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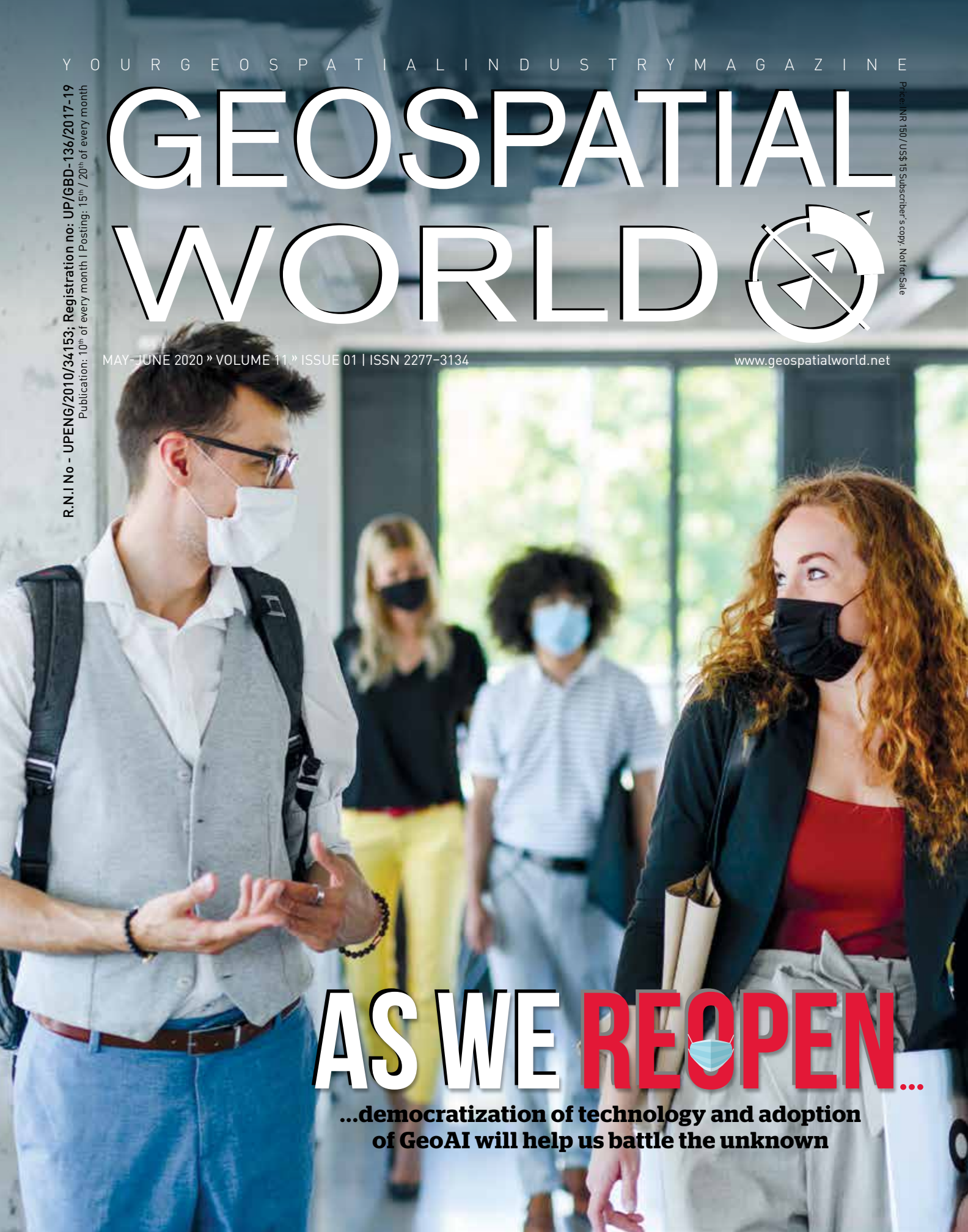

AS WE REOPEN...

...democratization of technology and adoption of GeoAI will help us battle the unknown

CONTENT

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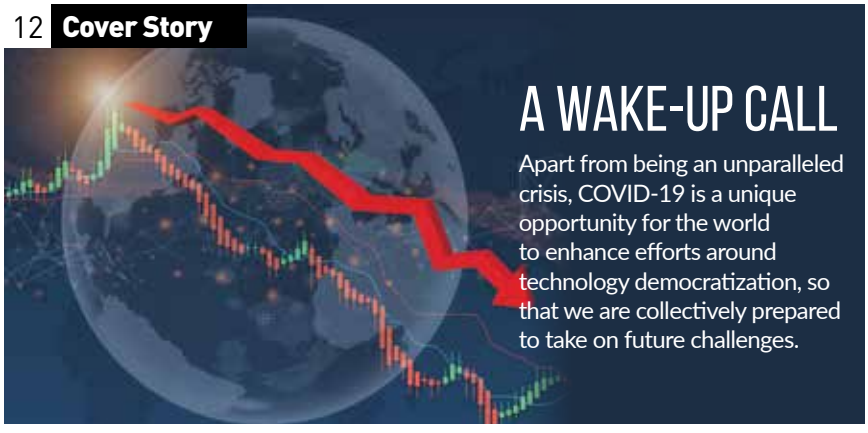
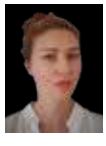


A WAKE-UP CALL

Apart from being an unparalleled crisis, COVID-19 is a unique opportunity for the world to enhance efforts around technology democratization, so that we are collectively prepared to take on future challenges.



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NAVIGATING THE UNKNOWN

Prof. Arup Dasgupta
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COVID-19 has impressed upon us the fear of the unknown. Airlines are collapsing as international travel has reduced drastically; and tourism is dying a slow death. Our healthcare systems are at breaking point. Livelihoods are affected and joblessness is growing. Yet we have begun to adjust to this through the "known". Meetings are now online, as are seminars. Students learn online in spite of the woeful state of the availability of the Internet in rural areas. What stands out in this bleak scenario is the importance of location. Never before has it become so essential to know "where". Where are the containment zones, where are the hospitals, where is the doctor, the ambulance, the address of the patient... the list goes on. This is the time for geospatial to show its utility.

Perhaps the earliest use of geospatial in India for COVID-19 control has been in the state of Kerala. Here, COVID-19 cases were plotted on a map and "heat maps" were created to indicate possible clusters and help delineate containment zones. There have been cases where the travel of COVID-19 affected individuals have been plotted and publicized and a post facto checkout of individuals who might have picked up the infection from these individuals was conducted. While geospatial systems have helped in mapping, the real control has been effected by feet on the ground. Health workers have used the system to keep track of the patients and their movement and contacts.

In sharp contrast are the contact tracing apps which have proliferated worldwide. Originally started by China and then picked up by South Korea, Singapore and India. MIT Technology Review has listed 30 such apps being used all over the world. Apple and Google have worked together to develop an API which has been picked up by 23 countries to create their own contact tracing apps. Most of these apps except the Apple-Google API do invade the privacy of the individual to a lesser or greater degree. Such apps are not a replacement of feet on the ground but only assists such workers. Much is made of individual safety. Consider the much-touted Singapore app. As only one-fifth of the population is using this app, the chances of any two persons in close proximity having this app on their smartphones is just 4%.

The real application of geospatial is when it is combined with other tools like AI. As an article in this edition shows, using these two technologies together, appropriately termed GeoAI, it was possible to detect the unusual cases of pneumonia in Wuhan back in December, which turned out to be COVID-19. Such techniques should be used to locate clusters and potential clusters based on travel data and contact tracing. More importantly, such applications can become an important tool in the armory of the healthcare organizations to sniff out potential pandemics.

An area which geospatial systems need to address is the post pandemic scenario. For one thing, COVID-19 is here to stay. What would be the implications of this to healthcare, travel, transportation, energy sources and industry? It is increasingly clear that the world is not returning to its pre-pandemic state very soon. Lockdowns have showed that the impact of wanton development can be reversed. While we cannot stay in a condition of permanent lockdown, it is clear that controlled development is the way forward. Geospatial technologies can and should provide the necessary information for future planners to help them to find a way towards a sustainable future.

2020 & ELASTICITY OF THE WORLD ORDER

On June 26, 1945, delegates from 50 nations came together to sign the United Nations Charter – a historic moment for global peace and progress which set the context for a new world order. Five years later, the Republic of India laid down the principles for the world's largest democracy, with ***वसुधैव कुटुम्बकम्*** (The World is one Family) engraved in the entrance hall of its Parliament.

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Over the last 75 years of post-World War II, humanity has thrived towards global peace, prosperity, and harmony. Several alliances have been formed to build cooperation in fields of security, economy, and sustainable development. Though some of the early alliances such as NATO and Warsaw Pact focused on military cooperation, soon, the world witnessed economically driven collaborations such as Organisation of Petroleum Exporting Countries (OPEC), Group of Seventy Seven (G-77), Organisation for Economic Cooperation and Development (OECD), and Group of Seven (G7).

The end of the Cold War around 1990 added even more meaningful dimensions to the world order, driven by aspirations of free trade (World Trade Organisation), political integration (European Union) and economic cooperation (Group of Twenty) and BRICS. And finally, the last decade witnessed the noble aspiration to 'Leave No One Behind'. The world got together to commit The 2030 Agenda for Sustainable Development – a blueprint for peace and prosperity for people and the planet. At the heart of the Agenda are 17 Sustainable Development Goals, making an urgent call for a global partnership to end poverty, improve health, and reduce inequality, while spurring economic growth and tackling Climate Change.

While we prepare to celebrate the 75th anniversary of the UN, reaffirming its collective commitment to multilateralism, the year 2020 seems to be adamant on challenging the elasticity of the world order by compressing its principles of one family. The year began with COVID-19, and within a fortnight, humanity was dismayed by the so called aspirational world order in which no one is left behind. Collaborative agreements of all kinds lost their relevance, and inward looking governments sealed their borders and dedicated all available resources to protect their own people. This inward approach percolated to municipal, and even household levels. Soon, social distancing also meant "emotional distancing".

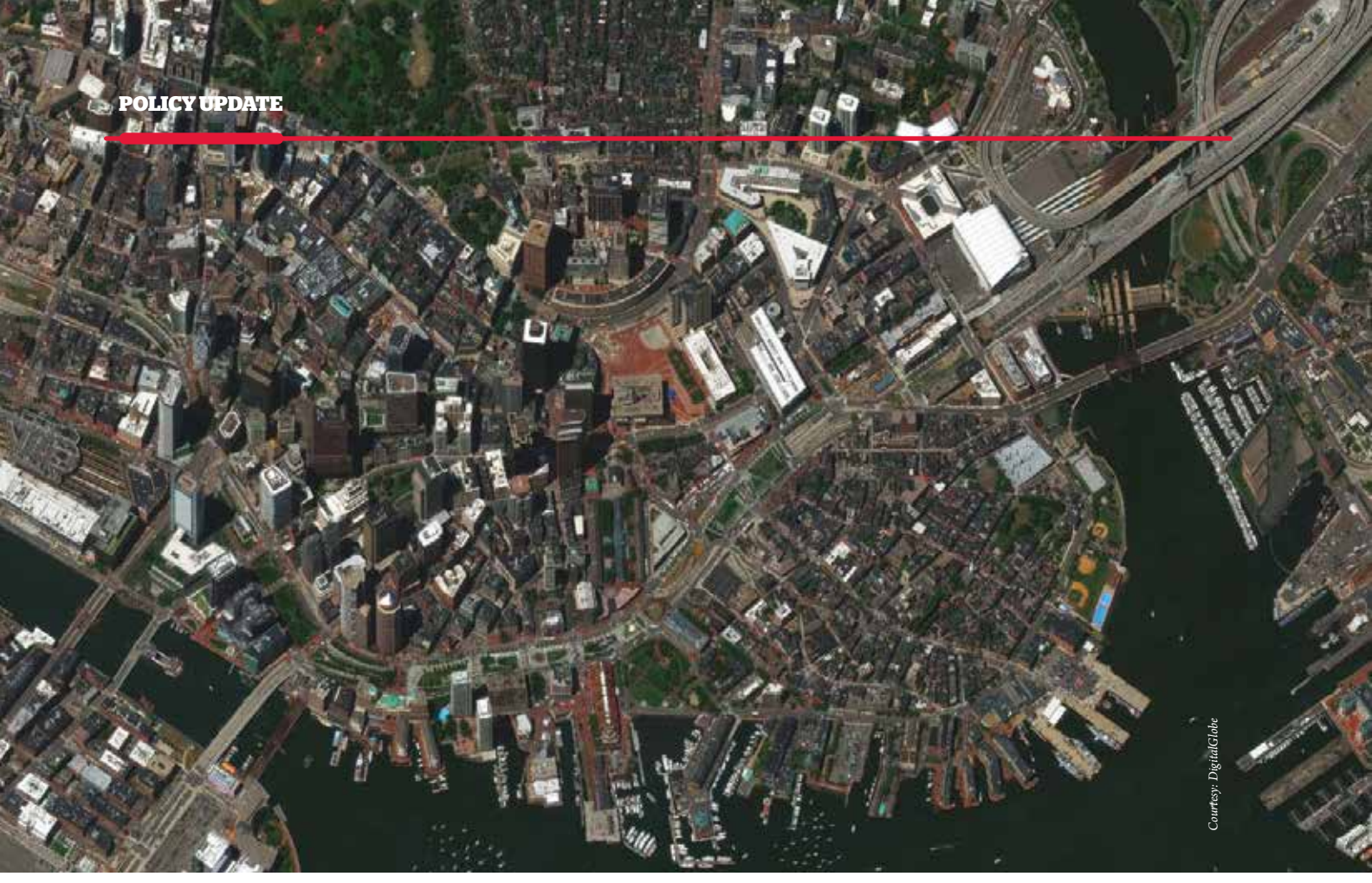
Since early March, international institutions, set up with the purpose of multilateralism and oneness, turned "deaf and dumb", and left countries at their own fate, irrespective of their capability to deal with pitiful realities. Leave aside helping with resources, there hasn't been even cooperation in terms of sharing quality information and learnings, which has resulted in chaotic decision-making and loss of livelihood for billion+ people worldwide.

It is a foregone conclusion that humanity is experiencing its biggest economic depression, and it may get worse than 1930s. At a time when the world leadership should have put its act together to combat this crisis, we have been observing an unaspiring, indifferent, inward, and isolated approach, which is focused at addressing local, and at best, national interest. Moreover, powerful economies have chosen to strengthen their supremacy by triggering conflict and unrest in different parts of the world.

The ideas that shaped the past 75 years have all but evaporated. A world order based on humanitarian approach has showed its theatrical character and fragility. The year 2020 has put elasticity of the world order to test by stretching and compressing its shape. The global response to COVID-19 has posed fundamental questions about the genuineness of a progressive world order and exposed its hypocritical intent of "oneness".

Hopefully, the future will witness an all-new progressive world order that can restore trust and values of peace, inclusivity and sustainability. Maybe the crisis will give rise to charismatic leadership and statesmanship, which will help the world regain its large-hearted shape.

अय नजिः परो वेतगिणना लघुचेतसाम् । उदारचरतिानां तु वसुधैव कुटुम्बकम् (the narrow-minded think of "this is mine" or "that is his". For the noble minded, the whole world is a family).



Courtesy: DigitalGlobe

ADVANCING US LEADERSHIP IN COMMERCIAL SPACE INDUSTRY

US Commerce Department's move to ease restrictions on Remote Sensing regulations will increase transparency and boost business.

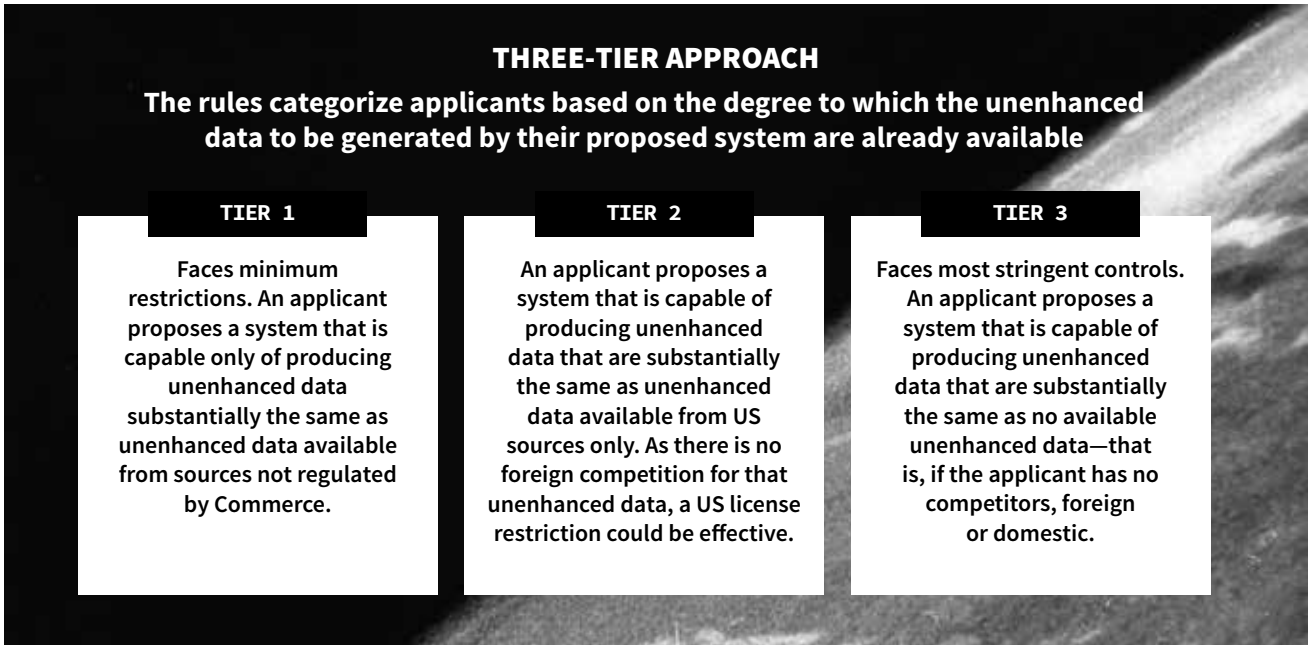
By Anusuya Datta

The United States Department of Commerce's decision to ease restrictions on remote sensing regulations has received a thumbs up from commercial satellite players in the country. Released on May 19, 2020, the regulations will improve the licensing process for private satellite remote sensing operations.

The rules are aimed at increasing openness and transparency in licensing and eliminating restrictions such as limits on the resolution of imagery and additional conditions by the government after issuance of license. Interestingly, the guidelines require the government to assess the remote sensing data already planned or available in the market to determine whether any conditions should be applied to companies.

The rules eliminate the special conditions in place for systems like synthetic aperture radar (SAR), shortwave infrared or nighttime imaging. The regulations also recognize the growing role of Artificial Intelligence, Cloud Computing and other advanced technologies in extracting unique information from remote sensing, and thus apply only to the Remote Sensing instruments and components that support their operation.

The development comes nearly a year after a draft version of the rules received severe criticism from the industry. "The streamlined remote sensing rules reflect the Trump Administration's commitment to advance American leadership throughout a diverse array of commercial space industries," **Wilbur Ross, US Secretary of Commerce** said in a statement. "We heard the message from industry loud and clear that previous regulations were too restrictive and were preventing the realization of unique economic opportunities from commercial satellite remote sensing systems. I am grateful to President Trump, Vice President Pence, the National Space Council, NOAA, and the Office of Space Commerce for their leadership in bringing these new rules to fruition," Ross added.



Praising the new regulations, **Dr. Scott Pace, Deputy Assistant to US President and Executive Secretary of the National Space Council**, said, "American industry is driving innovation in commercial remote sensing at an increasingly rapid rate. These streamlined and updated rules are critical to ensuring US regulations keep up with the speed of innovation and ensure the United States remains the flag of choice for commercial space businesses.

A welcome move

"Maxar is pleased with the significant update to the Commerce Department's remote sensing regulations, which relaxes many of the barriers that have held US companies back. We look forward to receiving updated licenses that embody the forward-leaning principles espoused in the preamble to the new rules," said **Dan Jablonsky, CEO of Maxar,** which is one of the largest commercial remote sensing operators in the US

In a statement soon after the announcement, smallsat major Planet said, "These streamlined, forward-looking regulations represent a philosophical shift in striking a balance between US technological innovation, competition from foreign actors and national security."

"In general, I view these proposed changes as quite encouraging for the space industry — primarily because I expect they will push forward new innovations and also allow US companies to be more competitive in the global market," said **Emiliano Kargieman, CEO and Founder of Satellogic**.

Echoed **SkyWatch CEO James Slifierz**. "We believe the revamped regulations will help the industry as a whole. We really look forward to seeing what new applications will be developed with these new datasets. We can avoid situations where US lawmakers try and play catch up with the speed of innovation, adding costs and delays to new constellations going up and stifling the growth of the industry."

Fresh categorization

The new rules mean that if a satellite imagery can be bought in a foreign country, US satellite companies have the right to sell it. For instance, when data is captured by an American company and sold through a Canadian platform to a Dutch client for their South African customers, things can get really complicated, explained Slifierz. With the expected increase in the volume of satellite data to be generated daily in the future, Artificial Intelligence/Machine Learning applications will play an increasingly larger role in how data is used. The revisited regulation should help data sellers and buyers across the globe.

The new guidelines do away with the earlier draft proposal to classify applications as "low risk" or "high risk" from a national security perspective and instead uses a three-tier approach.

"This (the earlier) rules worked under the assumption that Remote Sensing systems would be regulated so as to prevent them from causing harm to national security: more risk a system posed to national security, the more restrictive its license would be," the Department of Commerce said in the rule. The industry had argued the earlier regulation would have classified almost all commercial satellite companies as "high risk".

The new rules, however, have no bearing on US government Remote Sensing capabilities or the data policy regarding the availability of data or products therefrom, such as Landsat and NOAA's operational satellites. Only private remote sensing space systems operated by all other entities — commercial, non-profit, academic, or otherwise — will be under the purview of this regulation.

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Enhance Image Quality with Vexcel's UltraCam Osprey 4.1

The next generation UltraCam Osprey 4.1 is Vexcel's highly versatile large-format aerial camera. The UltraCam Osprey simultaneously collects photogrammetry grade nadir images (PAN, RGB and NIR) and oblique images (RGB) in four directions. Enabling unprecedented flight collection efficiency at superior radiometric and geometric quality, the UltraCam Osprey 4.1 sets a new standard in urban mapping and 3D city modeling.

As a result of a combination of leading customized lens systems, next generation image sensors with custom electronics, and a best-in-class image processing pipeline, the UltraCam Osprey 4.1 delivers imagery of unprecedented quality in terms of detail resolution, clarity and dynamic range. The system pushes urban flight productivity to new levels, collecting 1.1 Gigapixels every 0.7 seconds.

Its new and innovative Adaptive Motion Compensation (AMC) method compensates multi-directional motion inducted image blur and ground sampling distance variations in oblique images. Besides a new numbering format — the UltraCam Osprey 4.1 is a 4th generation camera in its first version — this new generation also introduces several design updates to increase the overall usability and user-friendliness.

Key Specifications

- → 20,544 x 14,016 pixels PAN image size (nadir)
- → 14,176 x 10,592 pixels color image size (oblique)
- → CMOS imaging sensors

Unveiled: New iPad Pro with Breakthrough LiDAR Scanner

Apple has announced its most advanced iPad Pro, which will be powered by a breakthrough LiDAR Scanner that delivers cutting-edge depth-sensing capabilities. The LiDAR Scanner, along with pro cameras, motion sensors, pro performance, pro audio, powerful apps and a Liquid Retina display will help the device maintain its lead as the world's best device for augmented reality (AR).

Apple's latest innovation is a first in the mobile industry. The new depth frameworks in iPadOS combine depth points measured by the LiDAR Scanner, data from both cameras and motion sensors, and is enhanced by computer vision algorithms on the A12Z Bionic for a more detailed understanding of a scene. According to experts, the LiDAR Scanner and the AR experiences are suited to work best in indoor and confined environments and for short travel distances (5 meters).

Key Features

- → Cutting-edge depth-sensing capabilities
- → Detailed understanding of a scene
- → Stunning AR experience

Boost for Monitoring Professionals: Trimble's Settop M1 Firmware v3.0

Trimble has recently announced the release of its Settop M1 firmware v3.0, which enables monitoring professionals to experience an even more user-friendly communication device, while also benefiting from enhanced remote management of total stations in real-time.

When used with Trimble 4D Control (T4D) software, the Settop M1 enhances the operation of a Trimble total station, combining the functionality of a field computer, device server, router and remote switch — all into one device. This streamlines the number of components needed in the field for buildings, mines, dams, bridges and other structural monitoring applications.

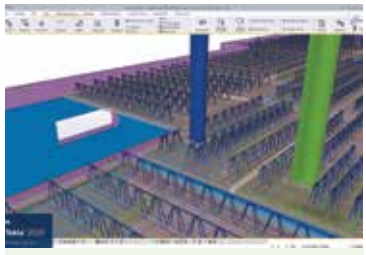
Product Features

- → New web user interface
- → Trimble internal camera support
- → Reset password feature
- → Last known position feature

Latest Version of Trimble's Tekla Software Solutions is Here

Trimble has recently introduced the latest versions of its Tekla software solutions for advanced Building Information Modeling (BIM), structural engineering and steel fabrication management — Tekla Structures 2020, Tekla Structural Designer 2020, Tekla Tedds 2020 and Tekla PowerFab 2020. Tekla software is at the heart of design and construction workflows building on the free flow of information, constructible models and improved collaboration. Tekla Structures supports the constructible process to transform the entire design, build and operate lifecycle.

Tekla Structures 2020 delivers enhancements, improvements and new features that enable efficient workflows for better productivity, increased mobility and collaboration across project teams.



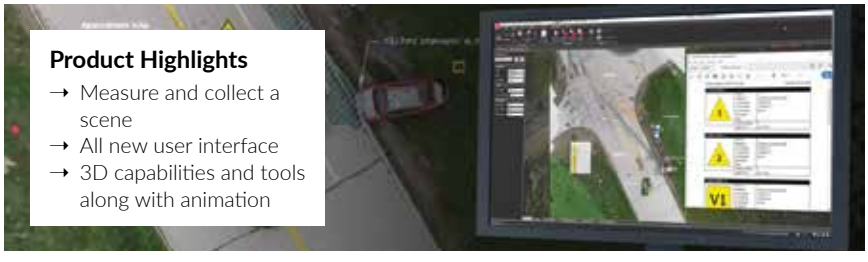
Product Strengths

- → Allows easier modeling of complex shapes with geometry improvements
- → Provides better usability, control and productivity with concrete rebar detailing enhancements
- → Enables quick and easy form-works modeling and improved hollowcore concrete detailing

Leica Geosystems' Map360 v4.0 to Simplify Incident Reconstruction

Leica Geosystems has come out with the latest version of Leica Map360 crash and crime scene diagramming and reconstruction software, bringing three editions to meet specific customer needs based on the technology used to measure and collect any scene. With an all new user experience and interface, Map360 v4.0 simplifies incident reconstruction activities for investigators, reconstructionists and other public safety personnel.

With 2D intuitive workflows, Map360 Sketch offers a program designed to create basic diagrams, floorplans and reports from manual measurements, imported points, or UAV imagery.



Product Highlights

- → Measure and collect a scene
- → All new user interface
- → 3D capabilities and tools along with animation

Supporting All Signals: CHCNAV's AT661 GNSS Geodetic Antenna

CHC Navigation (CHCNAV) has released its new AT661 GNSS geodetic antenna, which offers a performance rivalling that of high-cost and bulky conventional GNSS choke ring antennas. Its affordable price makes it the best choice for any GNSS networks or monitoring application. The AT661 supports all current and future GNSS signals, including GPS, GLONASS, BeiDou, Galileo, QZSS, IRNSS, SBAS and L-band. The antenna features both high gain LNA and wide beam width to provide excellent flexibility in applications requiring low elevation satellites reception and high availability of GNSS signals, especially in obstructed situations.

The accuracy of the antenna's phase center reaches the millimetre-level with extremely high stability and repeatability to ensure perfect processing of GNSS data regardless of the length of the baselines. Built to last, the AT661 withstands all types of weather, including high and low temperatures, and is protected by a waterproof radome.

Product Advantages

- → Compact
- → Affordable
- → Provides millimetre accuracy

Here Tech's Free Route Planning Solution for Indian SMEs

Here Technologies has recently launched its route planning solution, WeGo Deliver, in India to enable businesses optimize their delivery of goods and services. The solution will assist small enterprises in planning and dispatching deliveries without any software development or implementation cost. The company has made access to WeGo Deliver free of charge to all small or medium-sized businesses until 2021.

Users can upload their order destinations and number of drivers to the online planning dashboard and the solution will optimize each route and delivery sequence for them. Drivers can get their delivery route by email and can access the delivery route end points by using the Here WeGo mobile app.

Product Utility

- → Users can upload order destinations and number of drivers to get optimized routes and delivery sequence
- → Drivers can get their delivery route by email and can access the end points by using the Here WeGo mobile app

THE BIG COMMERCIAL FLIGHT

The SpaceX Demo 2 Mission, which saw a **Falcon 9** carrying NASA astronauts **Robert Behnken** and **Douglas Hurley** aboard a **Crew Dragon** capsule fly for the International Space Station (ISS), represents the final step before NASA certifies the SpaceX capsule to fly regular, long missions to the ISS.

DATE: May 30, 2020
TIME: 3.22 pm ET

LOCATION
Kennedy Space Center, Florida.

LAUNCHPAD
The iconic launchpad 39A at the Kennedy Space Center was used for Apollo 11 landing on Moon. It was later used for the Space Shuttle program.

SECOND TIME LUCKY
May 30, 2020 launch was the second attempt. The launch was called off due to bad weather on May 27, 2020.

WHY IS THIS SIGNIFICANT
- This is the first time in a decade that American astronauts have been launched from American soil on an American rocket.
- SpaceX is the first private company to send humans to space.

THE ROCKET
- Falcon 9 is SpaceX's workhorse and is the first orbital class rocket capable of reflight. It has been launched 85 times so far, with 46 landings and 32 reflown missions.
- Two-stage design allows refly of the most expensive parts of the rocket.
- Stands 70 meter tall and is 3.7 meter in diameter, with a payload capacity of 22,800 kg to LEO, 8,300 kg to GTO and 4,020 kg to Mars.

THE SPACECRAFT

- Crew Dragon is an evolved version of SpaceX's Dragon Cargo spacecraft that has visited the space station 22 times, with 9 reflown missions.
- Sits on top of the Falcon 9 in place of the traditional nose cone
- 8.1 meter tall with a trunk and 4 meter in diameter, with 37 sq meter trunk volume.
- Launch payload mass of 6,000 kg and return payload mass of 3,000 kg
- Capable of carrying up to 7 passengers to and from Earth's orbit, and beyond
- Trunk is the large lower half that's covered in solar panels, which can also carry cargo
- Trunk remains attached to Dragon until shortly before re-entry into Earth's atmosphere
- Allows transport of people as well as environmentally sensitive cargo

Falcon 9 lifts off from the historic Launch Complex 39A

IN THE DOCK

On May 31, 2020, 19 hours after the launch, the Crew Dragon successfully docked with the ISS.

THE ASTRONAUTS

- **Bob Behnken** and **Doug Hurley** were selected by NASA in its astronaut class of 2000. Both have been to Space twice before on Space Shuttle missions.
- Air Force veteran **Behnken, 49**, is the joint operations commander for the mission — responsible for reaching ISS and docking.
- A Navy and **Marines veteran, Hurley, 53**, is the spacecraft commander and is responsible for Crew Dragon's launch, landing and recovery.

COVID-19 PRECAUTIONS

Now is not the time: Given the coronavirus crisis, NASA made an unprecedented request — urging large crowds to not gather on the highways and beaches to watch the launch.

Extended quarantine: Astronauts Robert Behnken and Douglas Hurley officially entered a preflight quarantine on May 13, 2020, although they had been self-isolating since mid-March. While typically astronauts are quarantined before a mission, the protocol has been stricter for Demo-2 due to the pandemic.

Limited Contact: Direct interaction with the crew was not permitted without appropriate protective gear, and even the interaction with VIPs a day before launch was done through a glass wall.

Control room arrangements: In the Mission Control, different rooms were used to keep people safely distant from each other with plexiglass between seats and stations.

Concept: Anusuya Datta | Design: Subhash Kumar

"The United States has regained our place of prestige as the world leader. You can't be number one on Earth if you are number two in Space... Today's launch makes clear the commercial Space industry is the future."

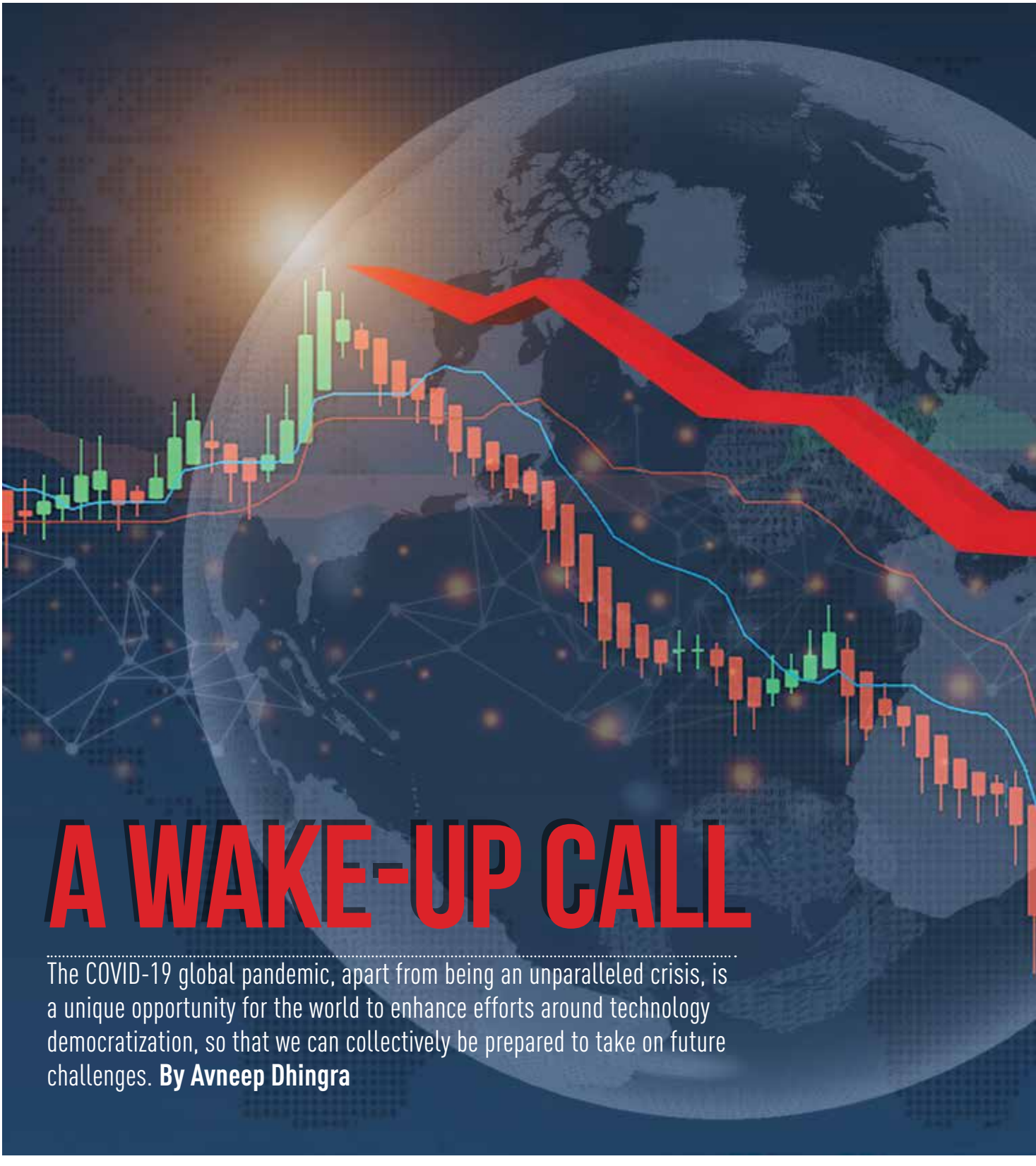
DONALD TRUMP
President, United States

"It's been nine years since we've launched American astronauts on American rockets from American soil, and now we have done it again."

JIM BRIDENSTINE
Administrator, NASA

"I'd like to acknowledge the incredible work of the people at SpaceX and NASA and everyone who created this technology – what has culminated in this incredible launch today."

ELON MUSK
Chief Engineer and CEO, SpaceX



A WAKE-UP CALL

The COVID-19 global pandemic, apart from being an unparalleled crisis, is a unique opportunity for the world to enhance efforts around technology democratization, so that we can collectively be prepared to take on future challenges. **By Avneep Dhingra**

In 47 least developed nations, over **80%** of population is still offline

In the most extreme case, a mere **2%** of population is using Internet

Women are lagging in terms of access to digital technologies in **two thirds** of countries around the world

In India, there is Internet density of **49.78%,** which means that every second person is not connected

In most parts of the world, digital divide is determined by factors such as **location, income, gender, age,** etc.

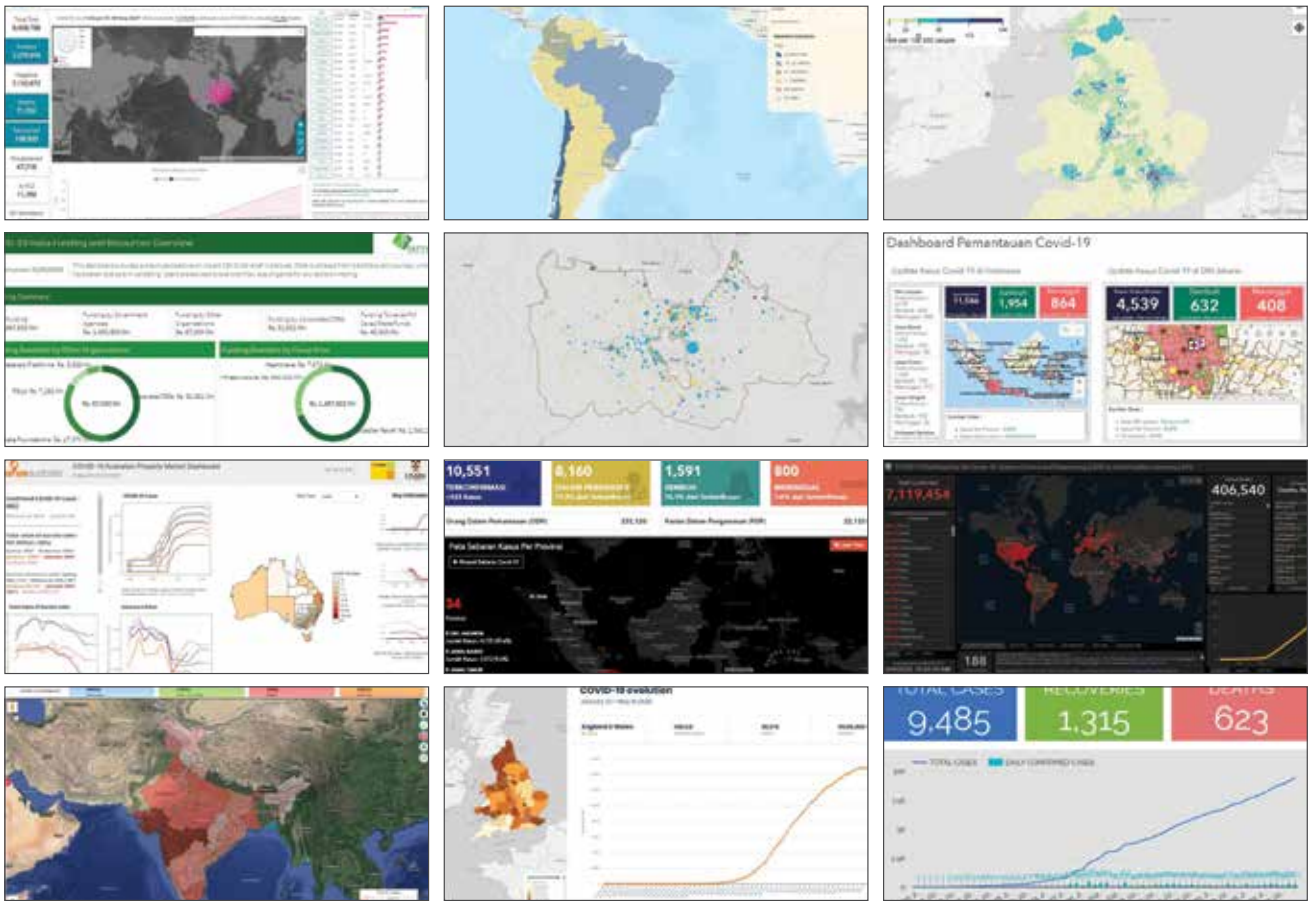
The ubiquity of technology in developed parts of the world is simply astonishing. Almost everyone has a smartphone and access to high-speed Internet. But netizens do not necessarily assert their ascendancy — for them it is part and parcel of living in a "connected society". No wonder that a handful of countries account for nearly 90% of the market capitalization value of the world's 70 largest digital platforms and over 75% of the cloud computing market (UNCTAD's Digital Economy Report, 2019).

But what about less developed parts of the world, where the "connected population" is below 20%. There is little or no access to mobile networks and the Internet, let alone emerging technologies, which have the power to boost governance and decision-making — thereby boosting socio-economic development. According to the World Economic Forum, among the many inequalities exposed by COVID-19, the digital divide is not only one of the starkest, but also among the most surprising.

How we are divided

A 2019 report *(Measuring digital development: Facts & figures)* by ITU's Telecommunication Development Bureau suggests that only 4.1 billion people, or just over 53% of the global population, are online, while a staggering 3.6 billion people are unconnected. Further, in 47 least developed nations, over 80% of the population is still offline. ITU data show that in the most extreme case, a mere 2% of the population is using the Internet. The report indicates that the women are lagging behind men in their ability to take advantage of the power of digital technologies in almost two thirds of countries around the world.

"Access to connectivity is not a luxury, but a critical service to society. As we have witnessed today, our networks must remain resilient and responsive to citizens' immediate needs — whether it is businesses (of all sizes), government institutions, education and healthcare systems, power utilities or transportation providers," says **Mike Calabrese, Vice President of Global Enterprise and Webscale at Nokia.** Even in a fast-developing country like India, there is Internet



With the world rushing to build maps, dashboards and apps to combat the COVID-19, the significance of technology, especially geospatial data and tools has once again come to the fore

density of 49.78%, which means that for every person who is connected, there exists one who lacks access to the Internet. In most parts of the world, this divide is determined by factors such as location, income, gender, age, etc.

According to the World Health Organization, the need to spread information about how to combat COVID-19 is most urgent in poorer countries, where migrants and the destitute are most vulnerable to the virus. Further, children's education has abruptly come to a halt, and work from home is an option for very few people. In the absence of technology access, these problems render governance ineffective, often leading to continued suffering for citizens. "This digital divide, which is not just about having the Internet, but about having data to make decisions, has to be bridged," emphasizes **Milorad Kovacevic, Chief of Statistics, United Nations Development Programme.**

How tech democratization can help

With the world rushing to build maps, dashboards and apps to combat COVID-19, the significance of technology, especially geospatial data and tools has once again come to the fore. Almost every major organization — ranging from businesses, academic institutions to news broadcasters — were seen using spatial data for planning, acting and information sharing. It did not take long for governments, healthcare service providers and other responders from all over the world to realize that they all needed such technology tools to mitigate the coronavirus crisis. "GIS is unique because users everywhere can create their own individual sets of information as map layers. Everyone's

> "Access to connectivity is not a luxury, but a critical service to society. Our networks must remain resilient and responsive to citizens' immediate needs"

MIKE CALABRESE
VICE PRESIDENT, GLOBAL ENTERPRISE AND WEBSCALE, NOKIA

content is compiled and is represented as a series of information overlays covering specific areas across the planet. In today's world of cloud computing, all of these layers have their own individual URLs, enabling these layers to be integrated and synthesized together," says **Esri Founder and President Jack Dangermond**.

Democratization of technology has the power to change people's lives. The access to technology, from the simple to the sophisticated provides the innovative environment to push technology further and to participate in its advancement meaningfully. "The opportunity to use technology gives us the tools to re-imagine and redefine jobs and industries that can help us thrive mentally, physically and economically as communities. That access is vital," argues **Trimble President and CEO Rob Painter**.

The real power of technology lies in the valuable information that can be derived from it. In any given situation, especially in case of a health emergency, connectivity and access to accurate information can make a world of difference. For instance, if we hadn't been able to trace the origin of the COVID-19 back to Wuhan, or track its movement and spread, the number of infected cases and fatalities, apart from the damage caused to the global economy would have been a lot higher. "The ability to access information from anywhere at any time has never been more important. For example, our companies, and even our governments, are now operating from thousands of locations where they hadn't been before — employees' homes. This means software and services that enable collaboration have become critical in ways we didn't expect, but now rely upon," explains **Hexagon CEO Ola Rollén**.

We are living in a fast-changing world, which poses new challenges to our survival every now and then. In such a scenario, technology is the best tool for crisis management

> "One of the most impactful traits of GIS information is the user community's strong interest in sharing — we all need access to each other's data"

JACK DANGERMOND
ESRI FOUNDER AND PRESIDENT

for all stakeholders. "Therefore, democratization of technology is tremendously important for governments, corporations and all other decision-makers who have a certain social responsibility, so that we are all able to act as timely as possible based on the most current and," feels **Matthew Zenus, Global Vice-President, HANA & Analytics, Solution Strategy at SAP**.

Why is 'where' so important

The COVID-19 outbreak has disrupted our entire world. From healthcare services to school education, business processes to everyday movement, each and every activity performed by human beings have undergone a drastic change. As we collectively adjust to the new normal, the knowledge of location and all the information related to it (what, how and when) will hold the key to our survival and well-being.

Today, governments around the world are using contact tracing through mobile applications to keep the people safe, and are relying on location tech to streamline work operations, strengthen supply chains and restart industries. For example, India's National Disaster Management Authority (NDMA) has developed an online dashboard to capture information regarding millions of migrant workers who were stranded due to the nationwide lockdown to provide them relief and facilitate their safe movement across states.

Today, governments around the world are using contact tracing through mobile applications to keep the people safe, and are relying on location tech to streamline work operations

> "The opportunity to use technology gives us the tools to re-imagine and redefine jobs and industries that can help us thrive mentally, physically and economically as communities. That access is vital"

ROB PAINTER
TRIMBLE PRESIDENT AND CEO

"Being able to visualize information about confirmed cases, fatalities, testing facilities, or where to buy supplies is a very powerful and effective way to communicate critical information. We have seen first-hand how governments are deploying feature-rich, yet accessible technologies to develop dynamic maps and dashboards that help their citizens understand the threat of COVID-19 at local, regional and national levels," says **Mladen Stojic, President, Hexagon Geospatial**.

How can geospatial make a difference

With data holding unprecedented significance in today's day and age, geospatial technologies provide not only the ability to manage and integrate data, but also the analytical tools that support quick decision-making, thereby saving both time and money. Using data in new ways helps in reviving sluggish economies and making governments and organizations efficient and resilient in the face of a crisis.

"Geospatial information provides context to information to determine the what, where, when and why of something. The influence and impact that knowledge can bring is powerful, particularly during a crisis such as COVID-19," adds Painter. Since the current pandemic began, developers, researchers, geoscientists and health organizations have been developing

> The ability to access information from anywhere at any time has never been more important. Our companies and governments, are now operating from thousands of locations where they hadn't been before

OLA ROLLÉN
HEXAGON CEO

technological tools and apps to help inform and enable societies to adapt and rebuild. Widely sharing these map-based resources are helping people and industries regain control and certainty.

Going forward, geospatial data and Location Intelligence are going to be critical for economic recovery — from being able to continue tracking the spread of the virus and its impact at any given time, to supporting cities and nations that are trying to understand what is the new normal for their essential services and management of everyday public life.

Who should lead the way and how

As we move ahead, It will be important that resource-rich organizations act as enablers in ensuring that people have equal access and support to create or adopt solutions that work specifically for them. "For example, in ArcGIS Online, users have created over 35 millions layers worldwide. We estimate that as many as 40-50% of these items are publicly shared," adds Dangermond, highlighting that since the beginning of 2020, extraordinary efforts worldwide sprang up as a global response to the coronavirus pandemic. "GIS practitioners and heroic people everywhere joined together to implement and apply community GIS in virtually every nation and global region as well as at local levels. One of the most impactful traits of GIS information is the user community's strong interest in sharing — we all need access to each other's data."

As we move ahead, it will be important that resource-rich organizations act as enablers in ensuring that people have equal access and support to create or adopt solutions that work specifically for them

Governments, businesses and trained developers can commit to creating and offering open-source approaches to information sharing, system development and data management, says Painter. For example, users in underdeveloped countries could use a free and open-source desktop GIS tool to work with geospatial data, analyze datasets, connect to external tools and publish and share geospatial information. User-friendly environments such as these give stakeholders efficiencies and confidence to build knowledge and develop systems and plans that best serve their communities.

Likewise, geospatial manufacturers can provide support and tools that enable developers to create specialized applications that bring the best value to their working environments. For instance, a trained developer could create simple, customized workflows to aid in locating and tracking virus hotspots and concentrations of infected people. "On-demand access to real-time, accurate geospatial data and Location Intelligence for all is critical for a coordinated, global response to any shared crisis," adds Rollén.

Providing access to technology is akin to providing opportunity, but that's possible only through partnerships and collaborations. "Governments, big and small businesses and societies would do well to partner in that and provide the hardware, software and infrastructure to allow local innovation to happen. Creating tools and applications to gain knowledge is one of the best ways to build strength and resilience to better respond to an 'unknown enemy' like a future pandemic," emphasizes Painter.

"It's definitely possible to work together and learn from each other's experiences and experiments, but there is no one-size-fits-all response. With the diversity of solutions needed across geospatial applications, the idea is the same. COVID-19 is an opportunity for sharing best practices to aid in future situations where we are experiencing the same challenges at different times for different reasons," feels Rollén.

Dangermond thinks that the geospatial community must work to ensure technologies are open, interoperable, and readily accessible worldwide. These goals include effective configuration and use of COTS tools, adoption of best practices, and open information sharing across geospatial organizations, because shared data layers are easily integrated in to GIS.

The COVID-19 pandemic may have caused tremendous disruption to the global society and economy, but has also acted as a wake-up call, a unique opportunity to enhance efforts around democratization of technology, so that we can collectively be prepared to take on future challenges.

If the Chinese use two brush strokes to write the word 'crisis', (as stated by John F. Kennedy) with one brush stroke standing for danger and the other for opportunity, perhaps it's time to shift focus to the second stroke of the brush.

Avneep Dhingra
Associate Editor - Policy & Public Affairs
avneep@geospatialmedia.net

LESSONS FOR INDIA IN COMMERCIALIZATION OF SPACE

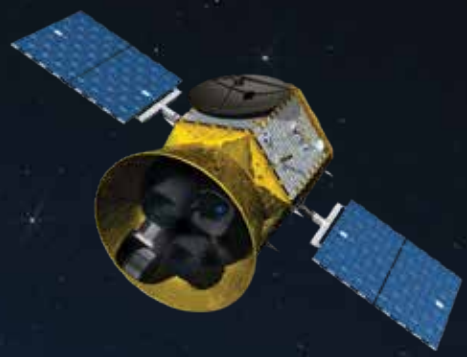
To be able to bring the policy statement to reality requires a major overhaul of government-led Space activities. Only then will the promises be realizable.

By Prof. Arup Dasgupta

On May 16, 2020, **Indian Finance Minister Nirmala Sitharaman** electrified the Space community with the bold announcement on boosting private participation in Space activities.

HERE IS WHAT THE MINISTER SAID

- Indian private sector will be a co-traveler in the country's Space sector journey
- India will provide level playing field for private companies in satellites, launches and Space-based services
- India will provide predictable policy and regulatory environment to private players
- Private sector will be allowed to use ISRO facilities and other relevant assets to improve their capacities
- Future projects for planetary exploration, outer Space travel, etc. will be open for private sector
- **There will be a liberal geospatial data policy for providing Remote Sensing data to tech-entrepreneurs**



Even though these bold statements have excited the Space communities in the technology and application areas, it needs to be said that a policy statement such as this, which gives a "feel good" warmth, needs to be followed up with cold and hard actions. A statement is not a policy. A policy needs to be backed up with processes which will give rise to programs and projects.

Example of policy implementation

When the US was losing the Space race to the erstwhile USSR, President John F. Kennedy declared in September 1962 that "we choose to go to the Moon in this decade and do the other things, not because they are easy, but because they are hard; because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one we intend to win, and the others, too." This was followed by the Apollo Program, and with Apollo 11, the first human, an American, stepped on the Moon in July 1969.

In these seven years, several US industries blossomed and grew into global Space giants which supported the US to further its Space ventures, till the tragic failures of the Space Shuttle, which effectively closed down human spaceflight from American soil on American vehicles. In the first decade of the new millennium, SpaceX, Virgin Galactic and many other private Space startups jumped in with new ideas and new programs.

On May 30, 2020 after nine years, NASA astronauts have once again ridden into Space from US soil on a US built vehicle. The only difference being that Falcon 9 launcher and the Crew Dragon spacecraft were designed, built and launched by SpaceX from a completely refurbished and a very aesthetically attractive Pad 39A of the NASA launch complex. It is also important to note that an old hand like Boeing lost out to a bold startup like SpaceX.

Origins of ISRO and its core purpose

As far back as the early 1960s, a scientist, Vikram Sarabhai, working with the Department of Atomic Energy, realized that Space could play an important role in India's development. In 1962, he formed the Indian National Committee for Space Research, INCOSPAR, with the support of the then Prime Minister Jawaharlal Nehru. INCOSPAR was managed by the Physical Research Laboratory, which was a grant-in-aid institution of the Department of Atomic Energy.

Courtesy: NASA

When the US was losing the Space race to the erstwhile USSR, President John F. Kennedy declared in September 1962 that his country will "go to the Moon in this decade". This was followed by the Apollo Program, and with Apollo 11, the first human, an American, stepped on the Moon (in picture) in July 1969

Eventually INCOSPAR activities migrated to the Indian Space Research Organisation, ISRO, a project of PRL. Under INCOSPAR and later ISRO, several projects were launched like sounding rockets for Space Sciences, Experimental Satellite Communications Earth Station for training in Earth station operations, Satellite Instructional Television Experiment, etc.

In an address to the first UN Conference on Peaceful Uses of Outer Space, UNISPACE, held in 1969, Vikram Sarabhai also recognized the importance of Remote Sensing for development, and these activities began under ISRO.

While the Indian Space Program is quite different from the US Space Program, and ISRO is quite different from NASA, it is necessary to learn from the US experience and those of other countries, to steer commercialization of Space activities in a "co-traveler" mode. It is also necessary to understand where ISRO stands today in terms of working with co-travelers. ISRO, it should be noted, is the primary research and development arm of the Department of Space, DOS. The key term is research and development.

R&D – an instrument of societal development

In 1971, Dr. Sarabhai, the architect of India's nascent Space program, passed away, leaving an inchoate ISRO to Prof. Satish Dhawan, who took over in 1972 and gave it a direction and defined specific goals. Prof. Dhawan realized that ISRO needed to co-travel with other Indian entities in order to be relevant. Under his leadership, ISRO forged ahead with launchers, primarily PSLV, INSAT communications satellites and IRS Remote Sensing satellites. While the launchers would ultimately serve to launch Indian satellites, the satellites themselves would have to serve India meaningfully in terms of communications, broadcasting, meteorology and natural resources management.

Thanks to his far-sightedness, the Indian Space Program formed very useful relationships for both upstream and downstream activities. The Indian industry, both heavy industries and MSMEs, were roped in to supply the essential components of launch vehicles and

Courtesy: ISRO

ISRO's transition, from a primarily R&D organization to an operational agency for the manufacture of launchers, communications satellites and Remote Sensing satellites, and the provision of services for launches, communications satellite management and Remote Sensing data services, has left several experts and old hands surprised

satellites. At the same time, ISRO engaged with the end users of communications, meteorology and natural resources management to evolve meaningful uses of the satellites in these areas.

Transformation of ISRO from research to operational institution

Most old ISRO hands wonder since when did a primarily R&D organization become an operational agency for the manufacture of launchers, communications satellites and Remote Sensing satellites, and the provision of services for launches, communications satellite management and Remote Sensing data services? It happened over time.

Diversion from core purpose to internalization of ISRO

From the heady and challenging days of working with other organizations, ISRO has steadily internalized its activities and turned itself into a launcher and satellite production and service agency. There is precious little R&D that goes on which we are aware about. The small satellite launch vehicle is an afterthought, as the same has been already proposed by NewSpace India participants. While the development of the cryogenic engine is significant, it should be noted that it got delayed due to a decision to tie up with Russia for the cryogenic engines and the subsequent geopolitical maneuvers and events.

We are far behind in the development of reusable launchers because our attention is more on increasing the number of launches. When PSLV is built with nearly 80% of contracted components, what is holding ISRO back from passing on the manufacture and launch activities of PSLV to the industry and concentrating on new developments in launcher technologies?

In applications too, the much vaunted 160 projects to be executed by end users to give a fillip to the use of Remote Sensing data by end user departments were internalized to a set of Bhuvan maps prepared by ISRO. There are hardly any applications that are significant, and that extend the capabilities of modeling and analysis. While data science has taken the world by storm, ISRO seems to be well insulated from these advances. There have been no significant developments in the communications field either on satellites or on the ground. IRNSS is an exception, but two years after its commissioning, its usage is still minimal.

The worst action of internalization was the unnecessary creation of the Remote Sensing Data Policy. Till this came, IRS data was available openly. On the other hand, decades old policies of Survey of India made it difficult for scientists to acquire topographic maps, particularly of coastal and international boundary areas, essential for the analysis of satellite imagery. Similarly, policies of the Ministries of Home and Defence made it extremely difficult to acquire aerial photographs and imagery, which were useful as supplementary data.

The RSDP ensured that ISRO joined the dubious club of data deniers. The decision to canalize import of high resolution imagery is another choke-point which smacks of conflict of interest. While the unstated desire is to promote high resolution IRS data, the RSDP effectively denies this data to users other than from the government or government-sponsored projects.

Worse still was its decision to sell imagery which was being generated using taxpayers' money. The result was to drive away potential users from industry and academia. Ostensibly, Bhuvan is designed to make data available to end users for free. In reality, Bhuvan, with its poor bandwidth, is no match for Landsat and Sentinel data, which are available for free to download from the Cloud, but policy restrictions prevent ISRO from doing the same.

Deterioration of leadership and disempowerment of young generation

The journey of ISRO under a Chairman who could boldly go out and face a hostile media after the failure of the first SLV launch to a Chairman whose prime interest is to launch, launch and launch, and who cries on the

There is need for a comprehensive Space policy, which has been hanging fire for long. Such a policy will encourage a vibrant Space industry independent of ISRO-DOS. And it must emerge from the Space industry and user communities, and not be driven by ISRO-DOS

Courtesy: PRL, Ahmedabad

A file photo of Vikram Sarabhai (left) with Jawaharlal Nehru. As far back as the early 1960s, Sarabhai, working with the Department of Atomic Energy, realized that Space could play an important role in India's development. In 1962, he formed the Indian National Committee for Space Research, with the support of the then Prime Minister Nehru

Courtesy: ISRO

Under the leadership of Vikram Sarabhai, ISRO forged ahead with launchers, primarily PSLV, INSAT communications satellites and IRS Remote Sensing satellites

shoulders of the Prime Minister after the failure of the Chandrayaan lander is not one that instills confidence in the organization's ability to co-travel with potential challengers in the fields of technology and applications.

Given this scenario, ISRO is most unsuited to take on the task of encouraging co-travelers. There is too much of bureaucratization and severe conflict of interest. The sad stories of Devas and TeamIndus strengthen this view. Leaving operational activities to others more suited for the task will be painful for ISRO because over time, it has given birth to a Siamese twin of R&D and operations. While the R&D is in the ICU, the operations part is thriving.

ISRO has world-class facilities for fabrication and testing, which are used by both, but operations get a higher priority and R&D suffers. Also, working on operational projects with a short life span is more interesting, as it

gives greater short-term visibility and therefore better career progression for the staff. R&D requires patience and the use of brain power. Success is slow in coming and not guaranteed.

Commercialization of capabilities

It should be noted that ISRO is just a part of the Department of Space, which is the main body akin to NASA. However, because of its size and the nature of its growth, it is easy to confuse ISRO with DOS and use the acronyms interchangeably. DOS has two other units which are not a part of ISRO. These include Antrix Corporation Limited, ACL, and NewSpace India Limited, NSIL. The latter should not be confused with NewSpace India, which represents an informal consortium of private Space entrepreneurs.

ACL is dubbed as the commercial arm of ISRO and is engaged in providing Space products and services to international customers worldwide. It is really the commercial arm of DOS, but it uses all ISRO facilities and manpower to further its business. Started as a one-and-a-half person organization, housed in ISRO headquarters, it relies heavily on the Space organization without any benefit to it in terms of sharing profits or even funding research there. In short, ISRO is forced into operational and commercial tasks through ACL, neglecting its mandated role of R&D, much to its detriment as explained above.

NSIL was set up recently with the "primary mandate of enabling Indian industries to scale up high-technology manufacturing and production base for Indian Space Program." Both ACL and NSIL are wholly owned Government of India entities under the administrative control of DOS. It seems that while ACL is to market ISRO products and services abroad, NSIL is to encourage industry to scale up to meet ISRO requirements of high technology manufacturing.

It is clear from the above information that the vision of DOS viz-a-viz private industry is one of managing contractors for ISRO requirements and not one of encouraging independent co-travelers. In order to realize the independent participation of private industry in Space activities, the government needs to look beyond ISRO-DOS.

Structural reforms & strengthening of research and exploration

To be able to bring the policy statement to reality requires a major overhaul of government led Space activities. Only then will the promises be realizable.

The first need is of a Space policy, which is hanging fire for long. Such a policy is needed to encourage a vibrant space industry independent of ISRO-DOS. Such a policy must emerge from the Space industry and user communities, and not be driven by ISRO-DOS. One such draft by an organization, Takshashila Institution, needs to be considered seriously.

Secondly, ISRO needs to be restructured by removing all operational activities including their related facilities and services. All services should be with ACL. The huge facilities in ISRO funded by the government should be made into national Space technology fabrication and testing assets which are open to both ISRO-DOS and Industry impartially. NSIL should be repurposed to manage these assets on behalf of the Government of India.

ISRO should concentrate on advanced launchers, payloads and ground systems for Earth related applications, Space Sciences and Human in Space programs. While interaction with ACL and NSIL will be necessary, it should be on strictly commercial terms as applicable to other co-travelers.

Scalability of societal impact

One of the very interesting ideas that has been posted recently is the possibility of independent industries to meet the needs of the defense forces independent of ISRO, which is essentially a civilian organization. It is also possible that private communications service providers could fund communications satellites using the MEO, as is happening in the rest of the world, maybe for 5G services for example. The same could apply for Remote Sensing constellations.

The government should break away and do only those things that industry cannot do. These include developing advanced technologies and systems for healthcare, education, Space sciences and humans in Space. Leave the industry to find its own way and do their own thing guided by an enabling Space policy which should be reviewed and modified from time to time in consultation with all stakeholders.

Prof. Arup Dasgupta
Managing Editor
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THE LEGACY OF A GPS PIONEER

JAVAD

www.javad.com

Front

Dear JAVAD Extended Family and Beyond

As you already know my father passed away Saturday, May 30th from COVID-19. I wanted to get a message out to all the friends of JAVAD to provide some insight into our plans for the future.

There are dozens and dozens of articles on the web and in print about the great Javad Ashjaee, and his 37-year history in this country, and his various achievements. Here, I'd like to address you all on a more personal level.

My father was very proud of all that he had accomplished, including setting up the Moscow office dating back to the late 1980's (through the financial crisis in Russia), the ahead-of-the-state-of-the-art manufacturing facilities in CA (following the US financial crisis), and the technical and operational capabilities that they possess. No other company in our industry was ever at the forefront of innovation and technology like the products we continually introduced into the market, and all of you had an integral part in making that happen. Most of all, my father was proud of his extended "family", as well as the partnership he had created between US and Russia—it was his "success story of cooperation".

Javad Ashjaee taking a break just before InterGeo 2019

We have a group of 200+ energetic, intelligent, passionate, and above all, kind employees, some of whom have been with the JAVAD group of companies for decades. And on May 30th, many of them lost someone whom they had worked with in business for many years. No matter how long it has been, we know that for all of you it was a meaningful impact on your lives.

JAVAD Nuclear Family

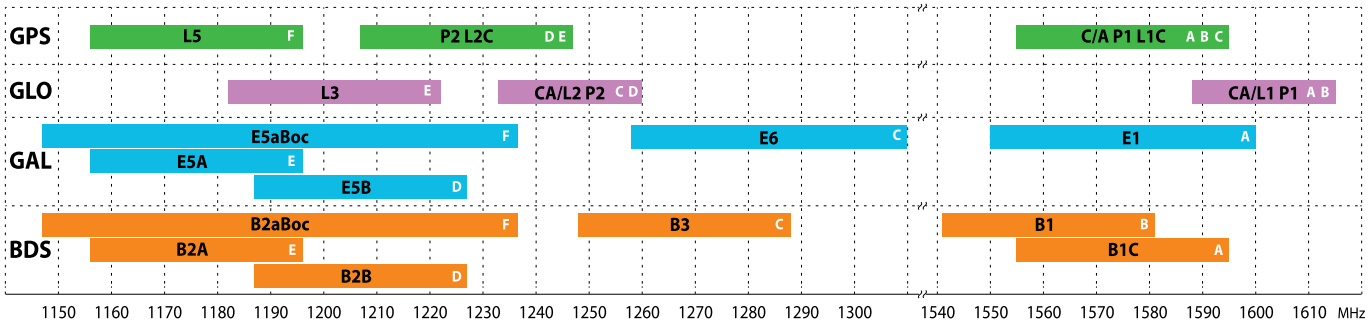
JAVAD Russia Family (JGNSS LLC)

JAVAD Armenia Family (JCOM)

1949 1983 1987 1989

All Available Signals Tracked

...and used in RTK!

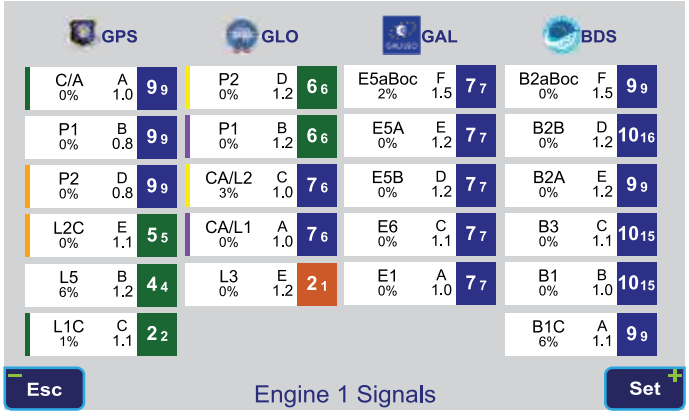


GNSS signals in the improved TRIUMPH-LS Plus with TRIUMPH 3 ASIC
GNSS bands for GPS, GLONASS, Galileo, and Beidou signals are depicted in the above figures

There are a total of 22 signals in 6 frequency bands labeled “A” to “F”. We categorize the GNSS signals, as shown on the right, and assign them a quality score. For example, Galileo and Beidou AltBOC signals are assigned a quality score of 1.5 because of their wider band and higher signal quality.

The columns (in order) represent the following:

- Name of signal and related noise in its band
- Designated band letter and quality score
- Number of satellites broadcasting the signal at the given moment. The multiplication of columns 2 and 3 defines the overall value of that signal for RTK



This screenshot to the left shows the four super engines. Each column shows the signals that are used for that engine.

The Four Super Engines
Available now on TRIUMPH-LS Plus!

Clicking on each engine resets the RTK fix
Long-clicking on each engine shows the settings

The numbers below each engine are:

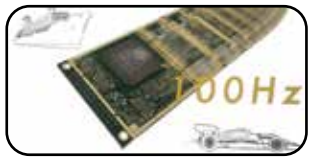
Number of RTK resets (last reason id) and counter of failed fixes

Number of signals used/number of signals rejected

Epochs since last reset

Solution difference from the first engine

Total run time Fixed Epochs



1989 1999 2002 2007

RTPK

Major post-processing advancement for surveyors!

PATENTS PENDING

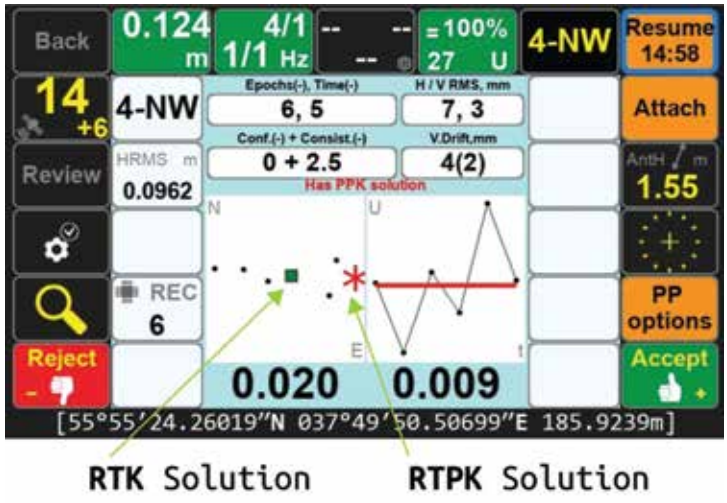
If RTK fails, RTPK comes to your rescue in a fraction of a second.

JAVAD GNSS introduces the new Real Time Postprocessed Kinematics (RTPK) solution, combining the strengths of RTK and PPK. This system can post-process your RTK data in parallel.

Available on the new TRIUMPH-LS Plus.

The Highlights

- TRIUMPH-LS Plus combines RTK and RTPK
- RTPK can post process the RTK data and **verify** your results in parallel and in real time.
- If RTK fails, RTPK comes to rescue in a fraction of a second.



2010 2012 2013 2014

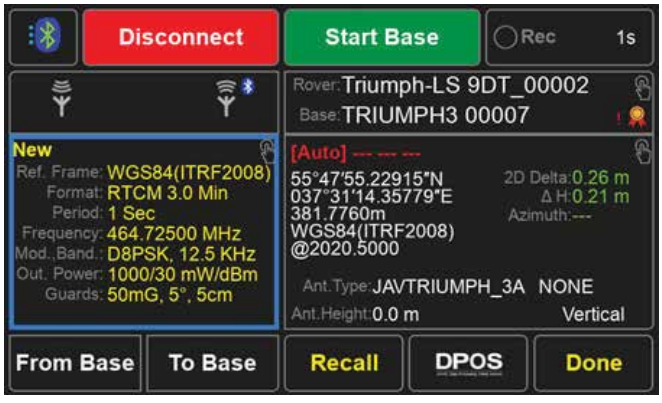
TRIUMPH-3

The latest-generation GNSS Receiver from JAVAD

TRIUMPH-3 is capable of efficient tracking even in difficult conditions. It can track all current signals (GPS/GLONASS/GALILEO/BEIDOU/QZSS/IRNSS) and is ready for any future satellite signals.

TRIUMPH-3 is self-sufficient for all jobs. No need to pay RTN service providers! The communications are done via integrated UHF, 4G/LTE, Wi-Fi, and Bluetooth channels.

Your own RTK base station is not far from your rover, and RTK solutions will be provided much faster and more reliably.



TRIUMPH-3 is designed to operate as a base together with TRIUMPH-LS and TRIUMPH-LS Plus to efficiently accomplish any geodetic job.

The list price of TRIUMPH-3 starts from $10,990.00

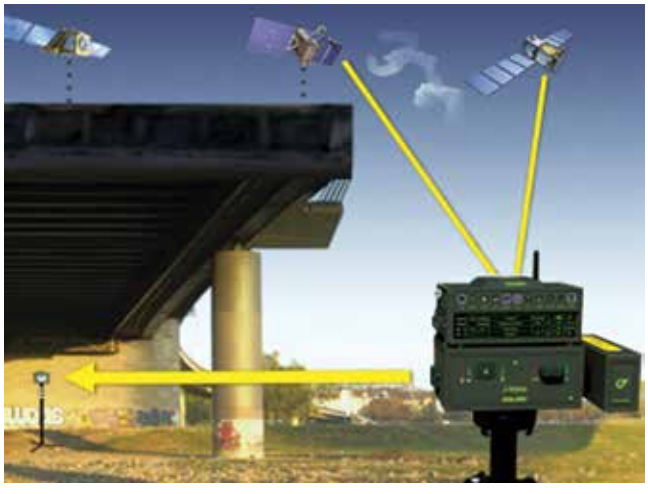
For more information, visit www.javad.com or contact us at sales@javad.com

The legacy continues...

2019 2019 2020

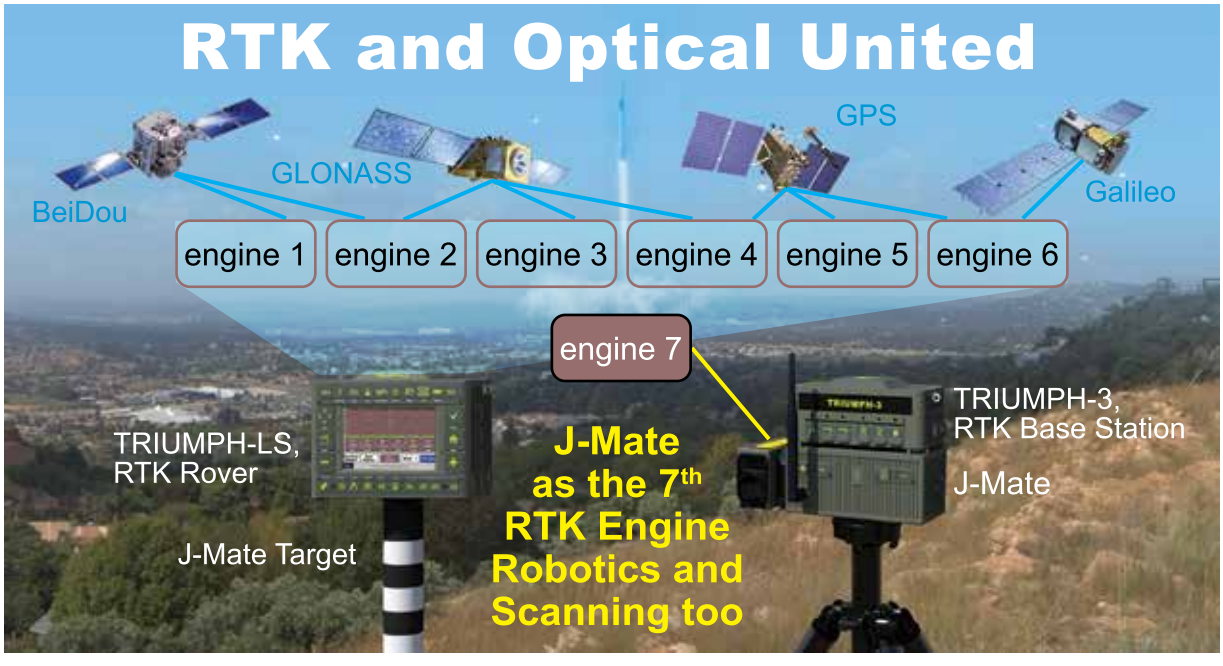
J-Mate

J-Mate is a bridge between RTK and areas that GNSS signal is not available.



- **Direct up to 300 feet**
- **Remote (Robotic) up to 150 feet**

J-Mate is not a total-station. J-Mate and TRIUMPH-LS together make the "Total Solution" which is a combination of GNSS, RTK, camera, angle encoders and laser range measurements that together do, conveniently and cost-effectively, a lot more than a total station. For long distances, you use GNSS and for short distances (maximum of 300 feet in Direct mode and 150 feet in Remote/Robotic mode), you use the J-Mate along with the TRIUMPH-LS. Together they provide RTK level accuracy (few centimeters) in ranges from zero to infinity.



JAVAD USA Family (JGNSS & JEMS)

JAVAD PLS Family (associated with JGNSS)

To honor the legacy and all that our father had put into these companies, we will continue to push ourselves toward the goal of remaining the technological and innovative leader in our industries. That would be the minimum he would expect of all of us. He was so very proud of what had been accomplished but knew that we had to challenge ourselves each and every day to make it better. Everyone we have communicated with is motivated more than ever to carry on his legacy and implement all his visions and dreams.

Those of you who have worked with us know our similarities to our father, and know when we have our minds set, not much will deter us. We may have a gentler hand but can be a force like he was. Of course...our training started since day one, and we have earned some battle scars...

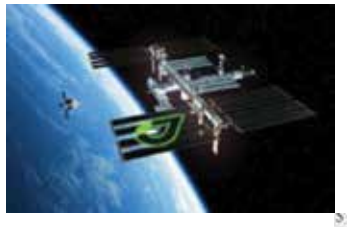
Our father also wrote me recently, "My only hope is that you and Nema focus on company as much as your energy allows." These words are in our heads and hearts every day, and with your help we will make him proud.

He was also a true visionary... including training the next generation early, and in his own special unique way.

Our hearts may be broken, but our resolve and spirits are not, and in fact are stronger than ever. The JAVAD group of companies is special, and the entire world knows this. We will harness his energy to carry on his legacy... and make us top not just in technology but also global presence.

To that end we will live and work each day with that expectation. We will continue to push ourselves to be better and continue to innovate and grow the companies that he started many years ago. This is the approach ingrained in all of us by Javad Ashjaee himself and this is something that we know for sure he would expect of all of us as we move forward without him. The best way to honor his legacy is to strive to make the company bigger, stronger and more successful than ever and that is what we will endeavor to do.

Javad Ashjaee started in 1986 with Ashtech and he will continue with the current JAVAD companies for generations to come. He is now literally with the stars and satellites (@International Space Station), still watching over us...so we better live up to his expectations!



Warm Regards,
Nedda Ashjaee

To the next generation of surveyors...

Students at Marshall Lane Elementary School and Rolling Hills Middle School in Saratoga, California, enjoying TRIUMPH-LS

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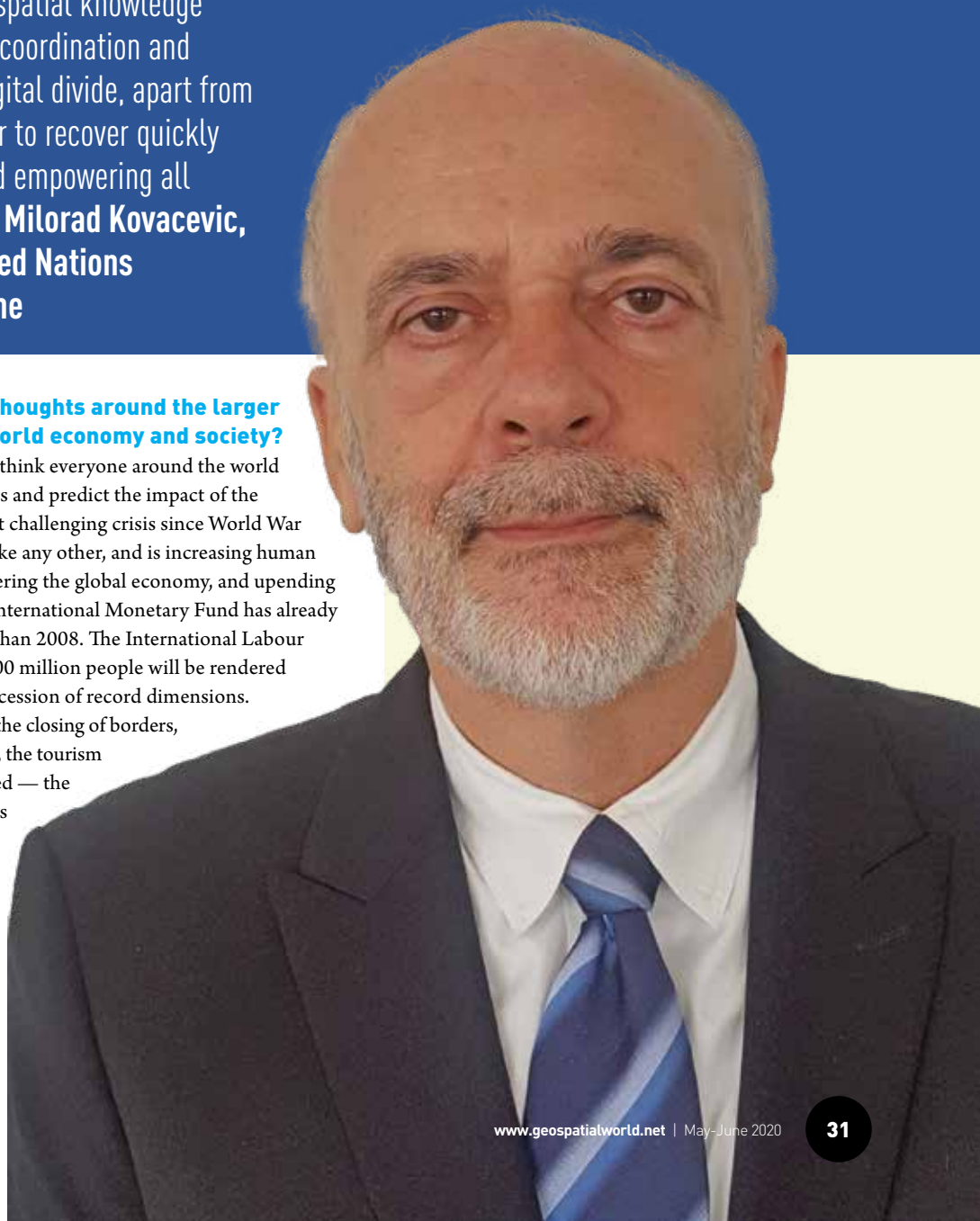
Geospatial Knowledge Infrastructure to Power Decisions at All Levels

If developed properly, geospatial knowledge infrastructure can help in coordination and bridging the geospatial digital divide, apart from enabling the private sector to recover quickly from the current crisis and empowering all stakeholders, emphasizes **Milorad Kovacevic, Chief of Statistics, United Nations Development Programme**



Can you share with us your thoughts around the larger impact of COVID-19 on the world economy and society?

This is a very important question. I think everyone around the world is currently trying to measure, assess and predict the impact of the pandemic. This is certainly the most challenging crisis since World War II. It is a global health calamity unlike any other, and is increasing human suffering, destabilizing and endangering the global economy, and upending the lives of billions of people. The International Monetary Fund has already predicted a global recession worse than 2008. The International Labour Organization has said that nearly 300 million people will be rendered jobless. We have entered a global recession of record dimensions.

As mitigating this crisis requires the closing of borders, travel bans and quarantine measures, the tourism sector has been completely devastated — the UN World Tourism Organization has predicted a 60%-80% decline in the sector.[1] The GDP growth of some developing countries, especially small island nations, is heavily dependent on tourism. Many other

1 *https://www.unwto.org/news/covid-19-may-statement-unwto-secretary-general.*

> Around 80% of the population in developed countries has access to the Internet, but when it comes to the least developed nations, less than 20% of people have proper access. This digital divide, which is not just about having the Internet but about having data to make decisions, has to be bridged

developing countries depend on the inflow of remittances to the extent of 5%-10% of GDP[2]. With worldwide recession and loss of jobs, these remittances will reduce dramatically. The United Nations has called for a large scale coordinated, comprehensive and multilateral response amounting to at least 10% of the national GDP, which is around 10% of the global economy, to prevent a prolonged economic crisis.

While most developed countries can manage economic crises from their own resources, the developing nations urgently need massive support. We should also remember that the global health system is as strong as the weakest national health system. That is why, global solidarity is not only a moral imperative, it is in everyone's interest — as this virus is attracted to all humanity regardless of geography or nationality. There is a proverb that says, "In the midst of every crisis lies a great opportunity." So, there is an opportunity to recover and build a better world, which is safer, healthier, more equal and sustainable.

2 *UNDP (2020). Global preparedness and vulnerability dashboards. Human Development Report Office. http://hdr.undp.org/en/content/global-preparedness-and-vulnerability-dashboards)*

Do you see location and geospatial data playing an important role in converting this crisis into an opportunity, and how can we leverage it at global, regional, national and sub-national levels to rebuild our economies and societies?

Data will play a crucial role in this process. Going forward, every decision should be based on accurate and reliable information. We are already seeing individuals and households around the world using information and communication technologies to minimize disruption and circumvent the obstacles they face in going about their daily lives. The UNDP has pointed out the vast inequality in terms of access to information and communication technologies which concerns some important ICT indicators. Around 80% of the population in developed countries has access to the Internet, but when it comes to the least developed nations, less than 20% of people have proper access. This digital divide, which is not just about having the Internet but about having data to make decisions, has to be bridged.

I think that educational institutions will have to focus on digital literacy during and after this crisis. Currently, billions of young people depend heavily on the Internet, and the number of such people is only going to grow. So, it's important to recognize the essential role of data and the need for it to be made available at all levels of governance across geographies. Collaborations between the private sector and governments and investment in innovation and data development will be critical. The UN and its agencies will support all stakeholders in this process. The expansion of data will bring better insights and decision-making and lead to better access to healthcare, finance and banking, and digital solutions.

Can you share the example of a country which is working towards building a data and technology-based system?

The UNDP has a well-designed plan on this. Today, many countries are using data, including traditional statistics and new data sources — Big Data, in a variety of sectors. UNDP designed the plan to track progress in achieving the Sustainable Development Goals. However, in the wake of this unprecedented crisis, Big Data is being heavily used to anticipate trends and support governments in advance to deal with the future impact of COVID-19.

We have built two dashboards[3] using traditional internationally standardized indicators to assess the preparedness of countries to handle a crisis of this magnitude. These dashboards feature a set of indicators and are easy to understand with color-coded ink. One can immediately recognize which countries and regions in the world are less prepared and are more vulnerable in the current situation. In general, reliable data is key to social and economic recovery, and the UN and UNDP are working with many countries to improve their use of data and digital technology.

How severely will this crisis impact the Sustainable Development Goals, and what should be our priority moving forward?

It is well known that countries agreed upon SDGs, or the 2030 Agenda, and also on the Paris Agreement on Climate Change. Many countries are on a good track to achieving these goals; they are progressing well on some fronts. However, we can already recognize that the pandemic will slow down and in some cases, reverse the progress if the aid is diverted exclusively to COVID-19 response. There are countries that are in a fragile situation and are not doing well on SDGs, especially in these testing times. So, yes, the SDGs will surely be affected, but differently in different countries — depending on their current state. The UN and UNDP are doing everything to support such nations in their path of sustainability.

3 *UNDP (2020). Global preparedness and vulnerability dashboards. Human Development Report Office. http://hdr.undp.org/en/content/global-preparedness-and-vulnerability-dashboards)*

Level of preparedness: High Medium Low

Note: For each indicator in the table, countries are divided into five groups of roughly equal sizes. The intention is not to suggest thresholds or target values for the indicators, but to allow a crude assessment of a country performance relative to others. For example, a country that is in the top quintile group in an indicator performs better than 80 percent countries in this indicator. Similarly, a country in the medium group performs better than 40 percent of countries but also worse than 40 percent of countries.
Data source: download at http://hdr.undp.org/sites/default/files/preparedness_vulnerability_dashboards_12.xlsx

Country	Human Development			Health system				Connectivity	
Country	Human development index (HDI) (value), 2018	Inequality-adjusted HDI (IHDI) (value), 2018	Inequality in HDI (percent), 2018	Physicians (per 10,000 people), 2010-18	Nurses and midwifes (per 10,000 people), 2010-18	Hospital beds (per 10,000 people), 2010-18	Current health expenditure (% of GDP), 2016	Mobile phone subscription (per 100 people), 2017-18	Fixed broadband subscriptions (per 100 people), 2017-18
Niger	0.377	0.272	27.8	0.5	3	3	6.2	40.6	0
Central African Republic	0.381	0.222	41.6	0.6	2	10	4.3	27.7	0
Chad	0.401	0.250	37.7	0.5	4	-	4.5	45.1	0
South Sudan	0.413	0.264	36.1	-	-	-	-	33.5	0
Burundi	0.423	0.296	30.1	0.5	7	8	6.2	56.5	0
Mali	0.427	0.294	31.2	1.4	4	1	3.8	115.1	0.6
Eritrea	0.434	-	-	-	-	7	3.0	20.4	0
Burkina Faso	0.434	0.303	30.0	0.6	6	4	6.6	97.9	0.1
Sierra Leone	0.438	0.282	35.7	0.3	10	-	16.5	88.5	-
Mozambique	0.446	0.309	30.7	0.7	8	7	5.1	47.7	0.2
Congo (Democratic Republic of the)	0.459	0.316	31.0	0.9	5	-	3.9	43.4	0

UNDP has built two dashboards to assess the preparedness of countries to handle the COVID-19 crisis

How much of geospatial information does your unit use and in what way?

UNDP is a large organization and it has a specialized unit dedicated to the application of geospatial data. There are many examples of UNDP using geospatial data to help countries around the world. For instance, UNDP is supporting small island states in the use of technologies such as geospatial to develop and use digital early warning systems, satellite imagery, drones. We are also supporting these countries in digitization of data with sufficient technology and knowledge, so that they are able to monitor what matters for them the most — natural weather events such as storms, floods, landslides, soil and coastal erosion, and land degradation.

I am currently based in UNDP's Human Development Report Office. We occasionally use geospatial data when we want to illustrate a specific geographic distribution of, for example, multi-dimensional poverty or when we look to find insights by blending and overlaying geospatial data with other data types.

How would building a data ecosystem, which consists of different datasets including geospatial information, demography, environment data and meteorological data help in rebuilding things post COVID-19?

For social and economic recovery, reliable data are very important. The key is to develop precise frameworks and organize the data in such a way so that they bring value in decision-making. The data ecosystems must also take into consideration that there are different stakeholders and different country-level needs, which must be tracked, reported, considered and answered. For example, data on supply chains and their disruptions, data on labor markets and their challenges and data on care systems and their overloaded situation. In some places, for example, the recovery will mean an extended paid leave or direct cash transfers to the poorest; in others, it will involve investments in the healthcare system and healthcare accessibility. For governments at all levels, the availability of reliable data ecosystem to inform decisions and track impact will be essential. Because we live in an interconnected world, if there is a bad decision locally, it may have an impact even at distant places.

Do you think this is the right time for building and strengthening geospatial knowledge infrastructure, and will that boost the global health response system?

The global geospatial knowledge infrastructure could help us build a robust health response system and enhance worldwide coordination and development. For instance, the integrated geospatial information framework that was developed jointly by the UN and World Bank in 2018 to assist countries in building capacities for using geospatial technology and geospatial management and help their movement towards e-economies and e-governance. 'E' is very important today because it could be used in some way in managing the health and economic crisis that we are currently facing. So, geospatial infrastructure, if well developed, can enhance government services and responses, including decision-making at all levels of governance. Further, it can help in bridging the geospatial digital divide, enable the private sector to recover quickly and empower all stakeholders.

Megha Datta
Director, Global Development Agenda
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A SPATIAL TOUCH

Machine Learning and data mining aided by high powered computing form the foundation of GeoAI, with geospatial science also offering the tools and technologies that help experts to visualize, understand and develop predictive models for real-world phenomena according to specific locations. Authorities and health experts are increasingly relying on GeoAI to tackle the COVID-19 pandemic. **By Anusuya Datta**

On December 30, 2019, BlueDot, a Canada-based Artificial Intelligence startup, sent out an alert to its clients about a cluster of "unusual pneumonia" cases being reported around a wet market in Wuhan, China.

BlueDot was reporting on what would come to be known as the COVID-19 pandemic in due course. It would be a good ten days before the World Health Organization finally made a formal announcement on January 9, 2020 about the emergence of a Novel Coronavirus in China. Since then, the virus has affected 216 countries around the world, infecting millions of people.

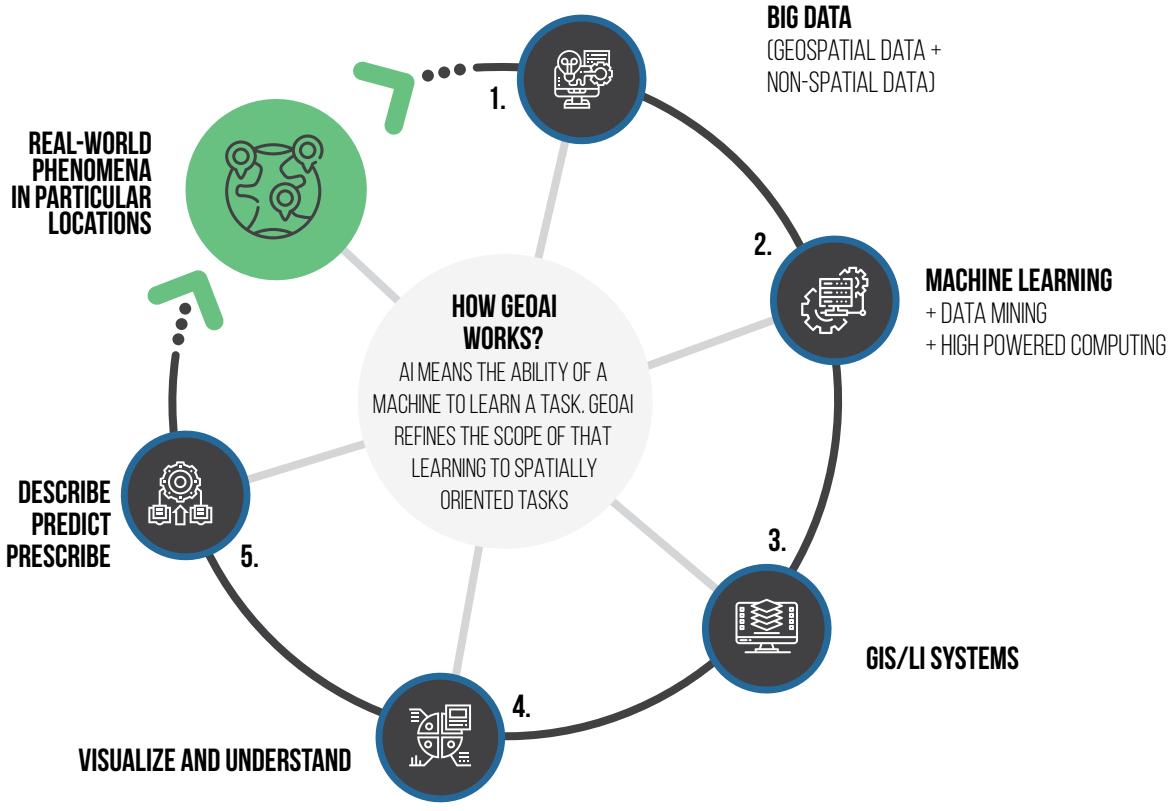
BlueDot, which claims to protect people around the world from infectious diseases with human and Artificial Intelligence, uses a what is known as GeoAI in technical parlance.

What is GeoAI?

Artificial Intelligence is a broad term that describes the ability of a machine to learn a task or workflow. So, Geospatial AI, or GeoAI, simply refines the scope of that learning to spatially oriented tasks, explains **Dr Este Geraghty, Chief Medical Officer, Esri.**

Machine Learning and data mining, aided by high powered computing, form the foundation of GeoAI, with geospatial science also offering the tools and technologies (right from sensors capturing location data to GIS or Location Intelligence systems) that help experts to visualize, understand and analyze real-world phenomena according to particular locations.

GeoAI is increasingly being used to model and capture the environment around



us, linking locations in which we live and work, or people/elements we interact with, to explore their potential role in influencing health outcomes. There is also extensive research into GeoAI being used for hypothesis generation, conducting new data linkages and predicting disease occurrence. Evaluation of hypotheticals helps people answer questions like "what if" — What if there were no stay at home orders? What if we open restaurants? What if we open public transport? This facilitates the evaluation of potential policy decisions.

For instance, if one could take patterns such as the direction of COVID-19 outbreak in an area, and then correlate that with other datasets such as air travel, public transportation or cities with high population density, and put it all on a predictive model along with local environment such as humidity or temperature, there could be some models that could come out of it, which could help local authorities to tackle the problem more specifically.

According to Luis Sanz, CEO, CARTO, innovative statistical methods and computational tools can be used for public health surveillance including spatio-temporal models for disease risk prediction, cluster detection, and travel-related spread of disease. This work can inform strategic policy in reducing the burden of diseases.

Location analytics provide useful tools to model behaviors and inform actions. "From maps that analyze the genetic profile of the virus as it spreads from place to place, to AI techniques that make sense of human movement data, we can enhance our understanding of viral transmission, determine if public health recommendations are being followed and predict whether travel bans and other measures will quell the spread of disease," adds Dr Geraghty.

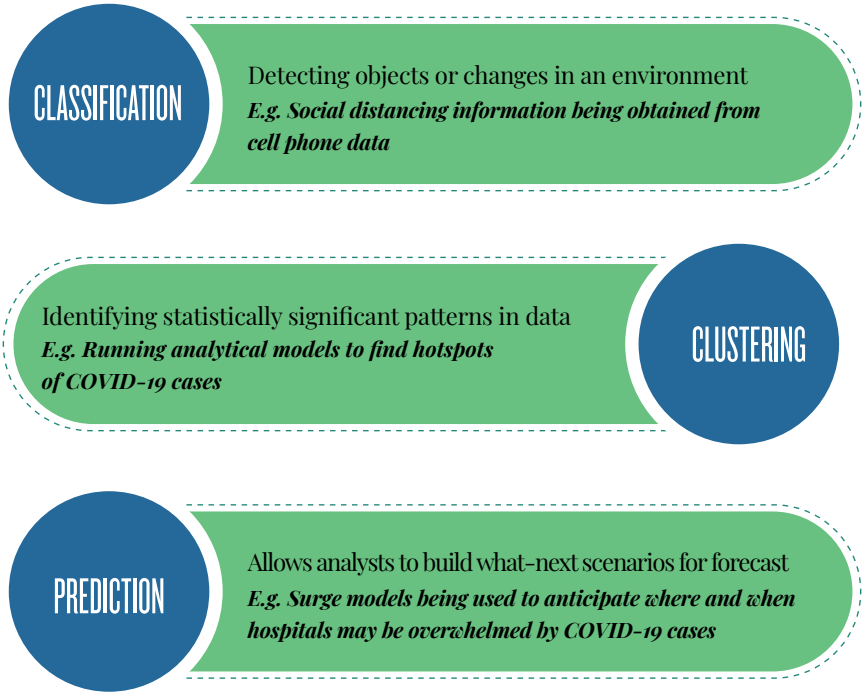
"Increasingly geospatial data is being included in more complex models used to inform early warning systems, model disease transmission and evaluate impacts of public health interventions," points out **Dr Kristine Belesova, Deputy Director, Centre on Climate Change and Planetary Health, London School of Hygiene and Tropical Medicine.**

For instance, the Centre uses advanced modeling techniques to link data on infectious diseases with climate and other environmental changes and develop early warning systems driven by Earth Observation data. Other examples include identifying spatial and environmental risk factors for infectious diseases by applying geo-statistical and Machine Learning approaches, using aerial (drone) and satellite-based Remote Sensing data to assess how ecological and environmental changes impact infectious disease transmission.

"We are in uncharted territory as a microscopic virus is now disrupting our entire planet. The COVID-19 pandemic has revealed the need to implement systems that proactively manage infectious disease risks which, in our rapidly changing world, are increasing in frequency, scale and impact," says **Dr Kamran Khan, Founder & CEO, BlueDot,** and an infectious disease specialist.

GeoAI to tackle COVID-19

We all know contract tracing has emerged as one of the primary methods in COVID-19



response. What many don't know is what all can be done with the data collected. Tracking mobile phone of users allows health authorities to collect all personal data including location. Thus, the authorities can quickly find suspected patients and close contacts through data retrospective analysis, and quarantine and cut off the source of infection in time, explains **Zhang Yaqing, Technical Director, Platform Center, SuperMap**, which was involved in the COVID-19 response operations in China.

Health professionals already deal with an overwhelming amount of data, especially in case of a widespread epidemic. This includes medical history and laboratory test results for each patient. Adding the spatial component on top of these enables experts to analyze and predict who are the people that should be tested or quarantined, or the pattern of the disease in a particular area, or where the next wave will come. Authorities across the world are using GeoAI applications to identify hotspots, prevent the disease from spreading and flatten the curve, which is paramount to preventing healthcare infrastructure from collapsing. It is also being used to plan for and provide medical expertise and supplies at hotspots. In many countries, analysis of such data is being made publicly available so that citizens can avoid areas with high infection rates.

Geo AI for classification, clustering and prediction

There are broadly three key areas of focus for geospatial AI which surround the concepts of classification, clustering and prediction. Classification is about detecting objects or changes in an environment. "For COVID-19 we have a good example with the social distancing information that is being obtained from cellphone data (aggregated and anonymized) and shows a change in human mobility patterns compared to pre-COVID-19 time periods," points out Dr Geraghty.

Clustering is about analytical models that find statistical patterns in data, such as hotspots of COVID-19 cases. Prediction allows analysts to build forecast scenarios on what may happen next. A great example of AI for prediction is the various hospital surge models being used to anticipate where and when hospitals may be overwhelmed by COVID-19 cases. Those models can be run using different assumptions about the level of social distancing being practiced within a locality.

In China, in the initial days when the virus was spreading, tech major Baidu leveraged AI-powered mapping systems to identify the flow of travel across high-risk areas using Baidu Maps Migration Big Data Platform to provide epidemiologists real-time insights into the virus spread to speed up local preparedness and response efforts.

In Taiwan, the government collected mobile data to identify cruise ship passengers who were potentially infected. The geospatial data layer obtained from telecommunications companies were then added to identify and make public potential high-risk areas.

"A lot of research institutes or even companies have been using data modeling to get insights into how the disease is spreading and in case of companies how it affects their businesses," says **Gladys Kong, CEO, UberMedia,** a Location Intelligence player with an innovative mobile DSP featuring Machine Learning powered optimization.

One of UberMedia's partners in the COVID-19 response work — a research institute — looked at people's movement and the distance traveled from home. As more and more cities begin to reopen, this can track how the numbers are changing and help prepare for a second wave. Further, based on predictive modeling, retailers and restaurants can figure out how to forecast their sales, how much staff they need and also some inventory, explains Kong.

However, many such models currently in use do not generalize well across large geographic areas, since they depend on uniformity — on the assumption of variables such as health factors, population density and mobility.

Role of social media in GeoAI

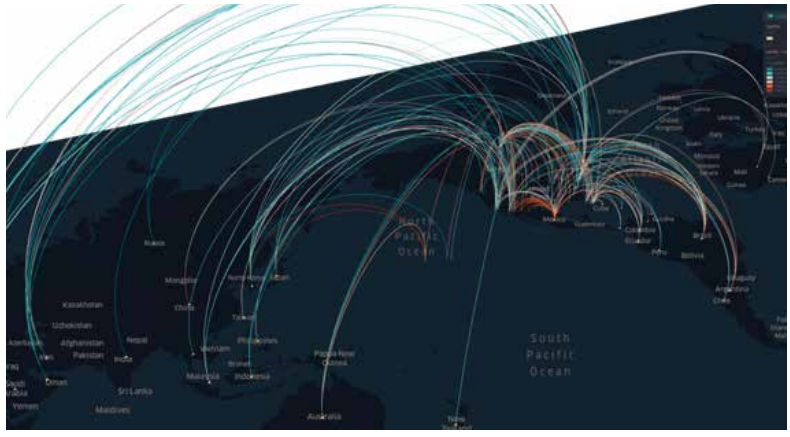
Advancements in AI have also seen a growing interest in real-time syndromic surveillance based on social media data. In fact, a common theme across GeoAI applications is the use of novel sources of spatial Big Data, such as social media, electronic health records, satellite Remote Sensing

and personal sensors (like Fitbits) to advance the science of public health (especially in the context of 'smart healthy cities') and potentially precision medicine, creating opportunities to comprehensively answer questions tackled in these fields as well as opportunities to answer new, emerging questions, explains *International Journal of Health Geographics.*

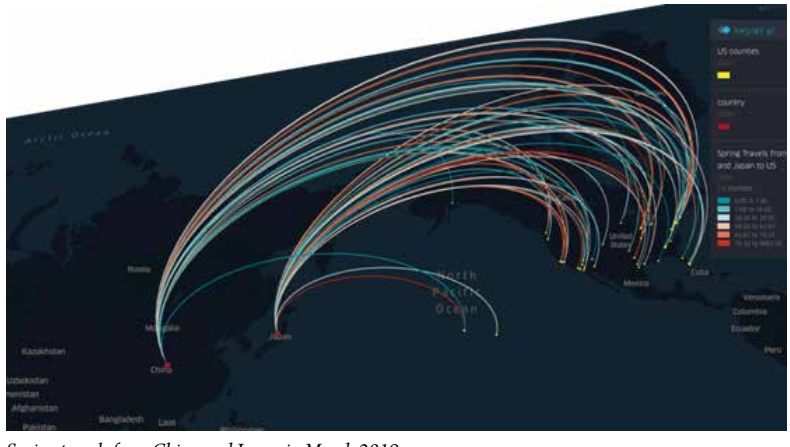
Deep Learning algorithms can be applied to Twitter data to detect disease outbreaks and then to build up and display information, including relevant news articles, to provide situational awareness. In the US, this has demonstrated an ability to detect symptoms for influenza-like illness, which were then confirmed from the CDC Morbidity and Mortality Weekly Reports (MMWR). There is further research onto improve on this surveillance system to incorporate disease-specific information (e.g., mode of transmission) to enhance disease forecasting accuracy.

For COVID-19 response too, AI-powered data analytics can be used to pull insights from online behavior such as Internet search queries and social media conversations to identify signals from a specific population in a particular location. An interesting example of this is how Boston Children's Hospital used an automated HealthMap system that scans online news and social media reports for early warning signs of outbreaks. This initial alert spurred more detailed reports from other agencies, including a warning from the Program for Monitoring Emerging Diseases (ProMed), a well-known volunteer-led organization, just half an hour after the first warning. HealthMap brings together disparate data sources, including online news aggregators, eyewitness reports, etc., which keeps on updating 24/7, with an automated process, monitoring, organizing, integrating and visualizing online information about emerging diseases, facilitating early detection of global public health threats.

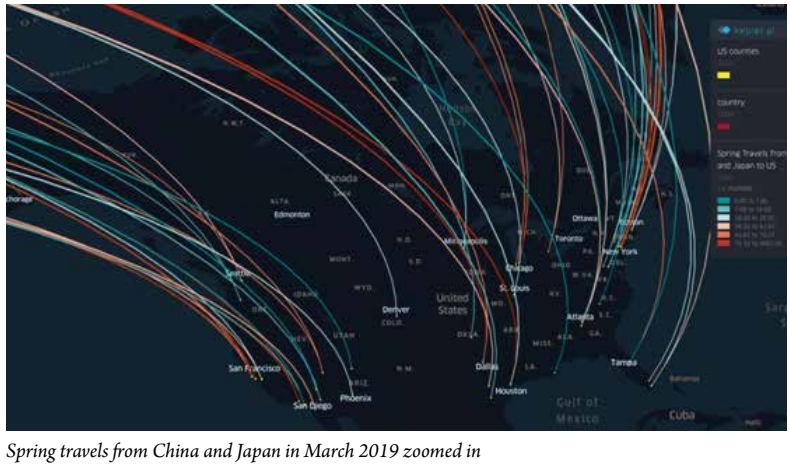
In Canada, the Public Health Agency of Canada (PHAC) as well as the Department of National Defence is using BlueDot's Insights software to track and assess risk from global and domestic infectious disease outbreaks, including COVID-19. BlueDot's



GeoDS Lab at University of Wisconsin, Madison used Country-to-US Counties flow data from March 2019 to show thousands of trips generated in the US. The team modeled this data back in March 2020 to predict a rapid growth of infection cases across the US



Spring travels from China and Japan in March 2019



Spring travels from China and Japan in March 2019 zoomed in

For COVID-19 response, AI-powered data analytics can be used to pull insights from online behavior such as Internet search queries and social media conversations to identify signals in a particular location

HealthMap brings together disparate data sources, including online news aggregators, eyewitness reports, expert-curated discussions and validated official reports, to achieve a comprehensive view of the current global state of infectious diseases

Insights tool uses AI to scan over 100,000 articles per day in 65 languages, searching for official and unofficial news of infectious disease outbreaks. The platform performs these Big Data analytics every 15 minutes around the clock. A team of subject matter experts then reviews the outputs before publishing on the Insights dashboard. The Insights platform then assesses the risk of spread to locations of interest around the world using data on local and global air travel patterns that draw from over 4 billion flight itineraries per year.

WHEN BIG G FAILED

Way back in 2008, Google had tried its hand at Flu Trends by aggregating Google Search queries with the help of AI, before quietly burying it in 2015. The idea behind Google Flu Trends was that by monitoring millions of users' health tracking behaviors online, the large number of Google search queries gathered can be analyzed to reveal if there is the presence of flu-like illness in a population. Google Flu Trends compared these findings to a historic baseline level of influenza activity for its corresponding region and then reports the activity level as either minimal, low, moderate, high, or intense. The initial reports stated that the predictions were 97% accurate when compared with CDC data. However, then subsequent reports asserted that the predictions were sometimes very inaccurate, especially around 2011-2013, when it consistently overestimated flu prevalence. For one interval in the 2012-2013 flu season, it predicted twice as many doctors' visits as the CDC recorded.

GeoAI to map psychological connect to health

There is a psychological connect to health and social media data analysis too. **Li Yunxia, Account Director, Platform Center, SuperMap**, explains when a major epidemic comes, the impact of panic on the society may exceed the disease itself. "To this end, it is necessary to track and evaluate the spatial spread of social emotions by analyzing massive social media data. For instance, when facing an epidemic, public behavior might be irrational, highly infectious, and conformable. It is required to build a knowledge base of epidemic-related emotions and to dig out the dynamic evolution of public opinion in time, space and semantics aspects from social media."

By using Internet search or social media data as a source, public topic categories related to the epidemic can be obtained by topic models and Machine Learning methods, which helps us to characterize the changes in public sentiments. These outcomes then contribute to the reveal of the temporal, spatial and semantic distribution characteristics and evolution patterns of public topic views under the COVID-19, he adds.

AI IN EHR

Optimization of EHR, or Electronic Health Record, is crucial at a time where health systems are under immense pressure. US based Epic, an EHR software company, was one of the first ones to make updates to its system and come up with a plan for how it can help its customers. To let providers at different organizations know about potential exposure risks, community members were encouraged to share travel screening documentation and infection status information with both Epic and non-Epic organizations through the Care Everywhere platform, Epic's interoperability network. It also updated its travel screening criteria as far back as January.

It also tracked patients who weren't been screened for travel to regions where COVID-19 was spreading quickly. Organizations could also use reports to monitor the isolation status of confirmed or suspected cases, review and identify infection trends over time, and follow-up with discharged patients. A number of hospitals in the US are using Epic's AI based system to predict which patient will become critically ill, or if a ventilator would be next available. Though under normal circumstances, hospitals would take time to test the tool on hundreds of patients before implementing but COVID-19 is not giving them that luxury.

So far, the digital footprints on Internet web searches and social media remain largely inaccessible to researchers and governments. If opened, this data could support not only in monitoring, surveillance and contact tracing, but also in running AI-based Big Data analytics for prediction and prevention. For COVID-19 response, Facebook has started providing mobility datasets of its users directly to researchers upon request to help analysis of population movement and patterns. Google also opened some of its search queries such as mobility reports, even as its Search and Maps divisions continue to release new data and tools to help small businesses pivot their operations during the pandemic.

The smart way forward

As cities become more connected and smarter, they are gathering, generating and consuming huge data, a major amount of which could be related to health and environment. GeoAI can play a key role in making sense of this data through intelligent, location-based Big Data analytics. IoT sensors and devices deployed in modern cities represent novel and alternative sources of generating geo-tagged Big Data.

Nikhil Kumar, Country Head - India, HERE Technologies, points to the emergence of wearables and connected devices in the past few years that are capable of collecting individual health information such as heart rate or sleeping patterns, etc. "Integrating this data into GIS could help healthcare workers uncover long-term geographic trends in health of certain demographics, thus opening new realms of healthcare research and insights not previously attainable."

Spatial energetics is an emerging field that focuses on mining dynamic, high-resolution measures of temporally matched location and behavior data through GPS, accelerometry, and GIS. However, there remains significant conceptual, technical, analytical, and ethical challenges stemming from the complex data streams that spatial energetics research generates, notes the US National Center for Biotechnology Information.

Further, information from ride sharing services such as Uber and Lyft etc can also be a novel source of data to add to this Big Data pool. As to how big this data is could be gauged from the fact that as of 2019, there were roughly 75 million active Uber riders across the world. Location is a key aspect of ride sharing as it relates to pick-ups and drops — giving insights into mobility data. Such information can be used to address queries related to spread of the virus in case of a pandemic. In normal situations, mobility data can also give insights into accident rate or injuries. Further, food delivery services, e.g. UberEats, Zomato etc., may also provide interesting insights into its potential role in promoting sedentary behaviors and childhood obesity.

COVID-19 has very firmly established the need for geospatial and location information and technologies in health sector. However, there is more that could be done with the use of GeoAI. But this can be only possible with collaborations, since it is difficult for governments, policy-makers and other leaders to sort through all of the new companies, initiative and solutions available out there. There is also a greater need to modernize and standardize our data systems in a way that allows for data sharing when needed, such as local governments and hospitals moving relevant data up the chain to provide a national picture, emphasizes Dr Geraghty**.** One clear and simple lesson is that public health has long been underfunded. The world needs a modern, well-funded, data-driven public health system to enable faster and optimally effective response.

As Dr Khan of BlueDot says, "It is with enhanced preparedness that we can get ahead of these threats to create a healthier, safer and more prosperous world."

The downstream effect would also protect economies.

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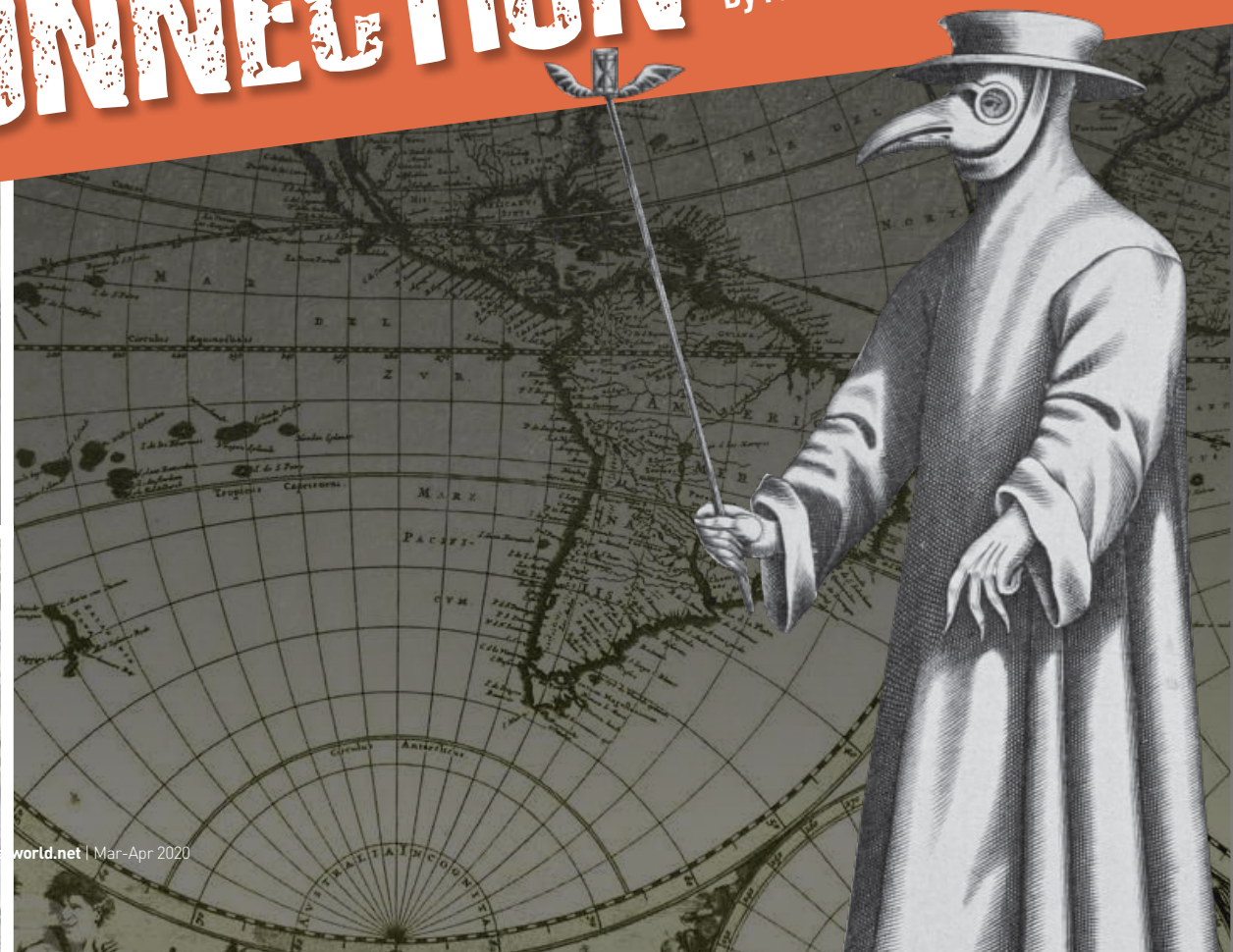
A HISTORIC CONNECTION

A sneak peek into the past reveals that geographic information has played a key role in epidemiological breakthroughs, highlighting the power of 'where' in healthcare.

By Mahashreveta Choudhary



We all are dealing with a common enemy today — SARS-CoV-2, or the Novel Coronavirus, which originated from Wuhan, China, towards the end of last year. Apart from causing deaths and infecting millions of people worldwide, the virus has quite literally pushed the global economy into recession, forcing our well-connected global village into self-quarantine. The picture is grim, but could have been a lot worse, if we hadn't figured out the origin of the virus, and could not track its movement.

History is replete with instances in which geographic information has played a key role in epidemiological breakthroughs, highlighting the power of 'where' in healthcare. Even today, governments and medical experts are extensively using maps to deal with all aspects of the pandemic — to from tracking cases to planning relief measures.

The practice of tracking a disease goes back to the 17th Century in 1692 when plague was wreaking havoc in Europe, Fillippo Arrieta, an Italian royal auditor, spatially visualized the strategy for containing the spread of the disease in Italy's Bari region. On Arrieta's map, Bari was separated from the rest of the country by a dashed line that represented a cordon sanitaire, which is similar to a containment zone of our times. The map shows two areas within Bari, separated from the cordoned-off province by a thick line.

Courtesy: ResearchGate

Through this map in 1692, Fillippo Arrieta, an Italian royal auditor, spatially visualized the strategy for containing the spread of plague in Italy's Bari region

There are several such fascinating stories, telling us about the strong connection between geographic information and epidemiology. Let's turn the pages of history to revisit some of these stories.

Yellow fever mystery

In 1793, Philadelphia city in the US state of Pennsylvania lost nearly 10% of its population to yellow fever. At that time, the authorities assumed that the fever springs from 'corruption' of the air, and that its 'violence' is in proportion to the continuance of the heat and moisture. In areas with high mortality, sanitarians assumed that the 'corruption' in the air originated from the foul odor emanating from stagnant ponds and unsanitary streets, where human and animal waste was left uncollected for days. Contagionists, on the other hand, believed that the fever was not locally generated, and was in fact 'imported' in the cargo holds of trading ships that brought slaves and raw goods to American ports.

In 1796, ***Dr Valentine Seaman***, with the help of maps designed on copper plates, attempted to correlate the location of yellow fever cases with waste sites in the city streets. Through his maps, Dr Seaman defined the nature of the disease and the scale of response required by public officials to prevent recurrent epidemics.

DR VALENTINE SEAMAN

(1770-1817)

Later, Dr Seaman also overlaid the location of yellow fever cases with the position of dumping areas and sewage sites in lower Manhattan. He marked these sites with a thick 'S'. Reflecting upon his observations, he concluded that the deadly outbreak was linked to certain areas with putrid emanations.

Courtesy: Brianaltonennph

In 1780, Dr Valentine Seaman overlaid the location of yellow fever cases with the position of dumping areas and sewage sites in lower Manhattan

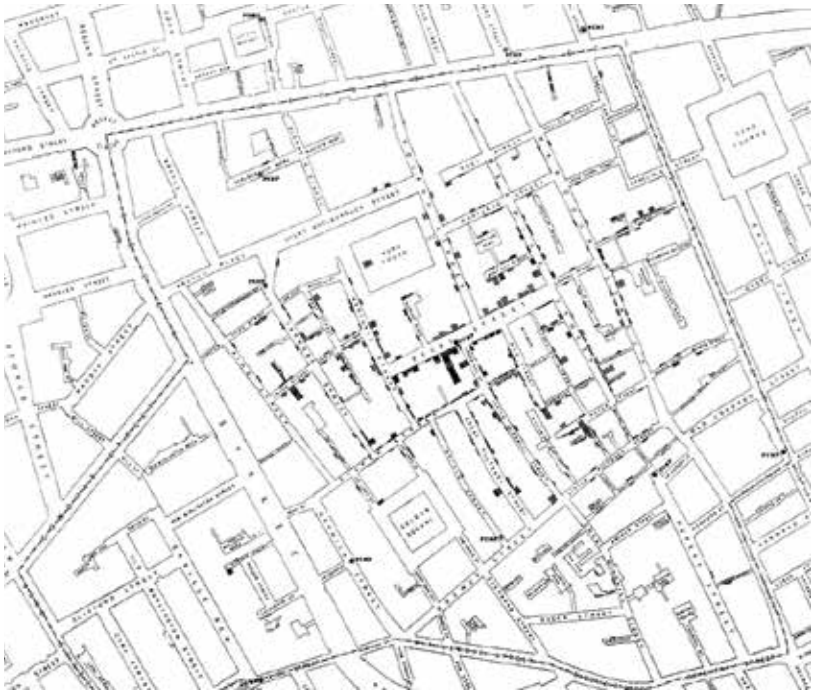
Cholera puzzle

JOHN SNOW

(1813-1858)

In the middle of the 19th Century, with the help of maps and other illustrative tools, ***Dr John Snow***, a scientist-physician, discovered that Cholera was a contagious waterborne disease. Termed Father of Medical Cartography, Dr Snow mapped the distribution of cholera deaths around a water pump on Broad Street in London's Soho in 1854. He identified the relation between the pump and the populace, and eventually convinced the authorities to get the pump handle removed.

Over the next century and a half, Dr Snow's story was reconstructed, as he crafted the map during the outbreak, and the evident clustering of deaths led to the famous breakthrough. Over time, his map evolved from an analytical tool to an effective cartographic communication device.



Courtesy: ResearchGate

Dr. John Snow mapped the distribution of cholera deaths around a water pump on Broad Street in London's Soho in 1854

In the middle of the 19th Century, with the help of maps and other illustrative tools, Dr John Snow, a scientist-physician, discovered that Cholera was a contagious waterborne disease

Courtesy: Pavel Fedotov

This 19th Century painting by Pavel Fedotov depicts death from cholera in Russia

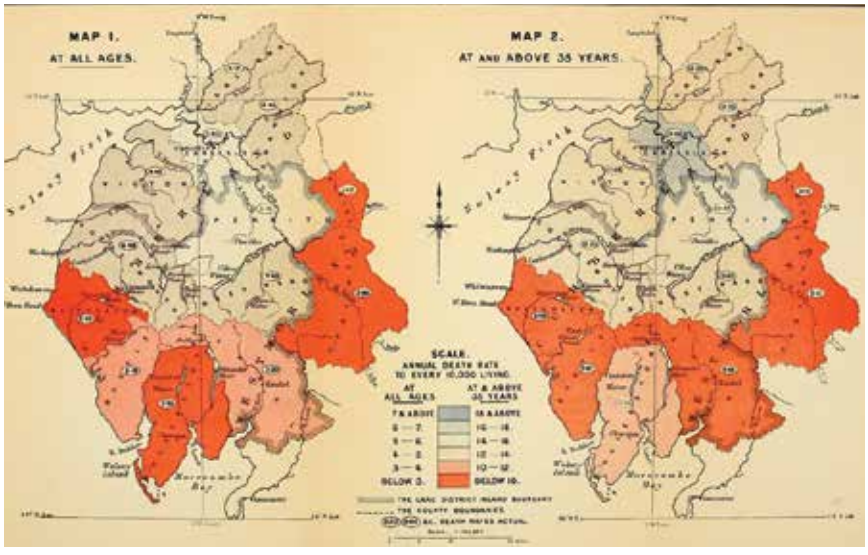
Tracking cholera morbus

In 1819, a new and violent epidemic, known as Cholera Morbus, was reported in the British army barracks of Peshawar, then India. Over the next decade, the disease spread to the Middle East, Russia and Europe. In a review article in 1831, when cholera arrived in England, the *Lancet* mapped the progress of the disease in Asia, Europe and Africa. The authors of the map claimed they had traced the epidemic through 700 'irruptions', and shown it ravaging nearly 2,000 towns.

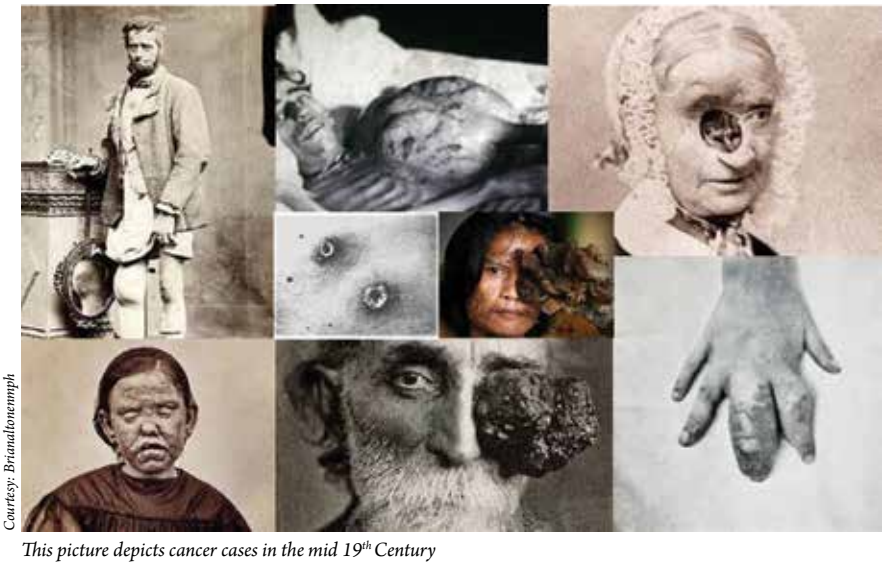
Each of these 'irruptions' was presented on the map as a circle, with a dot inside to mark a cholera-reporting city. In the mapping of geography, the extent of the disease as a single thing was constructed. This was for the first time that international data from a variety of public and professional sources was collected and organized in a manner describing the international geography of a disease.

Curious cases of cancer

In 1868, ***Dr Alfred Haviland*** used a map to advance a biogeographical explanation for higher cancer rates in certain parts of England. The intent behind the exercise was not only to



This map by Dr Alfred Haviland highlights bimodal depiction of cancer with orange color indicating the least medical hazard and grey color indicating the highest



Courtesy: Brianaltonenmph

This picture depicts cancer cases in the mid 19th Century

map the spread, but to figure out the aetiology of the fatal disease. Although limited to a specific region, Haviland's work sparked a series of studies and reports that identified an increasing incidence of different forms of cancer in the UK, with some of the cases connected to specific biogeographies.

Soon, those reports led to similar studies across the Commonwealth and elsewhere, transforming anomalous regional incidence into a global health concern — the cancer epidemic. The challenge was to identify specific biogeographical profiles that could explain high number of cases in certain towns, districts and regions. In 1975, *US Cancer Atlas* identified 'hotspots' on the basis of coastal shipyards, whose workers were exposed to asbestos. Elsewhere, high rates could be connected to air pollution from a copper smelter. These findings highlighted environmental and social variables that seemed to cause cancer.

DR ALFRED HAVILAND
(1824-1903)

In 1868, Dr Alfred Haviland used a map to advance a biogeographical explanation for higher cancer rates in certain parts of England

Learning from history

Epidemiologists have traditionally used maps to analyze the association between location, environment and disease, and it is a given that good epidemiology science and good geographic information science go hand in hand. Since the SARS outbreak in 2003, the world has seen a revolution in applied geography through web-based tools. Currently, there are umpteen maps and charts to show the alarming spread of COVID-19 and how health infrastructure across countries is under tremendous stress.

Location is the basic principle of any field investigation. In case of a global pandemic like COVID-19, the dimension of 'where' becomes more important than 'who' and 'when'. Geospatial tools and data have immense potential in epidemiology, and can help in mapping a disease, procuring relevant supplemental data and taking evidence-based decisions.

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UNLOCKING DATA POTENTIAL TO DEFEAT PANDEMIC

Findable, accessible, interoperable and reusable data holds the key to an effective COVID-19 response, explains **Thalia Baldwin, Director, Geospatial Commission, UK**

How do you view the impact of COVID-19 on the global economy?

COVID-19 has had an immediate and significant impact across all global economies, with a substantial reduction in economic output in many sectors. However, some sectors, such as hospitality, retail and leisure, have been hit harder than the others with many livelihoods destroyed across the globe.

Going forward, global collaboration will be vital. Every crisis, while creating adversity, presents opportunities. In the last few months, we have seen innovative ways of data use by both public and private enterprises, along with new partnerships. Moreover, local communities have come together to support each other. In the UK, the government's response aims to address these wide-ranging impacts based on scientific and data-driven evidence.

How can geospatial data and technology help in combatting the current pandemic?

The value of geospatial data to track and respond to a disease is not new. Since John Snow's mapping of the London cholera outbreak in 1854,this kind of data has been used to identify causes of a disease, track infection rates and monitor the recovery of patients. Advances in technology mean that more robust data collection and analytical methods are now at our disposal. We see this in the rapid deployment of tools to monitor the spread of a disease; model and predict future spread; mobilize and coordinate response efforts; and monitor the impact/compliance of policy interventions.

There has been a growth in near real-time use cases of geospatial data applications such as improved and accessible sensor, mobile location and consumer data — all enabling improved strategic coordination and response. We are in a period of rapid innovation driven by technology, and by the urgency to rethink how geospatial data can be deployed.

At the UK Geospatial Commission, we are not only interested in the direct application of geospatial data for COVID-19 response, but also in the long-term impact of the use of this data and associated technologies. We have established a specific program of activity to consider the medium to long-term application of this innovation for future statistical and health applications, and to provide for the broader opportunities for the use of geospatial data for economic, social and environmental benefit.

What is your opinion on the short and long-term impact of COVID-19 on the geospatial industry, and on national geospatial agencies?

As a short-term impact, we see an accelerated interest in the role of geospatial data in response to COVID-19, which also includes cross-sector data sharing. It will be interesting to see the long-term impact that new alliances and experiences from sharing data will have.

To support long-term priorities, including the UK's economic recovery, we are currently gathering evidence through a geospatial market study. The impact of the current pandemic on the market will be of interest, including how it supports disruption or a change of approach in some sectors. The diversity of business models that are informed in some way by geospatial data is apparent, and we will need to have an approach that creates opportunities for the market as a whole.

The UK has a multitude of bodies coordinating an active response to the current pandemic. These include public sector bodies such as the national mapping agency, Ordnance Survey, which is providing an active response through its Mapping for Emergencies Programme, as part of the services it has contracted to provide to the public sector through our Public Sector Geospatial Agreement.

This agreement includes using high definition mapping to identify the best sites for response facilities and the location of vulnerable people to ensure they receive the support they need.

Not only is this data made available to the public sector, but to anyone with a crucial role to play. To ensure this, the Ordnance Survey has now released a new short-term 'COVID-19 Licence'. The licence is enabling organizations, developers and individuals to use OS data for free, for the specific purpose of supporting the UK response to the coronavirus pandemic.

> At UK Geospatial Commission, we are not only interested in the direct application of geospatial data for COVID-19 response, but also in the long-term impact of the use of this data and associated technologies

It's being said that the need of the hour is to shift from data platforms to solution platforms. What are your thoughts on this issue?

Everyone is trying to figure out the maximum-value sector in the future data economy. The public sector is not traditionally seen as very promising in this regard. For data that is held by the public sector, we see the need to invest in the fundamentals first — findable, accessible, interoperable, and reusable data is the key. We are working with bodies across the UK public sector to develop and improve access to data. Only then it will be possible to unlock value from data by combining it across domains to reach a wider community of users who can innovate with it. Development of data to enable high-end technology and advanced analytics to apply is, of course, the prize, and some are already well-advanced in this respect. In the UK, we want to create the right market conditions and incentives for innovation, while safeguarding national security, intellectual property rights and individual privacy. At the same time, we recognize how advancing innovation and skill can help build the nation's capabilities.

Moving forward, what are your strategies and suggestions?

This is an unprecedented time for us all — no matter where we are in the world. Geospatial data is key to evidence-based and agile response. Reduced and new consumer and citizen demands are providing challenges and opportunities, with geospatial data central to meeting both.

In the UK, we might see an increased appetite for data sharing between the general public and the public sector, given that we now centrally rely on this data to support our COVID-19 response. Furthermore, with this appetite, if we can get the precise frameworks around data, that could not only support options to manage short-term impacts, but also long-term economic recovery. Therefore, the UK government is committed to maximizing the value of geospatial data.

The Geospatial Commission published the UK's Geospatial Strategy earlier in June. Our strategy aims to deliver a more explicit framework for how geospatial data can be accessed and used, coupled with critical programs and investment. In this way, we look to prove the case for further attention, investment or regulatory reform that improves geospatial data and its use.

It will also enhance activities like running the Public Sector Geospatial Agreement (PSGA), which is a £1 billion investment over ten years. We will continue our work on a new National Underground Assets Register, which will improve the efficiency and safety of underground infrastructure by creating a secure data exchange platform to provide digital records of assets' location. Moreover, we will start to explore where improvements to geospatial data can support greater efficiencies in the housing sector, environmental policy and future transport networks. All of this should support the UK's recovery in these challenging times.

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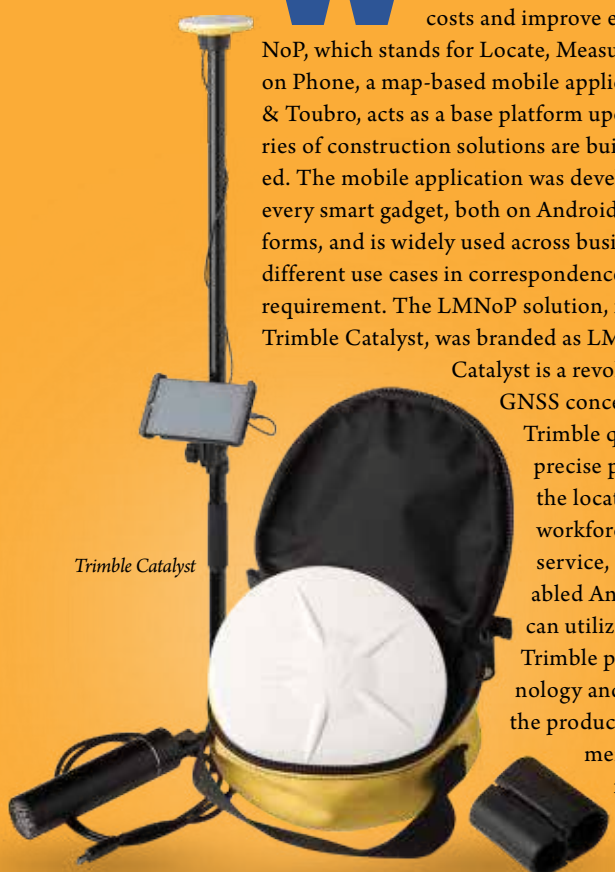
ACCURACY MATTERS

The integration of L&T's map-based mobile app LMNoP with Trimble Catalyst GNSS led to enhancement in positional accuracy and data quality, apart from saving data acquisition time.

With the ubiquitous use of smartphones, project sites leverage the power of mobile apps to reduce costs and improve efficiency. LMNoP, which stands for Locate, Measure and Navigate on Phone, a map-based mobile application by Larsen & Toubro, acts as a base platform upon which a series of construction solutions are built and integrated. The mobile application was developed to run on every smart gadget, both on Android and iOS platforms, and is widely used across business verticals in different use cases in correspondence with business requirement. The LMNoP solution, integrated with Trimble Catalyst, was branded as LMNoP+. Trimble Catalyst is a revolutionary GNSS concept, bringing Trimble quality and precise positioning to the location-enabled workforce. Using the service, any location-enabled Android field app can utilize the power of Trimble positioning technology and benefit from the productivity improvements that come from working with precise location.



Trimble Catalyst

The primary objective of the LMNoP application is to provide location information of a project site's assets, supporting site engineers in field operations. The app also enables site engineers to view the project's design drawings, toposheets, aerial photographs and other GIS layers superimposed on the project base map. The solution has been constantly growing with customized versions and builds generated, based on specific needs of projects.

Utility alignment tracking, material or resource planning and re-route analysis are some of the growing use cases of LMNoP solution. The data captured using the app across the project site serves as the base, which is further used as input data for engineering design, quantity estimation, progress monitoring, obstruction and hurdles management. The technical architecture of the LMNoP app includes both mobile and web application — while mobile application is used for field related activities, web application is used for monitoring and other decision-making process. Seamless connection between the web and mobile application ensures integration of both office and site activities.

The big challenge

Since mobile GPS receivers catch radio waves from connected satellites and use triangulation methods to derive where a person/object is, these receivers are not premium builds like dedicated GNSS receivers and sometimes do not provide accurate data. The initial version of LMNoP used relatively less accurate inbuilt mobile device GPS to derive location information, which had a deviation in positional accuracy of up to 30 metres. To enhance positional accuracy, data quality and save data acquisition time, LMNoP was integrated with Trimble Catalyst.

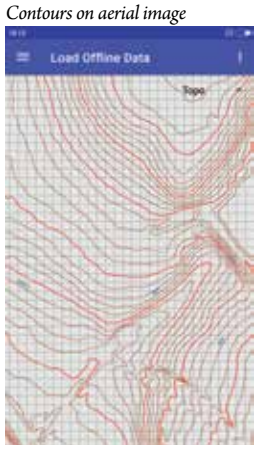
The objective behind the integration was clear: delivering professional grade positioning. Trimble Catalyst allows GNSS signals and satellite corrections

to be passed into android smartphones and tablets. The light weight, plug-and-play antenna simply connects with mobile using USB connection. Additionally, the easy push fit mount enables the users to capture data in corner and challenging points in an accurate manner. With the availability of open SDK, LMNoP application was integrated with Trimble involving several customizations.

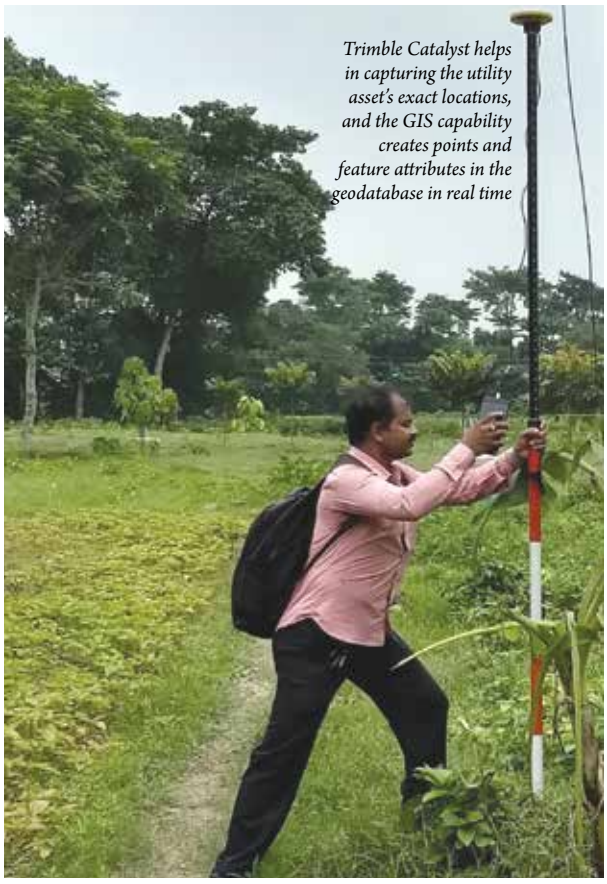
On ground experience

Under the Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY) scheme in the Indian state of West Bengal, asset information was captured using LMNoP+ for project sites. The objective of the scheme was to supply electricity to the rural households which would cover works relating to feeder separation, strengthening of sub-transmission and distribution systems, including metering of distribution transformers/feeders/consumers by addressing the areas of critical gap. The scope included engineering design and construction of new poles and replace the outdated poles with new ones, thereby electrifying the rural areas.

Contours on aerial image



Surface elevation in offline mode



Trimble Catalyst helps in capturing the utility asset's exact locations, and the GIS capability creates points and feature attributes in the geodatabase in real time

LMNoP+

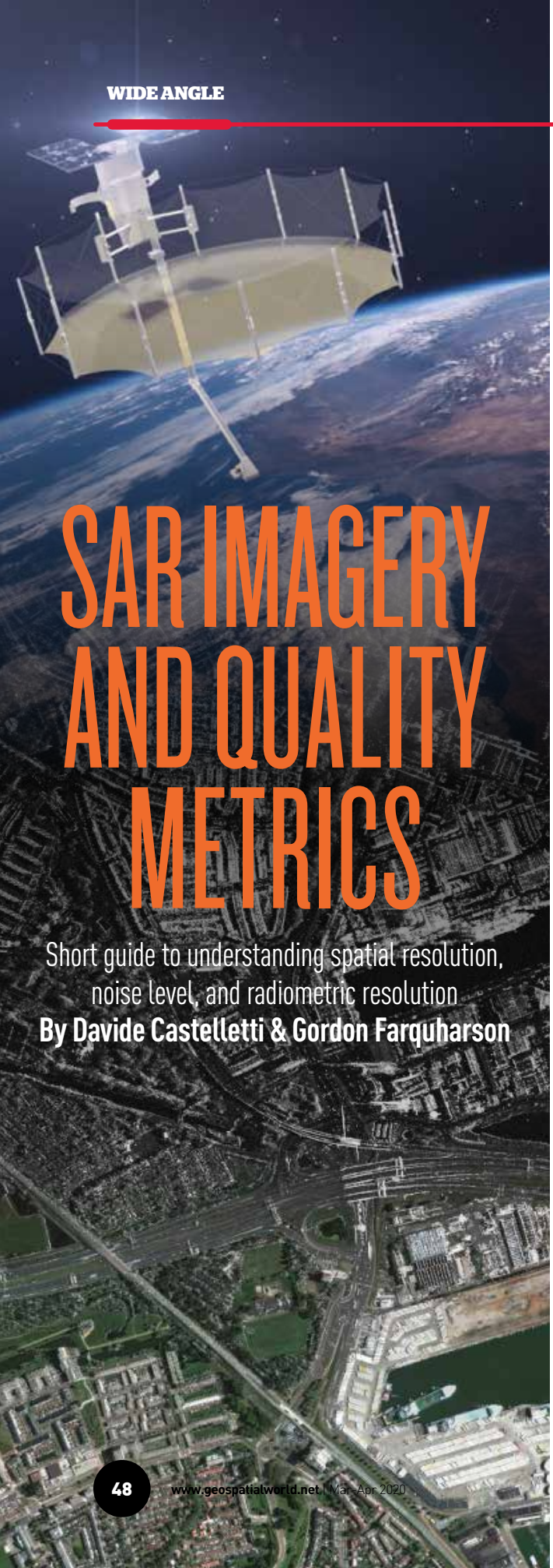
The critical part in rural electrification was to assess the existing conditions of assets and to determine the requirement of new assets. Unlike in other construction, where engineering design usually happens at office location and construction/erection happens at site location, this utility power project demanded engineering design of the poles at the site locations. By examining the condition of the geography, material used to erect the poles were designed both qualitatively and quantitatively at site location itself. LMNoP+ digitalized the entire field operations with higher accuracy, leading to more than 70% time saving.

Performance enhancer

The overall performance of LMNoP+ is enhanced by the integration with Trimble Catalyst, which gives centimetre level positional accuracy. This enables to precisely locate and map engineering information of the utility assets that has to be installed in the field. The distance between each collected point is automatically measured and updated in the web portal accurately.

Trimble Catalyst helps in capturing the utility asset's exact locations, the GIS capability creates points and feature attributes in the geodatabase in real time. Surveyors on site are guided by step-wise procedure with the help of predefined forms in the mobile app. The details entered in the mobile app are submitted and synchronized to the web portal seamlessly. For better visualization, the captured data is overlaid on a base map with all GIS mapping functionalities. This enables the generation of Bill of Quantities (BoQ) accurately for the quantity of materials irrespective of any existing/proposed asset. Precise BoQ helps in the reduction of material wastage and saves cost.

Courtesy: Trimble



SAR IMAGERY AND QUALITY METRICS

Short guide to understanding spatial resolution, noise level, and radiometric resolution

By Davide Castelletti & Gordon Farquharson

The number and variety of applications that exploit Synthetic Aperture Radar (SAR) data are growing. These applications include environmental monitoring, surveillance, emergency response, infrastructure monitoring, urban planning, and food security. With the growing demand for SAR images, the community of SAR users is also transforming. Radar images are now processed by GIS users, software developers, and computer vision and machine learning engineers, and are increasingly interpreted by non-radar specialists.

In this article, we describe key characteristics of SAR imagery, with the goal of providing a short guide to understanding SAR products. We present the aspects of spatial resolution that are particular to SAR, and cover concepts such as noise level and radiometric resolution that are related to radar design and image formation. We will see that resolution is not the only parameter one should consider when evaluating SAR image quality, but instead that a set of different parameters should be assessed collectively to select the best data for each specific application.

SAR acquisition geometry

In contrast to optical imagers, synthetic aperture radar systems only acquire imagery from the side of the scene **(Figure 1).**[1] A SAR image is formed from data collected by a coherent radar that transmits pulses of radio frequency energy toward the ground and measures the strength of the reflected signal as a function of distance ("time of flight") from the radar. In addition, the platform carries the SAR antenna along a track, and by this action, the ground is "scanned" in two dimensions. In the ranging ("range") dimension, objects are placed according to their distance from the radar. The second dimension is the "along-track" (or "cross-range" or "azimuth") dimension. In this dimension, the ground is scanned by the beam moving across the ground at a rate equal to the speed of the platform, and objects are placed in this dimension according to their position along the track. An image is built up from the reflected signals in both dimensions. As a result of this acquisition methodology, the resolution of a SAR image has two components: a range resolution and an azimuth resolution.

Spatial resolution: range and azimuth resolution

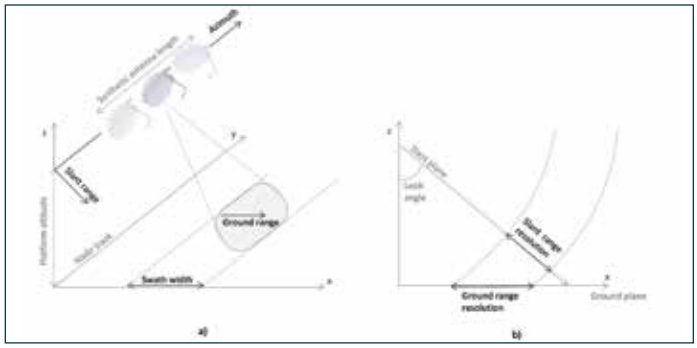


Figure 1: (a) SAR acquisition geometry and (b) mapping from slant plane to ground plane.

1 *Note that for simplicity, we will restrict this discussion to side-looking SAR systems, and not deal with squinted-SAR systems in this post.*

As outlined above, a SAR image has two dimensions, range and azimuth. The resolution in these dimensions is achieved using different aspects of the signal recorded by the radar, and as a result, the resolution in the range direction can (and most often is) different to that in the azimuth direction.[2]

The spatial resolution of SAR data is defined by the impulse response (IPR). The IPR of a SAR system is the response of the sensor and processing to a theorectical spatial impulse target, i.e., a target that is infinitesimally small in all dimensions.[3] IPR is a two-dimensional entity that is characterized by the range-dimension width (the width of the IPR in the ranging dimension) and the cross-range (or azimuth) dimension width. The generally-accepted definition of radar resolution is the width of the IPR at points at 3 dB below the peak of the IPR. In the range dimension, a larger transmitted bandwidth corresponds to improved range resolution. In the cross-range dimension, a larger Doppler bandwidth corresponds to better azimuth resolution. IPR is also affected by the processing used to form the image, e.g., windowing, and distortions in the signals due to hardware limitations or uncompensated platform motion.

Unless specified, IPR, and thus inherent SAR sensor resolution, is defined in the slant-range plane. When the SAR image is translated to the ground plane, the mapping from slant range to ground range causes the IPR to broaden **(Figure 1b)**. Therefore, the IPR-defined range resolution in the ground plane is always worse than that in the slant plane. Resolution in the cross-range direction does not change in the slant plane to ground plane mapping.[4]

The ground-range resolution (resolution in the ranging direction in the ground plane) depends on the bandwidth of the transmitted signal and the angle from which the ground is imaged (look angle[5]). Larger bandwidth enables a better range resolution. For instance, the theoretical resolution with a 300 MHz bandwidth is 0.5 m in the slant plane and 0.91 m in the ground plane at a look angle of 30 degrees. With a bandwidth of 500 MHz, the slant range resolution is 0.3 m and the ground-range resolution is 0.55 m for the same look angle.

As mentioned, the azimuth resolution depends on the Doppler bandwidth. A larger Doppler bandwidth can be obtained by pointing the antenna beam at a target for a longer time. Many existing SAR satellites use phased array antennas to steer the beam to dwell on objects. As these phased array antennas are designed to scan over a few degrees, the azimuth resolution achieved is on the order of tens of centimeters.

Capella SAR satellites have a transmitter bandwidth of 500 MHz, so can achieve 0.3 m resolution in the slant plane. The satellites have also been designed to point to a spot on the ground for tens of seconds, thereby achieving centimeter-scale azimuth resolution. This fine resolution is used to reduce speckle in the images (see section below) and provide high-quality multi-looked SAR imagery. An example of high-resolution multi-looked Capella imagery is shown in **Figure 2.**

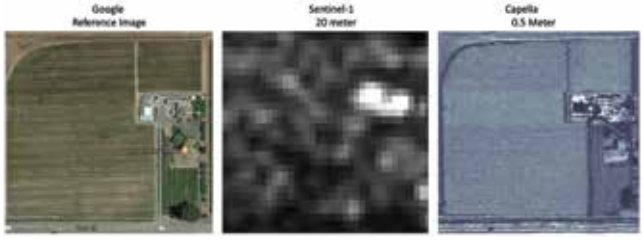


Figure 2: Optical (left), Sentinel-1 (middle), and Capella (right) images of a farm in California. The Sentinel-1 image has a resolution of 20 m. The Capella aerial image has been processed to 0.5 m ground-range resolution and 0.5 m azimuth resolution.

Noise level and image quality

In addition to spatial resolution, other metrics are important in overall interpretability of a SAR image. The radar measures the intensity of the reflected signal at each resolution cell in the image. The intensity depends on the transmitted power, antenna gain, distance between the scatterer and the radar, and geometry, roughness, and material properties of the object being imaged. For interpreting intensity in a radar image, two features are important: the ability to make out objects against the inherent noise generated by the sensor, and the ability to discriminate two objects that have similar intensities. The first is captured by the noise equivalent sigma zero (NESZ) of a SAR image. The second is captured by the concept of radiometric resolution.[6]

A target is detectable in a SAR image when, for a certain pixel resolution, the received power and therefore the intensity at the pixel level overcomes the thermal noise that the system electronics generate. In SAR, NESZ is the most commonly used metric that captures the effect of system noise on image quality. It can be analytically predicted during the design of the radar and can be empirically measured over "dark" targets in the SAR image. For instance, calm lakes are highly reflective targets in the side-looking geometry and allow the characterization of the noise level of the sensor.

The effect of NESZ on image interpretability is demonstrated with the images in **Figure 3**. The SAR data were processed to 0.5 m ground range resolution and 0.5 m azimuth resolution. In both cases, bright scatterers, e.g., buildings, are clearly detectable. The difference between the two is the NESZ (–10 dB versus –20 dB). The aircraft and the roads are far more discernible in the image that has an NESZ of –20 dB. In particular, the aircraft shadows are much clearer in the –20 dB NESZ image. This shows that lower NESZ values are preferable when targets with low-backscattering intensity need to be detected.

NESZ varies also with transmitted bandwidth (range resolution). A SAR image generated with a 300 MHz transmitted bandwidth (0.5 m

2 *For more details of SAR processing, please see A. Moreira, P. Prats-Iraola, M. Younis, G. Krieger, I. Hajnsek and K. P. Papathanassiou, "A tutorial on synthetic aperture radar," in IEEE Geoscience and Remote Sensing Magazine, vol. 1, no. 1, pp. 6-43, March 2013.*

3 *"Anatomy of a SAR Impulse Response" from Sandia National Laboratories.*

4 *Note that for squinted SAR, things are a little different, because the ranging and cross-ranging directions are not orthogonal to one another.*

5 *For spaceborne systems, the difference between look angle and incidence angle matters because of the curvature of the earth.*

6 *https://www.sciencedirect.com/topics/earth-and-planetary-sciences/radiometric-resolution.*

slant-range resolution) will have more noise than one generated with 150 MHz (1 m slant-range resolution). A wider bandwidth enables better resolution, but causes more noise in imagery (higher NESZ).

Speckle, radiometric resolution, and target detection & identification

Speckle is caused by the reflection of the radar signal from multiple objects (scatterers) that are distributed within a resolution cell. The branches and leaves of a tree, grass and rocks in a field, and bricks that make up the walls of a building are examples of objects that have distributed scatterers. The sum of the contribution from all the scatterers results in variation in the intensity of the measured signal in adjacent resolution cells. This variability in image intensity, called speckle, limits the radiometric resolution of a SAR sensor.

Speckle in images looks like the snowy noise found on old analog television sets. Speckle makes it harder to distinguish features in SAR images because it corrupts the outline of objects. Radiometric resolution is a metric that describes the ability of a sensor to discriminate between two objects that have similar radar cross sections (i.e., that are radiometrically similar). Radiometric resolution depends on the measured signal to noise ratio and the number of independent looks from which the pixel was formed. Overcoming speckle and improving radiometric resolution is only possible by averaging multiple SAR images or averaging pixels in a SAR image. This averaging process is commonly referred to as "multi-looking".

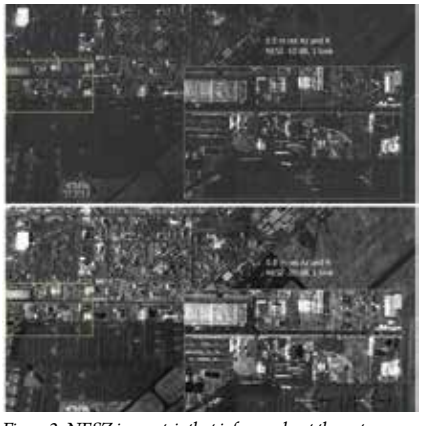


Figure 3: NESZ is a metric that informs about the system noise level in a SAR image. NESZ is usually provided as a log-scale quantity in dB, and more negative values indicate better image quality. For SAR users, the required NESZ depends on the application. Hard target detection and vegetation analysis have very different NESZ and resolution requirements.

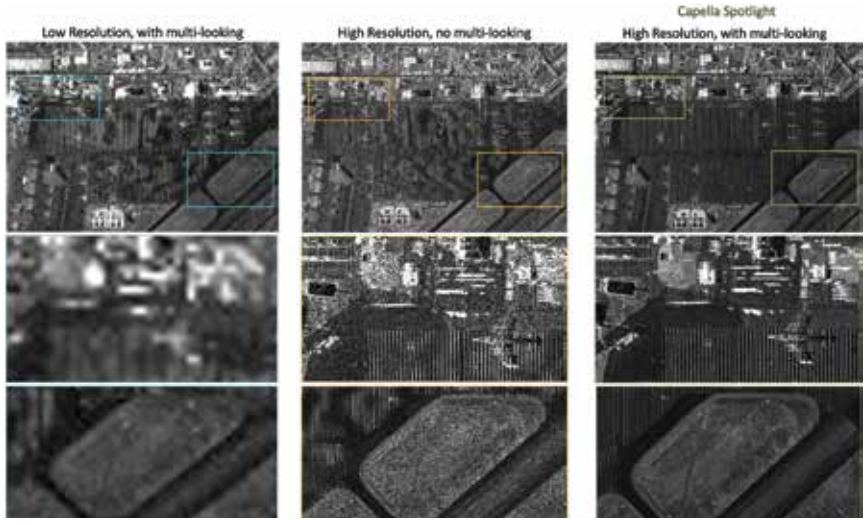


Figure 4: Low-resolution multi-looked image (left column), high-resolution single-look image (middle column), and high-resolution multi-looked image (right column). These images highlight that both resolution and speckle affect interpretation of the image.

Multi-looking in single SAR images is most typically done by averaging adjacent pixels. Sometimes this averaging is achieved using sophisticated techniques, but the result is always a loss of resolution compared to the original image. For example, a 4-look 1 m (slant range resolution) × 1 m (azimuth resolution) spotlight image could be created from a SAR acquisition that has a slant range-resolution of 1 m and an azimuth resolution of 0.25 m, by averaging 4 adjacent 0.25 m resolution cells to form a 1 m cell in the azimuth direction.

Multi-looking is a common pre-processing step for SAR users interested in change detection or in target detection or classification. We demonstrate the image quality improvement using multi-looking with Capella data. The images in the left column of **Figure 4** are from a low-resolution SAR imaging mode that has been multi-looked to reduce speckle and improve radiometric resolution. The boxed sections of the image have been reproduced below to show that the loss of spatial resolution significantly hinders identification of objects in the scene. The images in the middle column are single-look 0.5 m resolution images (both azimuth and ground range) where the speckle in the image hinders the identification of small targets. The image in the third column is a multi-looked 0.5 m resolution image. The shadow of the aircraft is significantly improved, and the features on the grassy areas are clearly visible.

Conclusion

In SAR, a few key metrics define the performance of the system. First, and not surprisingly, resolution is an important measure. Sub-meter resolution is considered a "must have", but as demonstrated in this article, image interpretation is a function of spatial resolution, NESZ, speckle, and radiometric resolution. Low-NESZ imagery is desirable because objects that scatter radar signals weakly are visible in low-NESZ SAR images, but high resolution and low NESZ are not the only factors that influence interpretation and detection in SAR images. Speckle makes it harder to distinguish features in SAR images because it reduces the contrast between objects. Thus, the interpretability of SAR images is determined by a complex mix of resolution, NESZ, and multi-looking. These factors are critical but are often overlooked in common discourse surrounding SAR. Novice and expert SAR users should consider all of these parameters when selecting SAR imagery for their application.

Davide Castelletti, SAR Technical Product Manager; **Gordon Farquharson**, Director of Radar Technologies, Capella Space

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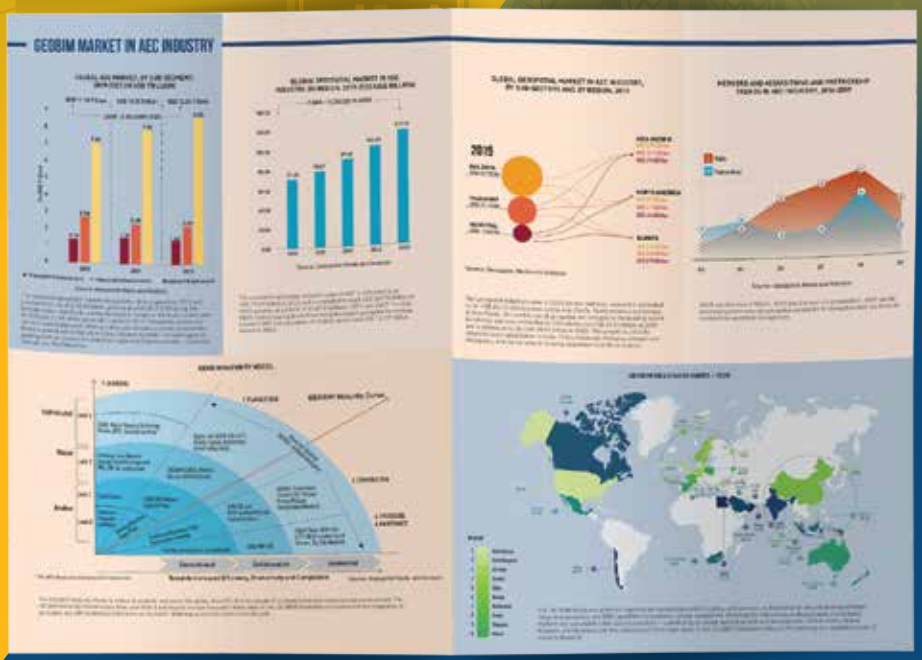

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