sphere measurement by total station, rotation of the markers and also the scan — are all executed automatically at the touch of a button.

Faced with this challenge, MAC was motivated to co-develop a new vehicle-mounted scanning system with Nishimatsu Construction, using the FARO Focus^{3D}. Mr. Miyahara adds, "Our system allows operators to perform point cloud measurement around the tunnel face, with a range of 10m (in front of and behind the vehicle) and an accuracy of 5mm in about six minutes. In the unlikely event, where there are parts of the tunnel that do not reach the excavation cross-section, this data can prevent the parts from being missed and ensure the regularity of the tunnel."

This feature empowers construction teams to conduct quick checks, even when surveying technicians are not on site. While construction work on mountain tunnels generally goes on round the clock, key contract personnel are usually not on duty during the night shift. However, with MAC's scanning system, workers operating heavy machinery can remotely perform point cloud measurements just by hitting a button on the tablet PC.

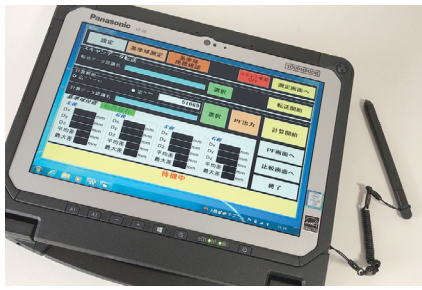
The vehicle-mounted scanning system also defies the common assumption that a high-specification workstation is required to process large volumes of point cloud data. As the team took care to equip the system with a function to automatically reduce the number of data points, it is comfortably operated with a low-specification computer system that runs on a 1.4GHz Core 2 processor and 2GB RAM.

FARO® Focus^{S} 350 Laser Scanner

Simplified tunnel maintenance for contractors

Previously, when contractors used general 3D terrestrial laser scanners or total stations with a tripod, the measurement of any tunnel deformity was limited to just once a day. To overcome that challenge, some project owners tried to permanently install 3D laser scanners or total stations onsite. However, there were issues with accuracy and obstruction using this method, because measurements had to be done from a distance to avoid the flying stones from blasting, and there was also limited space due to the heavy machinery involved.

MAC's vehicle-mounted scanning system resolves these difficulties. By conducting 3D measurement regularly during the tunnel construction, technicians can identify subtle displacements on the tunnel's inner wall that is not visible to the naked eye. This can also prevent accidents (e.g. falling rocks to partial collapse) that may happen during drilling work.



The tablet PC that controls the Mobile 3D Tunnel Scanning System

"Recently, the introduction of Construction Information Modeling (CIM), also known as Building Information Modeling (BIM), has been encouraged among Japanese contractors," explains Mr. Miyahara. "We are often asked to deliver as-build point cloud data at the time of tunnel completion. With this information, it would be much easier to manage tunnel wall displacement that happens with the passage of time."

MAC first introduced the FARO Focus^{3D} laser scanner as a trial in June 2016. Since then, they have purchased nine other Focus^{3D} laser scanners, including the one used in the vehicle- mounted scanning system.

"We chose the Focus^{3D} because it can be used on its own and provides high-speed point cloud measurement and fast data transmission via Wi-Fi," says Mr. Jyungo Miyachi, Section Chief of MAC's Development Department. "Furthermore, with the inherent harsh environment in tunnels, where dust and water cannot be avoided, having to insert and remove a memory card can be detrimental to a device."

Mr. Miyachi adds, "In the development of this system, we used both the Application Program Interface (API) and the Focus^{3D} software development kit (SDK) to control operations and data exchange functions on the vehicle-mounted scanning system. And the FARO development team provided excellent support throughout this process. This after-sales service also led to our decision to purchase more Focus^{3D} devices."

Courtesy: FARO Technologies Inc.

DRONES TAKE WING

How a technology that was designed to destroy is now being used for the betterment of mankind.

By Mahashreveta Choudhary

On a bright sunny day in the August of 1849, the streets of Venice were crowded with happy faces celebrating Festa della Madonna della Salute. The revelers had little idea that soon, the sky above them would not only put an end to the festivities, but would also lead to their country's surrender to Austria. For the first time in the history of wars, pilotless hot air balloons were used to drop bombs in the enemy territory. The technology was further developed after World War I and came to be known as drones several years later.

Thanks to their ability to reach inaccessible places, over the years, the use of drones in search and rescue operations, mapping and surveying, and in other civil applications such as policing and firefighting, has only multiplied. The exponential growth of unmanned aerial vehicles (UAVs), for drones as they are popularly called can be gauged from studies that predict the emerging global market for business services using drones to be worth over $125 billion in future.

Sky is the limit

Today, the application areas for drones are limitless. The technology that was once designed to destroy is now being used for the betterment of mankind. From wildlife conservation to disease control, emergency response, insurance to mapping, UAVs are being used in multiple sectors. **Lauren K. Venin, Landscape Architect at Dresdner Robin**, says, "The ability to safely and quickly gather data

access inaccessible locations opens a world of possibilities for of drones use. Their ability to thoroughly and accurately map natural features while minimizing human trespass may lead to better understanding of ecologically fragile areas."

Venin, who is also a Floodplain Manager and community volunteer, sees great potential in UAVs for emergency management agencies to assess damage in the wake of a natural disaster. Dresdner Robin based out of New Jersey has been using UAVs to provide critical data on river conditions to flood-prone communities. For one of its recent projects, the company reviewed Pompton Lakes' flood-prone waterways by using 11 individual flights 215 feet above the water level. The drones moved at 10mi/h, using a 15-millimeter fixed-zoom lens, capturing 60 feet sections of the terrain. Images were snapped every two seconds (1,042 in total) and were later analyzed to locate obstructions in the river channel. These pictures aided a stream-cleaning project that is part of the borough's flood mitigation program.

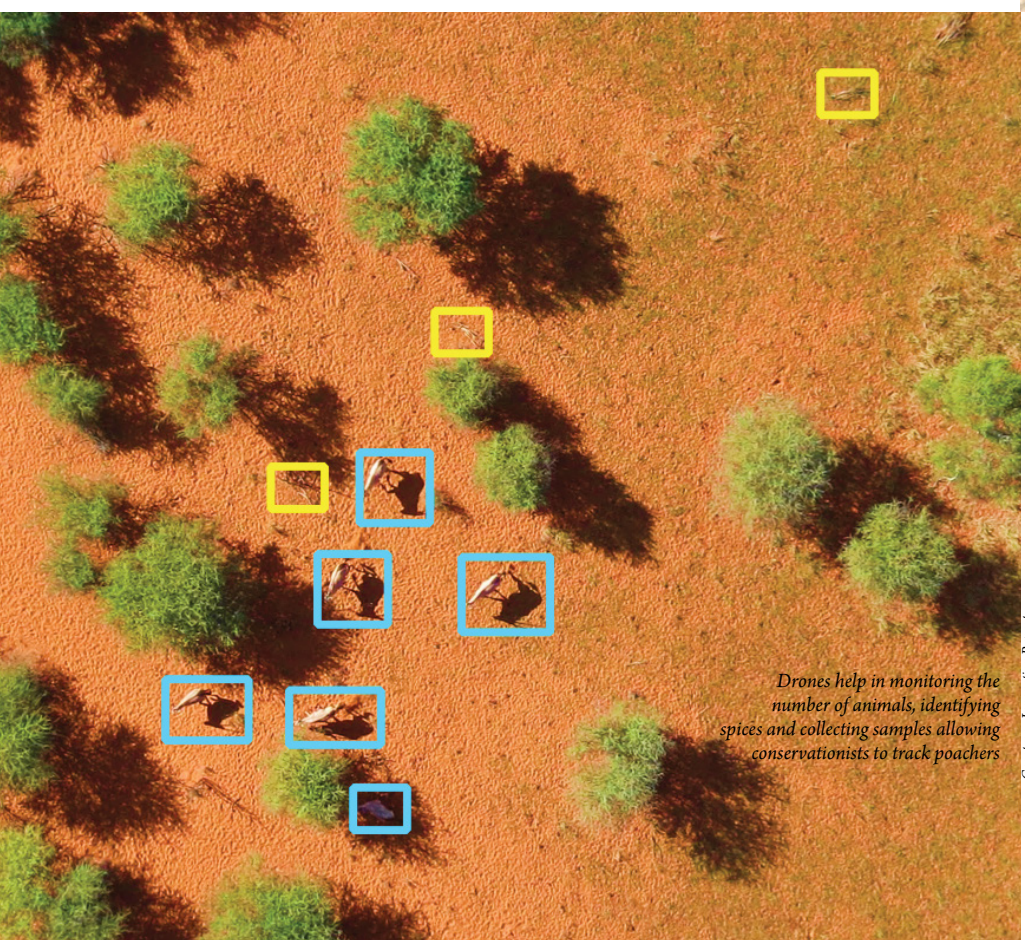
Another area in which drones are increasingly being used is the fight against deforestation. A good example of this can be found in remote fields in the south of Yangon, where mangrove saplings were planted by drones, exhibiting the ability of the technology to restore forests. Biocarbon Engineering, a startup that makes drones to plant trees and grasses, took up the initiative. The company has also planted trees at abandoned mines in Australia and in other parts of the world. In Myanmar, it is working with a non-profit organization called Worldview International Foundation. For plantation, drones are first flown over an area to map it and collect information about the topography and soil condition so that it can be combined with satellite data and analyzed to determine the best locations to plant seeds. Once the surveying is done, drones fire biodegradable pods filled with a germinated seeds and nutrients into the ground.

Dr Subhash Ashutosh, Director General of Forest Survey of India (FSI), which comes under the Ministry of Environment, Forests and Climate Change, says drone is

From disease control, wildlife conservation to emergency response, insurance to mapping, UAVs today are being used in multiple sectors

Drones in agriculture are used for soil and field analysis, planting, crop spraying, crop monitoring, irrigation and plant health assessment

Courtesy- Technology Review



Drones help in monitoring the number of animals, identifying spices and collecting samples allowing conservationists to track poachers

Courtesy - Innovation Report

a new technological addition to their data acquisition and collection methodology, and that FSI has been using UAVs for survey and demarcation of R&D applications in species identification. FSI deploys drones fitted with multispectral high-resolution cameras so that the algorithm for species identification can be used in an automated manner. Dr Ashutosh adds that soon after FSI started using the technology, several other departments picked it up for mapping and surveying.

Similarly, HESOFF, a project implemented in cooperation with the Institute of Aviation, Warsaw and the Forest Research Institute, Sekocin Stary, uses drones for forest health assessment. The project is co-financed by European Commission and the National Fund for Environmental Protection and Water Management.

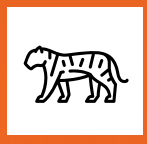
Marcin Spiralski, a GIS and teledetection specialist at the Institute of Aviation, Poland, says that they are using fixed-wing

ADVANTAGES OF DRONES

DISASTER MANAGEMENT
Assessing damage, locating victims and delivering aid

URBAN PLANNING
Providing instant mapping and ready to use data for planning

CONSTRUCTION
Creating accurate 2D and 3D data, maps and models: conducting surveys before, during, and after construction



WILDLIFE CONSERVATION
Monitoring the number of animals, species: collecting samples for conservationists to track poachers

AGRICULTURE
Planting, crops: monitoring, irrigation

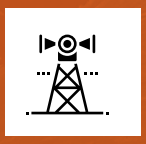
GEOGRAPHIC MAPPING
Acquiring high-resolution data: downloading imagery in difficult to reach locations like coastlines

HEALTHCARE
Delivering medical services in remote areas

WEATHER FORECASTING
Assessing weather trends to understand imminent dangers

WASTE MANAGEMENT
Identifying garbage sites

MINING
Measuring materials: surveying operations



UTILITIES
Inspecting telecommunication towers: tracking oil spills

LAW ENFORCEMENT
Monitoring large crowds: tracking illegal activities

drones to monitor forest health and drought possibility. "We use fixed-wing UAVs with multispectral six band camera for advance analysis for orthophoto maps with near infra-red channels up to 1000 meters to review forest condition," he says.

Agriculture is another sector where drones are completely changing the way operations are carried out. **Jovan Parusic, head of Business Development and Marketing, Agremo**, a drone company based in Belgrade, Serbia says, "Drones have a development story of growing from a toy to a life-saving tool. In agriculture, they will soon become as important as tractors. Drones can help in sprouting and monitoring crops, and can scale up the production and bring down costs." Drones can be employed for innovative rule-based reasoning to accurately count plants and determine stands from different angle orientation. They can help assess, prevent and correct crop damage throughout the season by routine monitoring and early detection. **Ira Devir, CEO of Agrowing**, based in Israel, agrees with Pursaic. Devir says, "The world is hungry and it needs food. The best way to cut down on crop losses is through early detection of plant diseases. This is where drones can be of great use."

Rajiv Sharma, President of 5th Dimension Technology, headquartered in Hyderabad that uses drones for collecting, analyzing and delivering information that transforms how businesses make decisions, points out, "Drones have many applications, some of which we have not yet imagined. UAVs are starting to replace hazardous works such as climbing tall structures, inspecting confined areas and traversing dangerous terrains. They are helping save lives during search and rescue efforts and are optimizing energy production and delivery." Sharma believes that in future, drones will be used to transport people and goods to hard-to-reach areas, delivering life changing access to healthcare and technology all over the world. UPS and autonomous drone technology firm Matternet has already started doing that. The company has been experimenting with medical deliveries using drones (Matternet's M2 quadcopters) to WakeMed hospital in Raleigh, North Caro-

Courtesy- Ghana Health Services.

With drones, early delivery of medical services in remote areas is now possible

Courtesy- Cicso

UAVs help in assessing damage, locating victims and delivering aid in disaster-hit areas

lina. The effort is the result of the FAA's Unmanned Aircraft System Integration Pilot Program, a three-year project set up to test the safe integration of drone technologies into commercial airspace.

Most preferred choice

Drones have become an eye in the sky to give us the view from above. They provide real-time, high-resolution imagery at a very low cost. Drone data is more likely to result in correct measurements in the first time, vastly reducing the time and cost of repeat site visits. **Darshan Divakaran, UAS Program Engineer, North Carolina Department of Transportation, Division of Aviation**, says, "Satellite imagery has played a pivotal role for almost two decades now. But, it has several limitations concerning cost, data sharing and time. In contrast, drones can capture aerial imagery at a far higher resolution, more quickly and at a much lower cost. And unlike satellites, people can own drones. UAVs also have real-time streaming capabilities that enable quick decision-making."

Backing Divakaran's argument, Lauren K. Venin says, "As a Landscape Architect, I appreciate the high quality of UAV imagery as well as the geo-referencing of images. Using drone photographs as a backdrop for graphic plans allow easy integration of aerial pictures into graphic presentations without the loss of image clarity that we generally encounter when using readily available satellite imagery."

With miniaturization of sensors, it has now become easy to capture imagery using drones. The advancement in sensors has two primary impacts: data quality and automation. Better visual and thermal sensors capture ever-higher resolution images, which means drone data is more accurate and easier to use. New sensors are also being used to guide a drone's flight path, keeping a consistent distance from a structure or the ground to enable automated flights and increase measurement precision.

"The future of drone technology depends on sensors in many ways. From multispectral camera sensors for agriculture to thermal sensors for search and rescue, we have seen this technology changing. Today, new drone mounted multi-sensor systems running Artificial Intelligence and Machine Learning are being used for critical infrastructure inspections. Further, chemical sensors can be attached to find out information about the chemical composition of an environment," says **Massimo Cipeletti, CEO of 3DT** based in Italy, a company that manufactures LiDAR for drones.

Better regulations mean easy flying

Right polices are a must for technologies to revolutionize the world. Drone, which was considered an immature technology till sometime back, has now started catching the attention of policy-makers. With drones being allowed for commercial use, an entire industry has emerged, enabling businesses to enhance safety and delivery standards.

Countries around the world are working to integrate drones into the national airspace. Until a year ago, there were a lot of restrictions that limited the use of UAVs. Now, operations Beyond Visual Line of Sight and at night are being considered, and unmanned traffic management is being tested in urban environments. Regulatory bodies are working with government agencies, industry and universities to streamline laws. Flexible rules have made the US, Europe and China the three largest potential markets in the world for commercial drones.

"Different markets have different applications of drones. In the US, you have an amazing market; people are using drones and are open to modern technology. At the same, in South Africa, which is a great country for agriculture, there are strict laws for drone operations. You have to wait for around 18 months to get a license, and when you do, you have to scale up your mapping crew from one drone pilot to four. This increases the cost raising questions about the applicability of the technology," Pursaic says.

With government and private entities across sectors opting for drones for key operations, many believe that the growth and success story of drones has just started.

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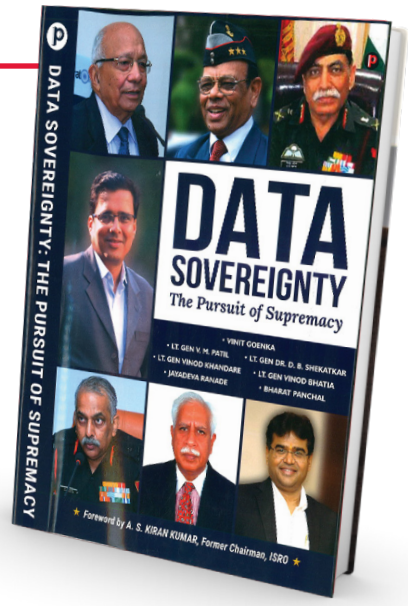
My Data in My Country



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Data Sovereignty: The Pursuit of Supremacy presents a fresh argument in the ongoing debate about the implications of data control in national policy frameworks and the regulations pertaining to it.

A lot is being said about the utility of data and its pre-eminent role as the bedrock of automation and the Fourth Industrial Revolution. The 'right' data can facilitate unprecedented technological innovation and deliver skyrocketing progress, marking the culmination of human-machine interaction and initiating a new epoch in our evolution.

The big question, however, is: who will own, control and have the authority to manipulate and exploit such data? If data indeed 'is the new oil', a popular phrase coined by *The Economist,* there is also a flipside to it: intense competition, subterfuge, dominance and conflicts.

According to Chris Hughes, a co-founder of Facebook and Antonio Garcia Martinez, a Silicon Valley whistleblower-turned-bestselling author, the new data revolution would translate into new private monopolies amassing astounding fortunes through control of data.

The book starts with the painful ordeal of colonization and its different manifestations throughout the years. While a lot has been written about the pernicious impact of colonialism and its subtler version, Neo-colonialism, which blighted the Third World for most part of the 20th Century, we know very little of the Western techno-social hegemony and the phenomenon of monopolization by a handful of corporations.

The premise of the authors is that most of the data centers and servers today are based thousands of miles away in Western countries and are subject to their jurisdictions. This means data of millions of Indians is stored in a server somewhere in say Ireland or New Mexico. In this scenario, the risk of user data infringement to psychologically and behaviorally manipulate people for ulterior motives sounds ominous.

The Facebook-Cambridge Analytica fiasco revealed that most big companies sell data to third party aggregators. And this data can be used for literally anything ranging from personalized targeted advertisements, manipulation of electorate to some dreadful mass scale socio-psychological experiment.

The authors compellingly argue that Indian data should be stored in servers that are within the geographic boundaries of the nation and subject to Indian jurisdiction — data localization and sovereignty would not only strengthen security but also boost the economy.

India's data centre infrastructure is expected to reach $4.5 bn by 2020. The global cata centre business exceeds $100 bn, while India's share is abysmal $2 bn

In the international fora, China and Russia are the staunchest advocates of data sovereignty. As per the laws in these countries, it is mandatory for an enterprise to store data in servers within the confines of national boundaries.

With an in-depth analysis of the data center business model, Vinit Goenka, one of the authors, asserts that with the impending saturation in conventional IT market, India cannot afford to miss the lucrative data center business. He further argues that India has the potential to capitalize on it and become a global hub of captive data centers.

What lends credence to his arguments about the immense possibilities in the Indian market is the fact that there would be 730 million Internet users in India by 2020.

India's data centre infrastructure is expected to reach $4.5 billion by 2020. The authors have given a blueprint for establishing a data centers in India and included a SWOT analysis in the book. The global Data centre business exceeds $100 billion, while India's share is only $2 billion.

The cost of operating a data center in India would be up to four times cheaper than anywhere else. Citing a study by NASSCOM, the book says that India ranks second in the world in terms of available talent pool for managing a data center.

The book is jointly authored by Vinit Goenka, Lt. Gen VM Patil, Lt. Gen Dr. DB Shekatkar, Lt. Gen Vinod Bhatia, Lt. Gen Vinod Khandare, Jayadeva Ranade and Bharat Panchal.

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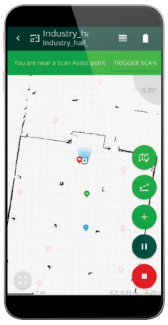

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