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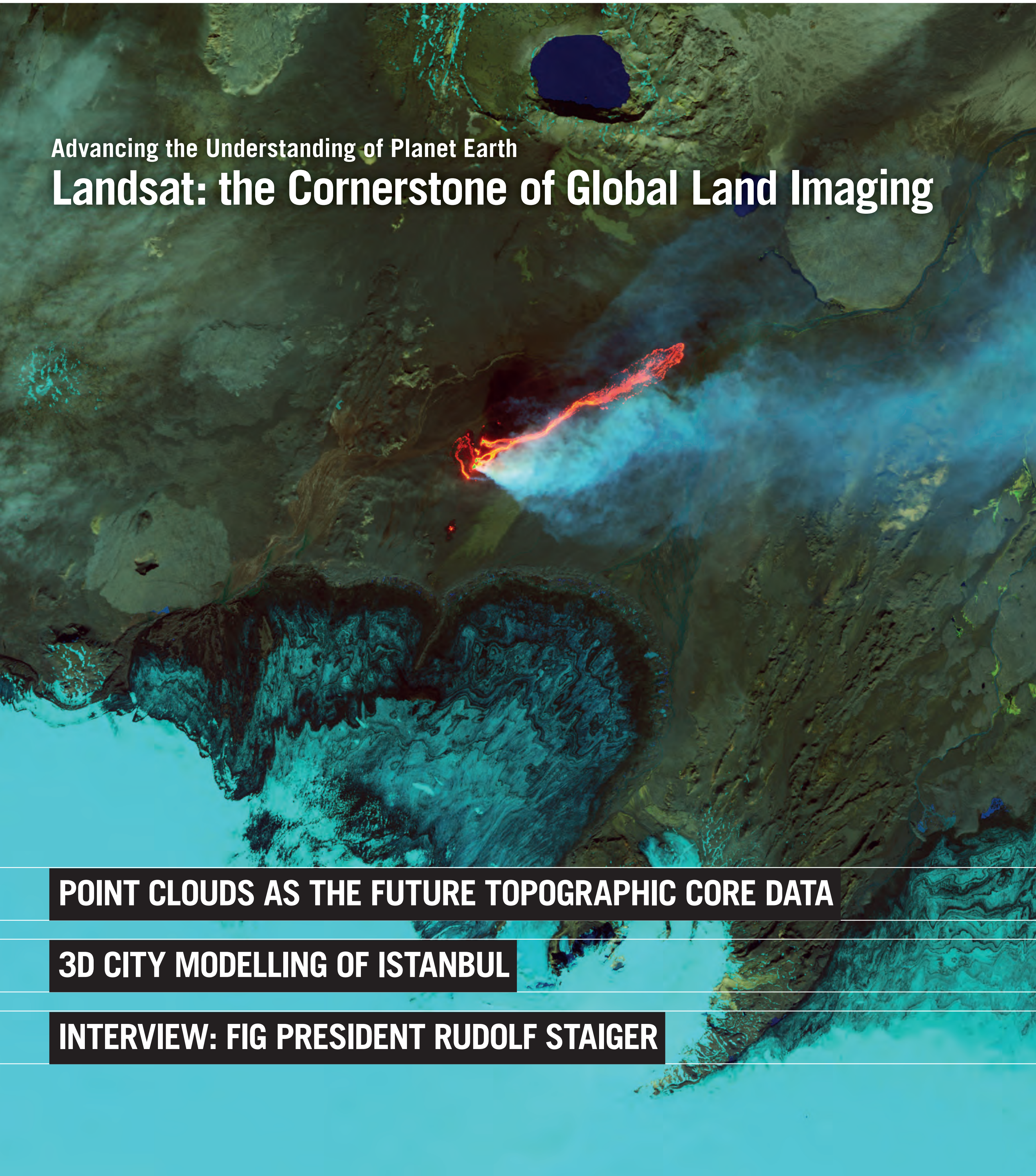

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Geomares
P.O. Box 112, 8530 AC Lemmer,
The Netherlands
T: +31 (0) 514-56 18 54
F: +31 (0) 514-56 38 98
gim-international@geomares.nl
www.gim-international.com

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COVER STORY

On 6 September 2014, the Operational Land Imager (OLI) on Landsat 8 captured this view of the Holuhraun lava field (between the Bárðarbunga and Askja volcanoes) in Iceland during an eruption. The false-colour images combine shortwave-infrared, near-infrared and green light (OLI bands 6-5-3). (Courtesy: NASA Earth Observatory)

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New Era

The members of the International Federation of Surveyors (FIG), the world's largest professional organization for the surveying profession, elected Rudolf Staiger from Germany as their new president last year in Istanbul during the four-yearly congress. Staiger took official office after a handover ceremony in Athens, where he succeeded Chryssy Potsiou who had headed up FIG for the past four years. A new FIG president always marks the start of a new era. It can undoubtedly be one of the industry's most influential positions, guiding the course of the surveying world when handled with the appropriate level of diplomacy. Rudolf Staiger, who has been active within FIG since the late 1990s, has worked both in the private sector and the academic world and is therefore ideally equipped for the job. For this edition of *GIM International*, we've interviewed Rudolf Staiger and asked him about the vision for his term. It is encouraging to hear that FIG's first priority for the profession is to deliver precise and up-to-date data as the basis for measuring the progress towards achieving the Sustainable Development Goals (SDGs). Staiger says: "The 17 SDGs as set by the United Nations are important milestones on the way to a better world in order to improve the living conditions for everybody. As a professional organization, FIG will support the accomplishment of these goals without restrictions." It is also good to hear that the new president sees a big role for younger surveyors and would like to see them climb the 'ranks' of FIG and other organizations during his term. To secure a flow of future talent into the industry, he also wants to make sure that young people in schools are made aware of the relevance and societal benefit of the surveying and geospatial profession. Read more about his views and insights on page 12 of this issue of *GIM International*. I would like to take this opportunity, at the start of Rudolf Staiger's term as president of FIG, to wish him wisdom and enduring success in carrying out this important task of serving the geospatial community!

Durk Haarsma, director strategy & business development
durk.haarsma@geomares.nl

Celebrating the Extraterrestrial Perspective

This year marks 50 years since man first set foot on the moon. The Apollo-11 spaceflight landed on the moon on 20 July 1969, and just a few hours later Neil Armstrong and Buzz Aldrin were the first two humans to step onto the lunar surface. The breathtaking photos of our planet taken from the moon – also the famous Earthrise photograph taken in December 1968 during the Apollo 8 mission – have since become some of the most iconic pictures ever. However, these were not the first images of Earth captured from space; the first satellite photographs of Earth were taken on by the U.S. Explorer 6 in August 1959. To be honest those images didn't give us much information. For example, the first image showed only a sunny area of the Central Pacific Ocean and its cloud cover. Now, 60 years later, it's impossible to imagine life without satellite imagery.

The evolution and rise of satellite technology has brought us an extra dimension. Satellite imagery is available everywhere nowadays, not least thanks to Google Earth – launched in 2001 – which renders a 3D representation of our planet built on satellite imagery. It combines satellite images, aerial photography and GIS data to create a 3D globe, including photorealistic 3D imagery of hundreds of cities all over the world. Google Earth uses digital elevation model data acquired by NASA's Shuttle Radar Topography Mission.

Generation Y (also known as the 'millennials') and especially generation Z – the 'digital natives' – take satellite imagery and its many applications for granted. But it is all the result of endless trial and error, a lot of pioneering work, continuous innovation and the unmeasurable brain capacity of some of the smartest scientists in the world. Satellite imaginary has made an immense impact on many aspects of life, ranging from cartography, hydrology and meteorology to agriculture, geology and intelligence. It has enriched society with countless new solutions to improve our daily lives – and it will be a key tool to overcome some of the most urgent problems currently faced by our planet.

Sometimes the methods for tackling these problems are surprisingly less complicated than one would expect. A striking example of this is the Farmer-managed natural regeneration (FMNR) technique used in Niger and some of its neighbouring countries. In the Sahel, a gigantic region in northern Africa that comprises a belt of over 1,000km from north to south and 5,500km from the Atlantic Ocean to the Indian Ocean, desertification is a major issue. 12 years ago, satellite images were key in Chris Reij, a Dutch sustainable agriculture expert at the World Resources Institute, ascertaining the extent of the greening phenomenon known as FMNR: 250 million trees across six million hectares. FMNR proved to be a way more successful method than the prestigious – and expensive – Great Green Wall, the flagship initiative to combat the effects of climate change and desertification in North Africa.

The satellite industry is a high-cost industry, but it also generates solutions that save money and make the world a better place. The natural regeneration project in Niger is an example that gives new hope and inspiration for a sustainable future – not only for the generations Y and Z, but also for their descendants.

Wim van Wegen, content manager
wim.van.wegen@geomares.nl

Space Power

The first permanent Earth observation (EO) satellite, initially called Earth Resources Technology Satellite 1 but today better known as Landsat 1, was launched in July 1972 by the National Aeronautics and Space Administration (NASA), USA. With a ground sampling distance (GSD) of 79 metres, the images captured by the Landsat Multispectral Scanner provided an astonishingly comprehensive and panoramic view of areas never before mapped. That is to say, astonishingly for that particular space era. But technology is evolving all the time... or perhaps I should rephrase that. After all, technology is not an independent being with a will of its own, but a product. Technology has no marital status, address or phone number. Technology is the result of the ingenuity and toil of a particular subgroup of mankind, often condescendingly referred to as 'techies' or 'nerds'. Why are the bearers of technology belittled in this way? Without them, mankind would suffer and ultimately starve.

Launched in August 2014, WorldView-3 – also made in the USA – has a nadir GSD of 31cm in the panchromatic band. This means that the GSD of spaceborne EO sensors has increased by a factor of more than 260 over a time span of 42 years. In other words, the area covered by one pixel in 1972 is covered by nearly 70,000 pixels today, a laudable year-on-year increase of 30% on average. This figure indicates a doubling of pixels per unit of area every two and a half years. In 1986, France joined the USA in space by putting the SPOT satellite into orbit, marking Europe's appearance on the space stage. The first of the Pléiades twins (identical satellites) was put into orbit in December 2011, and the second almost exactly a year later in December 2012. With a GSD of 50cm and a swath width of 20km, these two EO satellites challenged the WorldView family with respect to spatial resolution. But Europe is not intent on keeping its technology to itself. Airbus Defence and Space – successor of the European Aeronautic Defence and Space Company in January 2014 – built an EO satellite for Kazakhstan with a GSD of 1m. Launched on 30 April 2014, the KazEOSat-1 captures 220,000km² daily and can revisit any area in Kazakhstan within three days. On 20 June 2014 the satellite was joined by the KazEOSat-2 with a GSD of 6.5m, aimed at agricultural and resource monitoring, disaster management and land use mapping.

Kazakhstan's neighbouring country and former fellow member of the Soviet Union, Russia, permanently challenges the space power of USA and Europe by operating and gradually extending the Resurs-P family of EO satellites; Resurs-P 1 was launched in 2013, Resurs-P 2 in 2014 and Resurs-P 3, of which one of the solar panels failed to deploy, in 2016. These siblings have a GSD of 1m and a swath width of 38km. With the launches of the Resurs-P family, Russia joined USA and Europe in operating very-high-resolution (VHR) EO space stations, i.e. with a GSD of 1m or better.

Mathias Lemmens.

China is rapidly emerging as another nation which observes the Earth from space. The country is blasting EO satellites into space from the Gobi desert with such frequency that it could well usurp the USA as the leading space power before long. China launched 22 EO satellites in 2016 alone, and that annual figure increased to 40 in 2018. One of the satellites is equipped with a sensor which takes 20 frames per second with a GSD of 90cm and a swath width of 22.5km, which now qualifies China as a nation operating VHR EO satellites.

Today, over 30 nations have hundreds of 'eyes' in space. With respect to spatial resolution, Europe and the USA still take the lead. Obviously, these developed nations are not hampered by the law of the handicap of a head start – at least, not for the time being. In the meantime, nearly 50 years have passed since the undisputed dominant nation of the planet drastically changed our view of the Earth: from a hostile, injurious environment which should be tamed, to a tiny, vulnerable celestial body floating in the universe together with millions of others – a body which needs protection against human exploitation and malicious depletion. This feeling is aptly captured in one all-encompassing term: climate change. Meanwhile, space power is gradually being distributed more fairly among the nations of the world.

Mark Reichardt Honoured with Special Edition of OGC Gardels Award

At the December 2018 meeting of the Open Geospatial Consortium (OGC) Technical Committee in Fort Collins, Colorado, USA, OGC's outgoing president and CEO, Mark Reichardt, was awarded a special edition of OGC's prestigious Kenneth D. Gardels Award. The award is presented each year to an individual who has made an outstanding contribution to advancing OGC's vision of fully integrating geospatial information into the world's information systems. This special edition of the award, the second Gardels Award to be handed out in 2018, was given to Reichardt by the OGC Board of Directors in recognition of his years of leadership, commitment, passion and dedication to the advancement of interoperability and open OGC standards.

▸ **https://bit.ly/2VDEOSz**

Klau Geomatics Launches PPK Software for Phantom4 RTK UAV

Klau PPK processing software.

Klau Geomatics, specialized in PPK hardware and post-processing software, recently announced its new PPK software for the DJI Phantom4 RTK (P4RTK) unmanned aerial vehicle (UAV or 'drone'). The software enables professional users to achieve the most accurate and reliable results with their P4RTK drone without running it in RTK mode. RTK requires continuous communication between the drone and base station, limiting the operational range and data quality. PPK does not require any real-time connection to the base. Not only does this method save users the time and trouble of setting up a base station, but the data collected is also complete, with no losses due to communications links. Furthermore, as it is post-processed, the solution is more rigorous than a real-time RTK result with added efficiency, reliability and accuracy.

▸ **https://bit.ly/2FhOjUq**


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Australian Construction Industry Trials New Global Positioning Technology

The Personal Proximity Detection System uses SBAS to send a worker's location to the Collision Avoidance System on an excavator.

Construction is the latest of ten industry sectors to see significant improvements through increased safety and also greater productivity from a trial of advanced satellite-based positioning. On behalf of Geoscience Australia, the University of New South Wales and Position Partners recently completed the trial of a satellite-based augmentation system (SBAS) on construction sites in New South Wales and Victoria. Professor Chris Rizos from the University of NSW said the trial of positioning technologies that provide an accuracy of 10cm has received encouraging feedback from the five companies involved. "This was the first time the new-generation positioning technology has been used in construction and we expect uptake to really take off once the test-phase is complete," Professor Rizos said. "The technology used is a lot like that worn by sports stars on the field – it's worn on workers' hard hats or armbands and also put on the machinery. This information is then fed to the machine and a control room, where an alarm goes off if machinery like excavators or even people are too close to proximity sensors at geofenced exclusion areas. Likewise, it can tell you when a person is too close to machinery. We trialled this at a busy construction site in Melbourne and found the high accuracy of the information being relayed really helped to improve productivity," Rizos continued.

▸ **https://bit.ly/2QvJURJ**

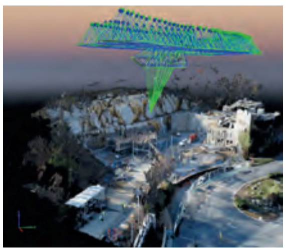
Satellite Monitoring Reveals Slow Flow Thinning for Glaciers in Asia

Picture taken from the Mera glacier in Nepal.

Providing water for drinking, irrigation and power, glaciers in the world's highest mountains are a lifeline for more than a billion people. As climate change takes a grip and glaciers lose mass, one might think that – lubricated by more meltwater – they flow more quickly. However, satellite images from over the last 30 years show that it isn't as simple as that. A paper published recently in *Nature Geoscience* describes how a multitude of satellite images reveal that there has actually been a slowdown in the rate at which glaciers slide down the high mountains of Asia. High-mountain Asia stretches from the Tien Shan and Hindu Kush in the northwest, to the eastern Himalayas in the southeast. The area is also part of what is known as 'the third pole' because these high-altitude ice fields contain the largest reserve of freshwater outside the polar regions. As the source of the ten major river systems, the third pole provides freshwater for over 1.3 billion people in Asia – nearly 20% of the world's population.

▸ **https://bit.ly/2FgmIRs**

What Surveyors Value Most about Their Geodata Acquisition Method



The UAV photogrammetry market continues to grow.

There are numerous software solutions available on the market for the photogrammetric processing of digital images and to generate 3D spatial data. Geoprofessionals can use the photogrammetric software to create orthomosaics, point clouds and models. Some photogrammetric software solutions are suitable for large-format images from aerial cameras and satellite processing, while others are especially developed for small and medium-format digital images acquired by unmanned aerial vehicles (UAVs or 'drones'). The Pix4D and Agisoft PhotoScan software solutions are currently out in front, but many geospatial professionals also mentioned Inpho (Trimble), ContextCapture (Bentley), DroneDeploy, Photomod (Racurs), Correlator3D (SimActive) and SURE (nFrames) as their software of choice in a recent survey conducted by *GIM International* among mapping and surveying professionals.

▸ **https://bit.ly/2C9iLKv**

NavVis Secures Million-dollar Funding for Indoor Mapping

The founding team of NavVis.

NavVis, a leading global provider of indoor spatial intelligence solutions, has announced that it has closed a new funding round, raising a total of US$35.5 million. The Series C funding round was led by Digital+ Partners, with additional participation from new investor Kozo Keikaku Engineering (KKE) and existing investors MIG, Target Partners and BayBG. The new funds will be used to accelerate NavVis' growth in the global enterprise market, where demand for indoor spatial intelligence solutions is being driven by the rapid adoption of digital twin technology. Digital twin technology is being used by an increasing number of enterprises to monitor and control assets and processes using a virtual representation of physical spaces. Gartner predicts that by 2021, half of all large industrial companies will use digital twins, resulting in those organizations gaining a significant 10% improvement in effectiveness. This rapid pace of adoption in the very near term has the digital twin market projected to be worth U$15.66 billion by 2023.

▸ **https://bit.ly/2RjppZ8**

Aerial Photomaps Reveal Secrets to Improving Farm Management

Aerial photography and AI offer many benefits for farmers.

Ultra-high-resolution aerial photography and 3D landscape models from Bluesky are helping Outfield Technologies to develop innovative image recognition techniques to improve agricultural land management and crop production. In addition to this pioneering research project, the Bluesky data is also providing estate managers with up-to-date and accurate mapping for subsidy applications, planning proposals and corroboration of existing data and reports. Supported by the Eastern Agri-Tech Growth Initiative, with funding from the UK government's Local Growth Fund, Outfield commissioned Bluesky to capture 7,000 hectares of 5cm-resolution photography. Covering farmed land, environmental focus areas and woodland on a large estate in East Anglia, the detailed record of land usage and crop types, for example, is helping with the development of machine learning algorithms to accurately identify features across different datasets and landscapes.

▸ **https://bit.ly/2SFoKxH**

Galileo Satellites Prove Einstein's Relativity Theory to Highest Accuracy Yet

Europe's Galileo navigation system.

Europe's Galileo satellite navigation system – which is already serving users globally – has now provided a historic service to the physics community worldwide. It has enabled the most accurate measurement ever made of how shifts in gravity alter the passing of time, a key element of Einstein's Theory of General Relativity. Two European fundamental physics teams working in parallel have independently achieved about a fivefold improvement in measuring accuracy of the gravity-driven time dilation effect known as 'gravitational redshift'. The prestigious *Physical Review Letters* journal has recently published the independent results obtained from both consortiums, gathered from more than a thousand days of data obtained from the pair of Galileo satellites in elongated orbits. "It is hugely satisfying for ESA to see that our original expectation that such results might be theoretically possible has now been borne out in practical terms, providing the first reported improvement of the gravitational redshift test for more than 40 years," comments Javier Ventura-Traveset, head of ESA's Galileo Navigation Science Office.

▸ **https://bit.ly/2FoluIB**

The Economic Value of Spatially Enabled Services in Finland

Helsinki, Finland.

Spatineo has conducted a meta-study on the economic value of spatially enabled services in Finland and the impact of the soon-to-be-finished national geospatial platform on that value. This study is a meta-analysis of international and Finnish studies in which the economic impacts of the use of spatial data have been analysed. It introduces results from international studies as well as their application to Finnish conditions. Only about 22% of the annual potential economic benefits from the use of spatial data have been realized in Finland – approximately €3 billion of the potential €13 billion in annual economic benefits. The estimated value of the direct economic benefits of the Geospatial Platform is about €150 million and the indirect benefits amount to approximately €400 million, totalling €550 million per annum starting in 2025 when the services of the platform are fully operational.

▸ **https://bit.ly/2CZO4uE**

Terra Drone Acquires Dutch Aerial Survey Company Skeye

Terra Drone, an unmanned aerial vehicle (UAV or 'drone') technology company headquartered in Japan, has acquired a majority stake in the European drone service provider Skeye, based in The Netherlands. Skeye will become the European headquarters of Terra Drone. This acquisition makes Terra Drone one of the world's leading drone service companies, with more than 250 employees and a presence on all continents. Terra Drone aims to serve its clients with safer, better and more efficient surveys and inspections by using and developing innovative technologies in the field of UAVs. Skeye is an aerial survey and inspection company with a focus on drones in the oil and gas market. It has its headquarters in The Netherlands, and offices in the United Kingdom and Belgium.

▸ https://bit.ly/2SJliBb

Skeye has vast experience in inspection and 3D surveys.

Registration Opens for YellowScan LiDAR for Drone 2019 Conference

YellowScan will be hosting its third user conference called 'LiDAR for Drone' from 19-21 March 2019 at the Domaine de Verchant near Montpellier, France. This event is an excellent opportunity to discuss the latest developments of UAV Lidar technologies, share experiences and meet peers that use Lidar. Attendees will gain insight into the Lidar industry, hear from interesting and innovative users of Lidar and be part of this great ecosystem.

▸ https://bit.ly/2Q0naYN

GIM INTERNATIONAL INTERVIEWS FIG PRESIDENT RUDOLF STAIGER

Supporting the Profession with Expertise, Proposals, Solutions and Platforms

The FIG president holds one of the most influential positions in the surveying field and helps to shape the profession. The new president, Rudolf Staiger, was elected during the Istanbul Congress in 2018 and officially took office for a period of four years in November. In this interview, *GIM International* asks him about his views on the profession, now and in the future, and also about who Rudolf Staiger actually is.

Congratulations on becoming the new president of FIG! Can you tell us a bit more about yourself?

Having grown up in the Black Forest in south Germany, I studied geodesy at the University of Karlsruhe, after which I spent a year in Paris, France, also studying geodesy, at the National Geographical Institute (IGN). After that I worked for a few years in the private sector, including at Wild, which was later taken over by Leica Geosystems and is now part of Hexagon. I then returned to the academic world, working as a researcher at the University of Essen and later Bochum. In Bochum I became vice-president of the university, responsible for research & transfer. I've always enjoyed sports; I used to swim, play volleyball and cycle, and nowadays I love going hiking and skiing – but unfortunately not as often as I would like.

Which positions have you previously held within FIG?

I have been active in FIG for 20 years. The first FIG event I attended was a Regional Conference in Malta organized by FIG Commission 5 back in 2000. I later became Chair of Commission 5 – Positioning and Measurement, and was appointed as chief editor for the peer-review process for the FIG Congress in Sydney in 2010. During that

Rudolf Staiger surrounded by representatives of the DVW, the German Society for Geodesy, Geoinformation and Land Management.

congress I was elected as vice-president for the 2011 to 2014 term, and in 2014 I was re-elected for a second period (2015-2018), before getting elected to become president last year in Istanbul.

What are your main fields of interest within the university?
My main interests are close-range metrology, laser scanning and optical 3D coordinate measurement devices in general. More specifically, I'm interested in instrumentation and calibration as well as testing and checking procedures of surveying equipment.

How does that fit with your work for FIG?
During my time as commission officer, the work I did at the university was closely connected to my work within FIG. Now, as president, I need to have an overall perspective on FIG and the many and varied fields that surveyors are covering. There is still a link to my current work, but I've already discovered that my time as university vice-president was good preparation and valuable experience for my FIG presidency.

The profession is in transition. Which new challenges and opportunities is the digital transformation creating for surveyors?
We are currently facing a general and global transition. I see various challenges, such as the rapid pace of technological change and the transformation of our markets and products into becoming more open and less restricted. At the same time that presents an opportunity, because geospatial products are used by everybody – think of Google Maps or navigation for self-driving cars. Geospatial products are seen as part of a beneficial and necessary infrastructure for the development and well-being of our society, so our products have shifted from being 'invisible' or 'classified' to being an essential and important element of our future digital society. Today, one of the major challenges for surveyors is to show clearly why their professional knowledge is needed to secure and interpret data and optimize the use of the available technologies.

Another key challenge for the surveying profession is to attract new students to geomatics. What is the right strategy, in your opinion?
The answer to a young person's question 'What am I going to study?' is obviously heavily influenced by the image that they have of the various professions. But how and where is this image created? It is strongly influenced by TV, social media and – most importantly – in school. We should therefore go into schools and present the surveying and geospatial profession, because a lot of school pupils have no idea about our tasks, tools and the way we work. We need to show them current opportunities in our profession and at the same time highlight how interesting and beneficial it can be – also for society as a whole – to work in this industry.

The acceleration of urbanization worldwide is placing high demands on spatial planning. What is the surveying community's role?
First of all we have to deliver all the geographic material and data in maps, 3D models and so on which are necessary for the planning, construction and maintenance of our urbanized world. Spatial planning based on those products is also an important part of our profession. In this respect, our planning specialists should bring in their expertise and ideas, because the catalogue of demands is quite complex: we want to create a future society with improved living conditions, also taking account of aspects like climate change, sea-level rise, limited energy resources and affordable housing. Former FIG president Professor Holger Magel gave a very inspiring speech at the FIG handover meeting in Athens last November. A key point in his message was that if we want to slow down the pace of urbanization, we have to make rural areas more attractive. He underlined his approach using several examples from his home region of Bavaria.

▲ *Rudolf Staiger.*

IF WE WANT TO SLOW DOWN THE PACE OF URBANIZATION, WE HAVE TO MAKE RURAL AREAS MORE ATTRACTIVE

In 2015 the 17 Sustainable Development Goals (SDGs) were set by the United Nations General Assembly. How would you define the role of geospatial information in accomplishing these goals?
If you want to 'measure' the 17 SDGs and their degree of fulfilment, it is obvious that more than 70% of the goals are directly related to geospatial data. So the first priority for our profession is to deliver precise and up-to-date data enabling SDG-related performance to be measured. There is no doubt that the 17 SDGs are important milestones on the way to a better world in order to improve the living conditions for everybody. FIG will support the accomplishment of these goals without restrictions. The role of a professional organization like FIG is to offer expertise in the form of proposals, approaches or even solutions. In addition to this, with events like our Working Weeks and our Congress, FIG provides platforms where experts from all over the world – coming from academia (universities, research institutions), national mapping agencies, cadastre agencies, private-sector companies and international bodies – can gather and meet.

A well-functioning land administration system is an important pillar for national stability and social welfare. For many countries this still is quite a challenge. What's your vision on this?
I agree with this statement 100%. If you live in a well-developed country with an existing

land administration system that has been up and running for decades, then it can be hard to understand why the implementation of such a system is so difficult. That is understandable when seen from a technological point of view, but the technology-only view is far too limited and a little arrogant. It fails to take account of the lack of infrastructure (compared to better developed countries), the time factor (it took decades to implement our land registration systems) and the other non-technical aspects including the necessary financial efforts. Irrespective of this, a well-functioning land administration system is an indispensable pillar for national and regional stability, well-being, peace and social welfare. As a consequence, we have to support the implementation of land administration systems all over the world.

National mapping agencies take care of the national geospatial data enterprise, which is a huge task. What is their role in this age of digital transformation?
Up until 1990 the national mapping agencies, along with the national military institutions, had the exclusive access to geospatial data. Nowadays this is totally different: geospatial information has become a public good and is available in high quality, often free of charge. In addition to this significant change, we are facing another challenge in the form of big data. Due to the enormous progress in data acquisition, especially regarding the degree of automation and the speed, it will be essential to develop strategies and software solutions for the handling and treatment of the huge datasets which are collected every day.

It has been said that unmanned aerial vehicles (UAVs) are democratizing geoinformation and turning citizens into surveyors. Is this a hype, or the new reality of a changing geospatial landscape?
It is also said that 'the difference between men and boys is the value of their toys!' This is one possible perspective if we talk about UAVs, but it's definitely too shortsighted because UAVs are offering fantastic opportunities. Let's start with the technical part: at first glance, a UAV is nothing more then a 'flying tripod'. But combining this with new digital cameras and treating the acquired data with SLAM software packages, such as AGISOFT, gives us totally new and exciting products and tools which can be used in a variety of applications. In this respect, UAVs can become a basic toolset for our entire profession. However, there are also some threats. The first is safety, for instance – especially when flying over inhabited areas. As far as I know there haven't been any UAV-related fatalities so far, and I hope this will remain so in the future, but there is a general risk of administrative restrictions due to (potential) accidents. Secondly, privacy; in general, we don't want to be observed or inspected in detail on our private property and in our homes by our neighbours, private companies, authorities or anybody else using a UAV! So in conclusion, I am convinced that UAVs and their usage for the collection of geospatial data is very promising. Over the next decades UAVs will become an essential tool, providing that we find solutions and reach agreements regarding flight safety and the privacy of individuals.

In the light of all the above, what will be FIG's role in the changing landscape?
FIG is a professional organization of volunteers. Our goal is to promote the profession as a whole. In this light, we will of course also promote technology, but at the same time we have to create awareness for the risks as mentioned.

In general, how do you see the future of the geospatial societies?
As geospatial societies, we play a very important role today: we offer a global platform of exchange for our stakeholders – authorities (national and international), administration, private companies, education and manufacturers. The geospatial societies are supporting and promoting our profession as an entity and our approach is non-commercial and for the sake of the whole profession and our society.

Which main goals do you hope will be achieved during your presidency?
The FIG 'brand' is very well known and we are the biggest international society representing the geospatial and surveying profession on a very broad base. Nevertheless, except for our FIG office in Copenhagen, we are all volunteers. We have to strengthen our organization and prepare it for the near future. One of the major tasks will be to activate people who are willing to contribute to all FIG's commissions, networks and taskforces in the future. Also, we have to prepare our members for rapid and fast technological change, including the digital transformation and the resulting opportunities. And, last but not least, we want to continue playing an active and well-respected role within the UN system, together with the World Bank and other organizations.

▲ *Hagen Graeff and Louise Friis Hansen present Rudolf Staiger with the ceremonial chains of office.*

In four years from now, you will be able to look back on the outcomes of your presidency. What would make you really proud?
I would be very proud if FIG has gained an even stronger position as one of the leading geospatial societies and if the current generation of FIG Young Surveyors has become active as the next generation of FIG.

What's your message for the readers of* GIM International*?
In these times of 'fake news', it is very important that our sources of information, including regarding our profession, are accessible, factual, objective and independent. *GIM International* is such a source. Use it! ◀

ABOUT RUDOLF STAIGER

Rudolf Staiger studied geodesy in Karlsruhe (Germany) and Paris (France). After working in the private sector for a few years, he returned to the academic world and became professor of applied geodesy with a focus on instrumentation at the University of Essen in 1994. He has held the same position at the University of Bochum since 2005, where he is also vice-president of research and transfer. Staiger has been active in FIG in numerous positions since 1997, becoming vice-president in 2010 and president in 2018. Staiger has published articles in more than 60 publications, including the textbook titled *Instrumentenkunde der Vermessungstechnik* (Wichmann-Verlag, Heidelberg, 2002).

ISSUES, CHALLENGES AND LIMITATIONS

3D City Modelling of Istanbul

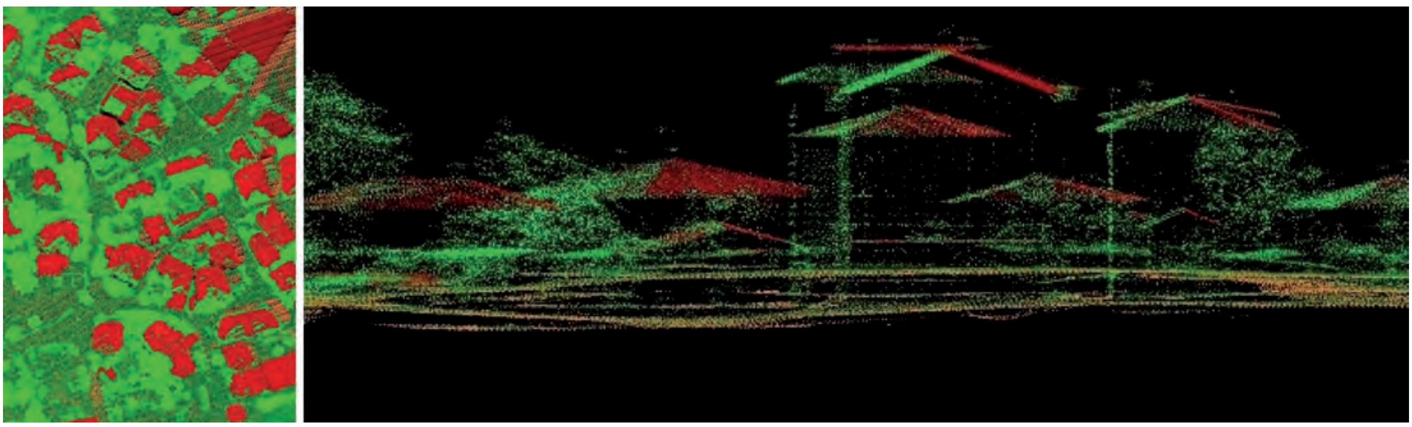
The Turkish metropolis of Istanbul is developing a 3D city model mainly aimed at urban planning. The data sources used so far include airborne Lidar, aerial images and 2D maps containing footprints of buildings. Everybody engaged in creating 3D models of large cities faces many issues, challenges and limitations, including excessive data storage requirements, the need for manual editing, incompleteness and other data quality problems. In this article, the authors share their experiences of creating models of the city of Istanbul at the level of detail (LOD) 2 and 3.

The core data for creating the 3D city model of Istanbul was collected by a helicopter flying at a height of 500m and a speed of 80 knots (150km/h) during surveys carried out in 2012 and 2014. The helicopter was equipped with a Q680i Lidar system from RIEGL (Austria), a DigiCam 60MP camera, an AeroControl GNSS/IMU navigation system and an IGI CCNS-5 flight management system. The Lidar point cloud was captured with an average point density of 16 points/m^2. The images were recorded with a ground sampling distance (GSD) of 5cm and with 60% along-track and 30% across-track overlap. To ensure high geometric accuracy, eight GNSS base stations were used. The recording of the whole city covering 5,400km^2 required thorough flight planning as the flying height and overlap determine a major part of the data quality. Added to this, data accuracy is directly affected by how good the boresights of IMU, GNSS and camera are calibrated and remain stable during the surveys.

PROCESSING

The Lidar point clouds were geometrically corrected using RIEGL RiPROCESS and RiANALYZE. The Lidar point cloud was stored in 17,000 LAS files, each covering an area of 500m by 700m. Next these LAS files were used for generating a digital surface model (DSM), a digital elevation model (DEM) and a DSM in which the heights of buildings and other objects refer to the ground surface instead of a local or national reference system. Such a DSM is called a normalized DSM (nDSM). The GSD of the three digital terrain models was 25cm. Combining the DSM with the simultaneously recorded images enabled the creation of orthoimages. The LAS files were also used for classifying the points on

AUTOMATIC CLASSIFICATION FACES LIMITATIONS; THE WRONG CLASS WAS OFTEN ASSIGNED TO BUILDINGS CLOSE TO HIGH TREES



▲ *Figure 1: Top view on the classification of buildings (red) and vegetation (green) in part of the city of Istanbul (left) and profile showing the misclassification due to cluttering of buildings and vegetation.*

Figure 2: LOD 2 and LOD 3 buildings in downtown Istanbul.

the ground, on buildings and in low, medium and high vegetation using MicroStation V8i Connect, TerraSolid and TerraScan software.

AUTOMATIC CLASSIFICATION

The automatic classification of points was done with 90% accuracy. Automatic classification faces severe limitations when adjacent objects clutter. For example, the wrong class was often assigned to buildings close to high trees (Figure 1). Extensive visual checks and manual editing were required to improve the quality of the classification result. Next, the classified points were combined with building footprints extracted from the 1:1,000 base map and with the orthoimages using TerraModeller software to automatically generate around 1.5 million building cubes. Cubes are a 3D representation of level of detail (LOD) 2 (see side bar). Next, the building blocks were augmented by automatically adding roofs using TerraModeller. Mosques, churches, bridges and other complex structures had to be manually mapped using ZMAP software, however. The base map was created from aerial images. Since roof outlines are mapped rather than the actual building footprints, it is not always possible to separate roofs from high trees automatically, thus again requiring extensive manual editing.

LOD

By Mathias Lemmens

3D city models consist of digital elevation models (DEMs) of the ground surface overlaid with structure and texture of buildings and possibly other objects. Such models may be made at five levels of detail (LOD). The simplest level is LOD 0: a DEM with superimposed ortho-rectified aerial or satellite imagery or a map. At LOD 1, basic block-shaped depictions of buildings are placed over LOD 0. LOD 2 adds detailed roof shapes to LOD 1. LOD 3 represents further expansion by adding to LOD 2 structural elements of greater detail, such as facades and pillars, and draping all objects with photo texture. The highest level, LOD 4, is achieved when buildings can be 'visited' virtually and viewed from the inside.

CITYGML

The files generated from processing Lidar point clouds, aerial images and 2D base maps were converted to CityGML using an FME Workbench. Next, topologically and semantically correct LOD 2 3D models of buildings were created – in total 1.5 million – with the help of CityGRID software

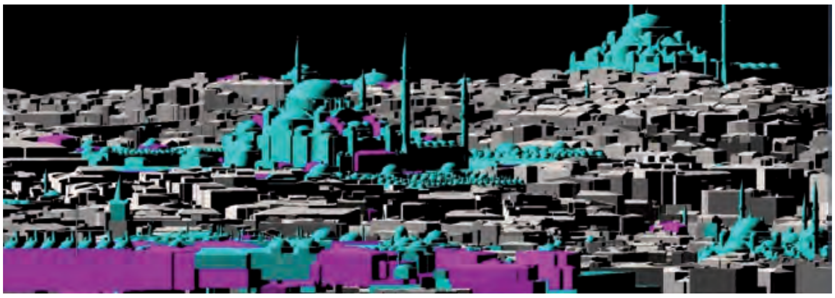


Figure 3: Mosques and other complex buildings were generated using architectural 3D CAD files.


YellowScan

(Figure 2). Various classifications and automatic and manual corrections were made until the 3D model contained the desired details. Based on architectural 3D CAD files (Figure 3), 3,800 landmarks such as mosques were modelled with greater geometric details of facades and roofs (LOD 3) than other buildings. Since no georeferenced photos taken at street level were available, no photo texture was draped over any of the buildings, including the landmarks (Figure 4). The non-textured LOD 3 models were based on the CityGRID XML format to facilitate the topologically correct outlining of roofs, facades, footprints and details such as balconies, dormers and chimneys. In a next step, the created files must be converted to a full CityGML structure.

GEOSPATIAL DATABASE

The database currently consumes 135 terabytes and all objects are stored in flat files. However, advanced use of the CityGML spatial database, which properly supports urban planning, requires its querying and visualization. One of the options for querying is the open-source 3DCityDB Webclient, which is CityGML compliant, used within Oracle Spatial, PostgresSQL or PostGIS. For visualization purposes, the authors plan to use Cesium Virtual Globe – an open-source JavaScript for creating 3D globes and maps. The proposed system architecture is shown in Figure 5.

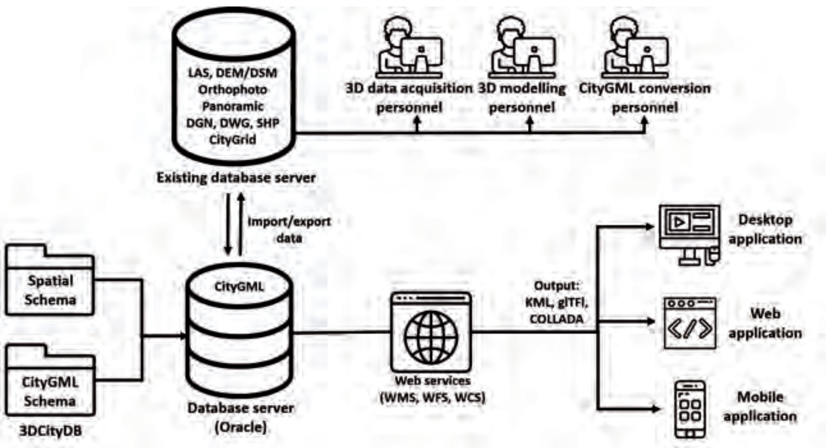
FUTURE

The creation of the 3D city model of Istanbul is still work in progress. Presently, the main data sources consist of an airborne Lidar point cloud, simultaneously recorded aerial images and the building footprints from the 2D base map of Istanbul. Ground-based data collection has been scheduled to increase the level of detail, with respect to both the geometry and the image texture. The preferred technology is laser scanning and 360º panoramic imaging simultaneously captured from a moving car. Many streets in downtown Istanbul are small and narrow and thus inaccessible for cars. It is planned to capture these parts of the city with backpack mobile mapping systems. For the whole of Istanbul, the ground-based data will cover 32,000 kilometres of roads and streets resulting in 2.73 petabytes of panoramic image data. The 3D city model is not yet connected to a database containing semantic building information, but this is part of the future development work. ◄

THE CREATION OF THE 3D MODEL IS WORK IN PROGRESS. GROUND-BASED DATA COLLECTION HAS BEEN SCHEDULED TO INCREASE LOD

ACKNOWLEDGEMENTS

All the efforts and help on data collection and processing received from the BIMTAS colleagues – Mr Serdar Bayburt and Dr Ismail Büyüksalih especially – is greatly acknowledged. Thanks also go to Mr Hanis Rashidan for the design of Figure 5.



▲ *Figure 5: Proposed system architecture of the 3D spatial database and sub-systems.*

▲ *Figure 4: LOD 2 and LOD 3 geometric models without photo texture.*

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ABOUT THE AUTHORS

Peyami Başkaraca is general manager of the BIMTAS company of Istanbul Greater Municipality (IBB) and highly experienced in 3D city modelling project management.
✉ pbaskaraca@bimtas.istanbul

Gürcan Büyüksalih is an associate professor and manager of the 3D GIS and Mapping Division of BIMTAS. He holds a PhD degree in photogrammetry and remote sensing from the University of Glasgow, UK, and is key in the Istanbul 3D city modelling project.
✉ gb@bimtas.istanbul

Alias Abdul Rahman holds a PhD from the University of Glasgow, UK, and is a professor at the Universiti Teknologi Malaysia (UTM), where he has headed up the 3D GIS Research Lab since 2000. His research interests include 3D GIS, 3D city modelling and 3D spatial databases.
✉ alias@utm.my

TECHNOLOGIES AND MEANS TOWARDS A PARADIGM SHIFT

Point Clouds as the Future **Topographic Core Data**

Could 3D point cloud data be used as the framework for topographic information in the future? Point clouds can be captured with an ever-increasing number of means from ground-based, airborne and spaceborne platforms to understand the surrounding reality and detect critical developments. What are the future technologies and processes that will build the capability for high-density 3D data? This article explores the possibilities based on the latest developments in the industry.

'Data on demand' is a recognized megatrend in the geospatial industry. National topographic databases store data refined from field measurements, imagery and laser scanning data at certain specifications and for certain purposes, but lack the dynamic aspect in terms of human aspirations, changing needs and situational awareness.

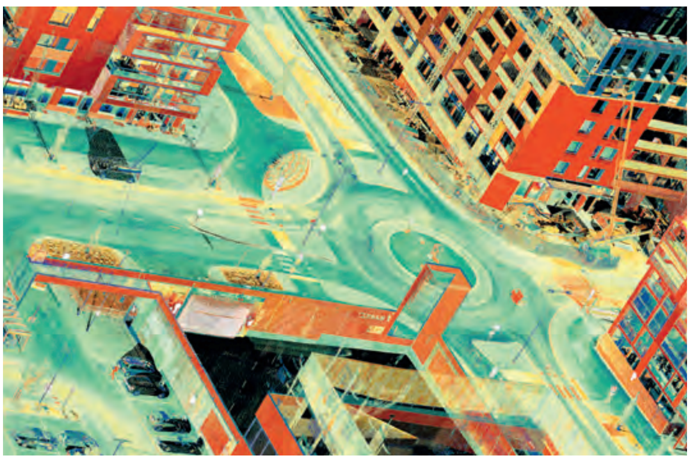
FRAMEWORK FOR FUTURE TOPOGRAPHIC DATA

Point cloud data can be captured with an ever-increasing number of means from ground-based, airborne and space platforms, helping users to understand the surrounding reality. Different scales and viewpoints – from grain scale to a global overview – provide comprehensive multimodal data for environmental analysis, assessment of natural resources and development of urban infrastructure and critical services. Semantic point clouds, temporal coverage, multimodal data sources and automated processing form the framework for future topographic data.

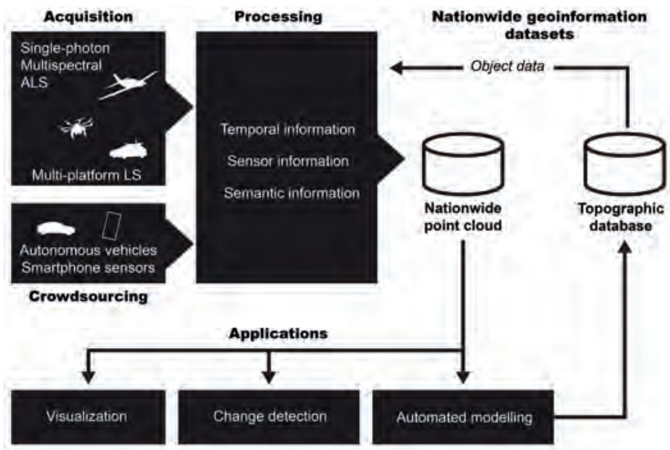
MULTI-PLATFORM MOBILE LASER SCANNING

Vehicle-mounted laser scanning systems have proven to be very efficient in measuring road and city environments. Multi-platform systems expand the use cases of mobile laser scanning (MLS) to natural environments, industrial installations and urban environments that cannot be easily accessed by a vehicle-mounted system. With the development of algorithms that allow simultaneous localization and mapping (SLAM), mobile laser scanning has also advanced to provide 3D data from GNSS-denied environments, e.g. indoors and industrial sites.

Affordable high-performance systems are already changing the ways of producing topographic data. The unmanned aerial vehicle (UAV or 'drone') is an emerging technology that, coupled with advanced systems featuring laser scanning and imaging sensors, enables rapid capturing of aerial data for various purposes. Combining UAV-based airborne sensors and mobile laser scanning with imagery brings together the flexibility of mobile systems and allows short response times and low mobilization costs. Use of these systems provides data



▲ *A dense and geometrically accurate point cloud offers photographic capture of the reality for mapping, modelling and monitoring.*



▲ *Framework for point cloud-based topographic data production (adapted from Virtanen et al., Nationwide Point Cloud – The Future Topographic Core Data,* International Journal of Geo-information *2017, 6, 243).*

Backpack scanning is a suitable method for collecting 3D data from cultural heritage sites, buildings, streets and terrain features.

with minimized occlusions enabled by easily accessed viewpoints. This data typically represents the objects of interest in a very high level of detail, down to a scale of a single railing, cobblestone or cable.

AUTONOMOUS VEHICLES AND CROWDSOURCED MAPPING

Autonomous vehicles have attracted considerable industrial interest in recent years. Following the DARPA Grand Challenge competition for self-driving cars, several major manufacturers have announced their future goals of providing autonomous vehicles. This requires fitting the vehicles with highly capable 3D mapping systems, much like those encountered in contemporary MLS. For the geospatial information community, these future autonomous vehicles are a potential source of highly detailed and frequently updated 3D mapping data.

In addition to vehicles, 3D mapping capabilities are increasingly carried by consumers in their smart devices. At the simplest level, smartphone camera images and positioning information may contribute to mapping. More capabilities are offered by other sensors such as depth cameras and 3D image interpretation. These technological developments hold the potential to replace the prevailing centralized mapping conventions by decentralized, distributed and frequent crowdsourced mapping.

MULTISPECTRAL SENSORS – COLOUR VISION WITH LASER

Multispectral laser scanning technology is currently in its technological adaptation phase, promising an increase of active spectral information for mapping and detection. The first example of this was the recording of laser backscatter intensity and the use of intensity values in the visualization of point clouds and in certain classification tasks. The emerging multispectral laser scanning (e.g. Optech Titan for ALS) increases the amount and quality of spectral information obtainable. Actively sensed radiometric properties of target objects do not suffer from illumination variations and

Airborne mapping produces point clouds over wide areas at different altitudes and scales suitable for elevation modelling, building detection, forestry and power networks.

▲ *Vehicle-mounted kinematic mapping systems are useful for road and street data capture for mapping and maintenance purposes. Such data provides high-density base map data for autonomous driving, which is a good example of a new kind of mapping task for the future.*

anomalies caused by solar illumination present in passive imaging products. The autonomous driving industry is also expected to explore this opportunity in the future.

Classification results with the data from the first multispectral ALS systems have been promising. For example, a very high overall accuracy (96%) of land cover classification results has been achieved in some studies, with six categories (building, tree, asphalt, gravel, rocky, low vegetation).

SINGLE-PHOTON SYSTEMS

Single-photon technology is an emerging technological breakthrough for airborne laser scanning. Single-photon systems require only one detected photon, compared to hundreds or even thousands of photons needed in conventional Lidar. As a result, pulse densities of ten to 100 times higher can be obtained compared with conventional sensors. In addition, the sensitivity of the detector to energies in the single photon range allows the systems to attain higher maximum ranges and remain eye-safe. This has also contributed to the recent launch of spaceborne Lidar for global monitoring aboard ICESat-2 ATLAS. Similarly, the single-photon technology can be used in autonomous driving and drone sensors.

CHANGE DETECTION AND AUTOMATED MODELLING AND MAPPING

The developments in acquiring point cloud and spectral data are significantly increasing the data volumes produced. Automation is needed to translate the increased measuring frequency and point cloud density into efficiency and a high level of detail in mapping. The emergence of national laser scanning campaigns, such as those in The Netherlands, Sweden and Finland, highlight the need for automated processing methods.

On a more limited scale, multitemporal point clouds have been applied to change detection, both in the urban and natural areas, for management of resources and coping with hazards, effectively showing the potential of multitemporal 3D data. Combining these methods with automation and periodically

ABOUT THE AUTHORS

Prof Antero Kukko leads the Mobile Mapping group at the Finnish Geospatial Research Institute FGI and holds an adjunct professor position at Aalto University, Finland. His research includes development of laser scanning systems, applications, data calibration and processing.
✉ antero.kukko@nls.fi

M.A. Juho-Pekka Virtanen is currently working as a doctoral student and a project manager at the Institute of Measuring and Modelling for the Built Environment at Aalto University. His research topics include applications of 3D virtual models and 3D measuring technology.
✉ juho-pekka.virtanen@aalto.fi

Prof Hannu Hyyppä is the director of the Institute of Measuring and Modelling for the Built Environment at Aalto University. His interests include modelling of the built environment, use of laser scanning in cultural heritage and popularization of science.
✉ hannu.hyyppa@aalto.fi

▲ *GNSS-IMU and SLAM-based laser scanning systems can be mounted on virtually any kind of platform to carry out tasks in variable environments, for varying data requirements and at different scales. The system shown here is collecting 3D data for forestry and simulating forest harvester localization.*

repeated countrywide scanning campaigns would allow spectral and geometrical change detection in unseen detail.

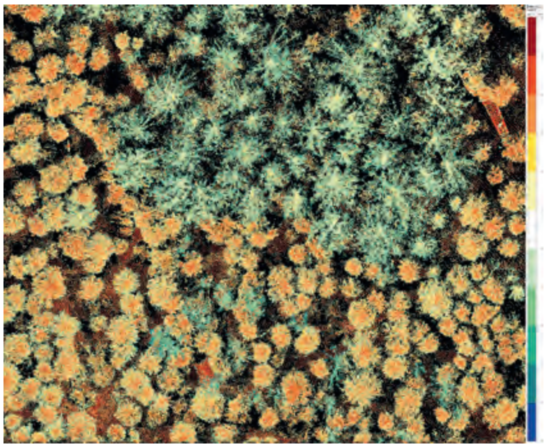
In addition to change detection, automation is required for various modelling tasks. In urban environments, the automated generation of simple building models has become the default approach for 3D city modelling. Several algorithms for detailed building modelling have been introduced, potentially raising the level of detail in automated modelling. In a similar fashion, algorithms have been developed for modelling road environment objects from dense mobile laser scanning point clouds. In natural environments and forestry, point cloud datasets have been applied both for producing parameter information over larger areas – e.g. for hydraulic modelling and flooding analysis or permafrost processes – and detailed modelling of individual trees for forest resource assessments.

Ideally, the change detection and modelling should be combined. Possible changes are detectable based on multitemporal data, and modelling, maintenance or any similar action or effort can be focused based on data-derived signals or an early warning to save costs and avoid indirect damage.

POINT CLOUDS AS NATIONAL CORE DATASETS

Current topographic databases are commonly based on aerial images and maintained by national mapping agencies, with a significant amount of manual work. Developments in laser scanning and point cloud processing could provide significant cost savings via automation in mapping. Upcoming single-photon technology has the most potential as a sensor solution for providing dense point clouds with low unit costs for country-level data acquisition. Multimodal laser scanning from airborne and terrestrial perspectives can be utilized for obtaining more detailed data from selected areas.

Dense point clouds with spectral information provide a common starting point for automated modelling workflows and direct visualization applications, forming the future topographic core data. They represent a significant asset for business in improved forestry and infrastructure management, and provide a platform for developing several future applications. ◀



▲ *Laser-derived reflectance of a forest at 905nm wavelength reveals tree species-specific spectral characteristics. Combined with simultaneous data at different wavelength regions, multi-spectral information helps greatly in classification and object recognition.*

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ADDING CHANNELS TO LASER SCANNERS WILL DISRUPT LIDAR-BASED TARGET IDENTIFICATION

The **Multispectral** Journey of **Lidar**

Optech Titan-3 has ushered in the era of multispectral airborne laser scanning, but multispectral terrestrial laser scanning (TLS) is still only available via research instruments, mostly for ecological vegetation studies. Analysing spectral ratios can reveal much about vegetation status and health, and multi-wavelength Lidar enables this analysis in 3D. However, multispectral Lidar will disrupt many other fields in the future. This article provides some first glimpses of how and why.

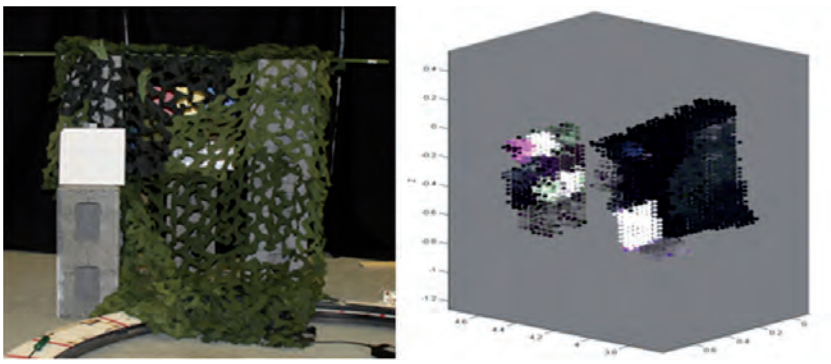
Four research groups have published 3D TLS point clouds since 2012, and many others have already focused on the multispectral laser return rather than spatial analysis. Multi-wavelength point clouds are available from groups at Boston University (the Dual-Wavelength Echidna Lidar (DWEL)), University of Salford (the Salford Advanced Laser Canopy Analyser (SALCA) [1], the Finnish Geospatial Research Institute Hyperspectral Lidar (FGI-HSL) and the spectral Laser Detection And Ranging (LADAR) laboratory demonstrator in Maryland. All these are full-waveform digitizing scanning Lidars and provide the first insights into spatial distribution of spectral data.

There are a couple of ways to extend a conventional Lidar approach to a multi-channel one: using multiple or tunable lasers, or a supercontinuum, i.e. the so-called 'white' laser. Multiple or tunable lasers offer eye safety and signal to noise (S/N) ratios comparable to traditional Lidars. Supercontinuum lasers provide a continuous spectrum, but it is a challenge to achieve an eye-safe power level that gives sufficient return signals for remote measurement. This can be accounted for by restricting the wavelength range to near-infrared (NIR) or indoor operation with limited access, which then limits its usage in the urban environment, for example. The detector usually comprises a pair or an array of photodiodes and a digitizer that is fast enough to record the incoming waveforms. The multi-wavelength function poses more demands for this equipment.

FUTURE PROSPECTS FOR DISRUPTIVE APPLICATIONS

Active spectral imaging initially emerged for military purposes. Targets concealed behind camouflage nets can be detected from their spectral features. Adding spatial data enhances that as object distances and shapes can be differentiated (Figure 1). Defence and security-related imaging also calls for long-range measurement, for distances up to 1.5km, which is feasible with high-power supercontinuum lasers [2].

Vegetation photosynthetic capacity and health can be mapped over entire trees with multispectral point clouds, as chlorophyll can be inferred from spectral indices. This is a novelty, as high spatial resolution (leaf level) can be provided in larger scales than before, even up to stand level with TLS [3]. Another disruptive aspect comes from the fact that destructive sampling is not needed, which enables the creation of time series. DWEL and SALCA have also been applied in the separation of leaves from bark.



▲ *Fig. 1: Example of the benefits of a hyperspectral point cloud: the targets hidden behind a camouflage net (left) can be separated both spectrally and spatially (right) as both spectral and distance information can be applied. (Image courtesy: Olli Nevalainen, FGI)*

The FGI scientists have done initial tests with the HSL to explore applications other than vegetation. These include distinguishing pollution in snow, detecting obscured targets, separating artificial objects from vegetation and observing target moisture in buildings. Multispectral Lidar has the potential to replace visual identification in separating minerals from gangue (waste rock) in mines [4], see also Figure 2.

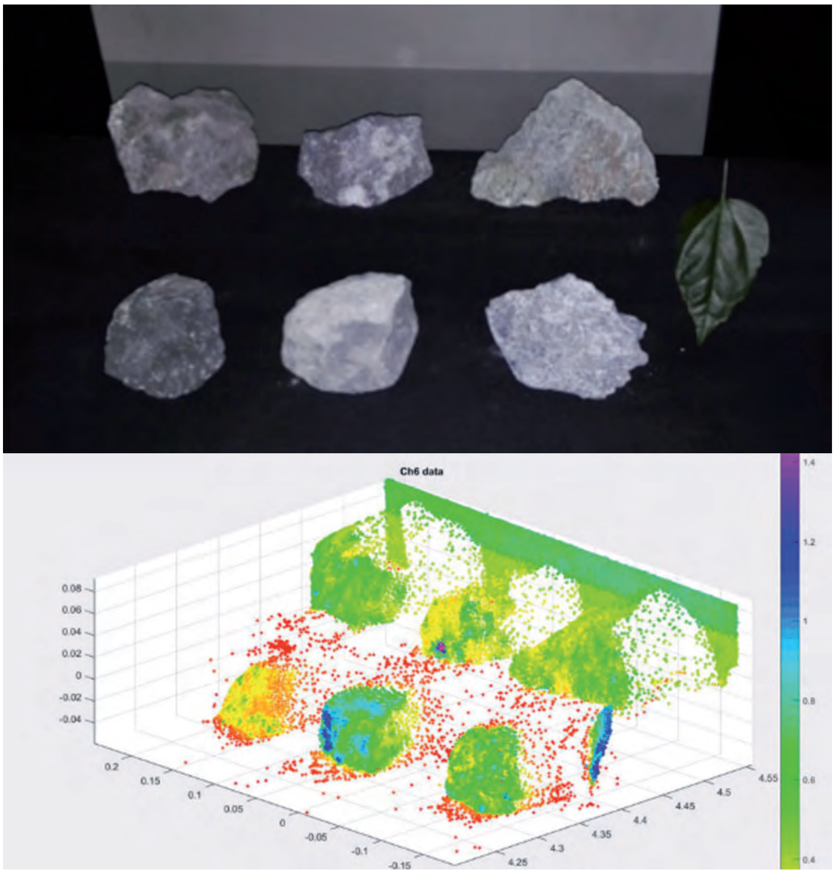
CHALLENGES OF MULTISPECTRAL LIDAR

The reason that many multispectral Lidars still focus mainly on spectral data is that consistent spectral performance

is challenging with laser and there are greater demands for accurate radiometric calibration than in the single wavelength case. This calls for an improved level of technological readiness. Beam alignment is an issue in multi-laser instruments, whereas supercontinuum lasers have synchronization and stability problems of their own. On top of that, conventional Lidar features such as multiple echoes (which are more difficult to interpret in the multi-wavelength case), waveform sampling and range measurement need to be optimized simultaneously and they sometimes compromise the spectral accuracy. This may be the reason for such a limited number of studies that actually present point clouds. However, as the range resolution and accuracy of multispectral Lidars is increasing with constant instrument development, topographic information is becoming more accurate. The same goes for recently published radiometric calibration efforts, which will improve the spectral resolution and the retrieval of spectral ratios and indices. This comes at the cost of computing time, however, as multi-channel point clouds are vast and slow to process.

CONCLUSION

Multispectral terrestrial Lidar instruments represent the next generation of terrestrial laser scanning, and they are slowly reaching technical maturity for commercial application. Further R&D will be needed for optimized operation, data processing for real-time environment perception, overcoming the eye-safety issues and fully utilizing the spatially distributed spectral data. These may never be realized with a general-purpose instrument, but the hardware could be custom-made for a specific application. Commercial availability may also be implemented as a service, with point clouds being the product, or as part of a large platform of instruments (e.g. mounted in a robot or on a vehicle) to complement the situational awareness gathered from multiple sources. ◀



▲ *Fig. 2: Intensity in NIR plotted over FGI-HSL point clouds of mineral rocks. Minerals can be identified from gangue by comparing differences in reflection properties at different channels. (Image courtesy: Tuomo Malkamäki, FGI)*

COMBINING WITH OTHER SENSORS

Lidars are rarely used as stand-alone instruments. They have always been combined with positioning to produce georeferenced point clouds and they are increasingly used as a component in a multi-sensor ecosystem. Improved sensor-based situational awareness will be an essential part of Lidar usage in the future. This is necessary for autonomous vehicles, as they need to perceive the environment and cannot rely on satellite positioning only. Satellite positioning is prone to vulnerabilities and not available in all conditions. Sensor fusion is also being tested in indoor or underground conditions by combining inertial, radio frequency (such as ultrawide band) and visual sensors. This, and the emergence of hyperspectral laser scanning, will take indoor simultaneous localization and mapping (SLAM) to a totally new level, but real-time processing of vast data volumes still needs a major effort. It is fast to analyse a spectrum from one point, but utilizing the full 3D representation takes more time. Artificial intelligence is being explored as a potential approach. The hardware will also need to be cost-effective and small, which will also affect the instrument design of multispectral Lidars.

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ABOUT THE AUTHOR

Sanna Kaasalainen is a professor and a deputy director at the Department of Navigation and Positioning at the Finnish Geospatial Research Institute of the National Land Survey of Finland (FGI-NLS). Her research interests include sensor positioning, multispectral laser scanning and their applications in environmental perception and situational awareness.
✉ sanna.kaasalainen@nls.fi

How **Earth Observation** is Driving the Development of the Human Race

While the demand for satellite imagery and value-added services soars in the Earth observation (EO) market amidst the global space race 2.0, enhanced resolution is driving the creation of a queryable digital Earth. We are fixed on a rapid growth curve towards real-time intelligence in under five years. By sharing the true potential and benefits of real-time imagery, we can better help communities enjoy worthwhile life improvements. Hence, as the capacity of ecosystems thrusts towards a period of hyper-acceleration and an unimaginable reality, imaging satellites will be a key driver in the development of the human race.

As industries gravitate towards capital demand, developing the global economy begins from the ground up. From predicting poverty to resolving water sustainability and revolutionizing farming in rural communities, geospatial insight is a powerful alternative dataset to bolster the quality of life in developing nations. By aiding NGOs with affordable product rates and by supporting philanthropic efforts of large corporations, the EO community is helping mankind estimate when we will achieve each UN Sustainable Development Goal. The Group on Earth Observations (GEO) provides a robust 2030 Agenda to help us better achieve sustainable development. As stated by Gary Watmough, geospatial researcher at the University of Edinburgh, “the use of satellite images makes it much cheaper to keep track of how far we are in reaching the United Nations’ goals for sustainable development”.

Given that our careers and capacities are driven by intrinsic passions, individuals in the remote sensing field can gravitate towards any sector of interest. Extractable geomatics may be one of the most influential datasets to reduce the time and costs of permitting approval, smart regulation and construction projects specific to foreign direct investment and infrastructure development. By recognizing the capabilities and performance empowerment of real-time imagery data analytics on processes, critical path methods and time-cost savings evaluations across every industry, we can better express the profound benefits of how geospatial insight is transforming the way we do business.

With the plummeting cost of imagery data and diminishing barriers to space, satellite-derived solutions with IoT, sensor and financial archives are transforming the predictive era. Reliable and scalable machine-learning computation is manifesting next-generation products akin to the real-time simulation of global supply chains and distribution networks with progressive economic development rates from a host of geospatial variables in national ecosystems. From forecasting the movement of trade across our skies to predicting resource demand and supply levels, we can begin to capitalize on market trend fluctuations on any scale right from the start. By incentivizing bilateral relations in the geospatial domain between governments and international entities, we can democratize access to Earth observation.

“That’s when we will evolve this smaller industry, which is about a US$5 billion addressable market, to be part of the business-to-business information services economy, a US$100 billion to US$200 billion industry. That’s what we’re focused on,” said Robbie Schingler, co-founder of Planet Labs. To grow into a US$200 billion industry, we can communicate the substantial life and community improvements of what the Earth observation industry will be capable of in under five years. We can better convey long-term savings from real-time insight from high-resolution imagery to decision-makers in end-user markets to accelerate approvals of financial resources.

The growth in capital demand not only enables us to expand satellite systems, but also to embrace higher risk for exponential technologies such as synthetic aperture radar, alternative propulsion sources, on-orbit servicing, quantum software-defined spacecraft and 3D printed extraterrestrial structures by capitalizing on cost-saving evaluations from exponential technologies. Advancements in Earth observation and satellite technology are establishing foundations for humanity to accomplish the unthinkable in deep space exploration.

A glimpse into the future of eight geospatial capabilities for global development.


MicroSurvey

ADVANCING THE UNDERSTANDING OF PLANET EARTH

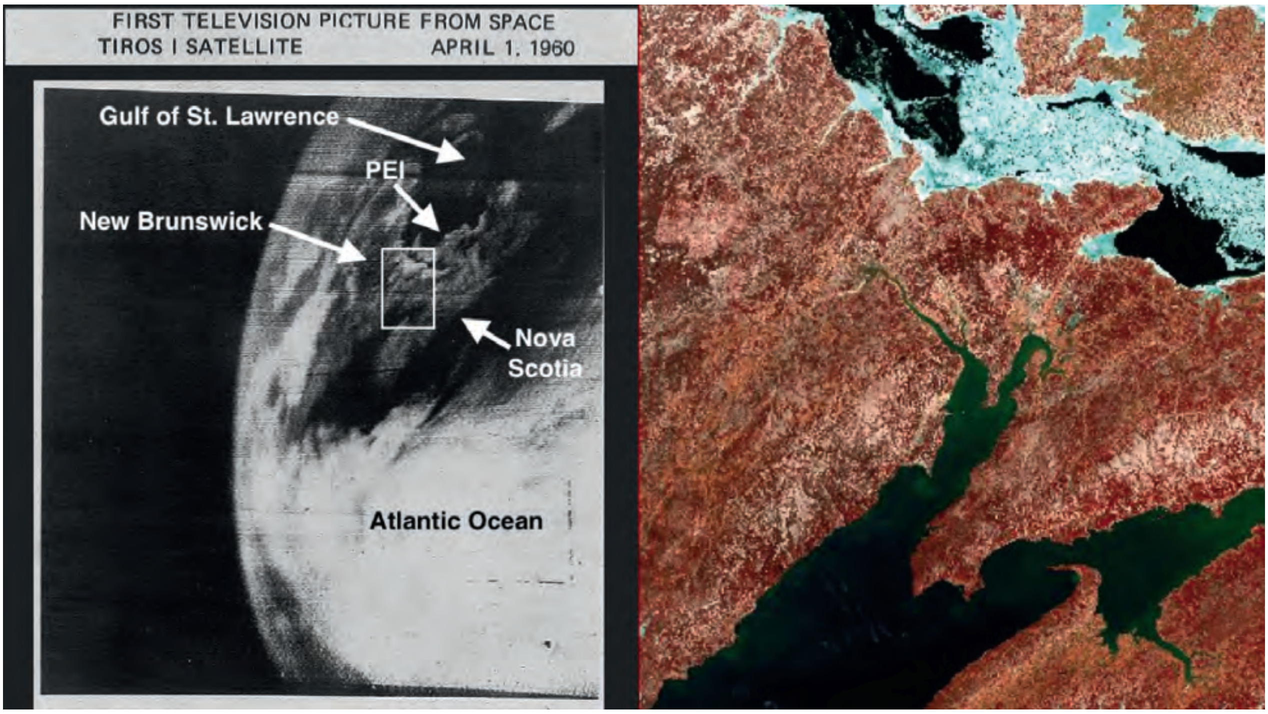
Landsat: the Cornerstone of **Global Land Imaging**

The Landsat satellites provide an uninterrupted space-based data record of the Earth's land surface to help advance scientific research towards understanding our changing planet. In this article, the authors look at how the use of data from Landsat satellites has evolved over time to become a cornerstone of global land imaging with broad societal benefits.

Since 1972, the Landsat satellites have provided an uninterrupted space-based data record of the Earth's land surface to help advance scientific research towards understanding our changing planet. Early Landsat satellites generated a wealth of new data that improved mapping of remote areas and geological features along with digital analysis of vegetation. Landsat's spatial and spectral resolutions have advanced its use for broader societal benefits such as global crop forecasting, forest monitoring, water use, carbon assessments and as the basis for Google Maps. Landsat's long-term data record provides an unrivalled resource for observing land cover and land-use change over a time scale of decades. The free and open Landsat data policy announced in 2008 unleashed global-level research without the onus of data cost. Evolving analytical and computing capabilities make it possible to tackle complex world problems in search of a solution. The Landsat archive is poised to shift into a more real-time monitoring capability to help further our understanding of a changing Earth.

A REVOLUTIONARY NEW VIEW OF OUR PLANET

In the early 1970s, the environmental movement ushered in a new awareness about our planet. The convergence of this



▲ *Multispectral scanner system (MSS) data provides improved spatial resolution resolving more land features than were possible with previous Earth observing satellites like the Television and Infrared Observation Satellite (TIROS) weather satellite, and also capture in seconds a field-of-view that would require days to survey by air. April 1960 TIROS-1 image (left) compared to Landsat 1 MSS image (right) from March 1973. Image courtesy: NOAA (left) and USGS EROS (right)*

▲ *Early Landsat imagery exposed many errors in contemporary nautical charts. For example, researchers saw that reefs, banks and islands were erroneously located or left out entirely in the Chagos Archipelago (left). Landsat provided information to warn sailors in the region until a revised chart (middle) included the newly discovered Colvocoresses Reef and adjusted position of Speakers Bank. The Landsat image from 2 April 2018 (right) shows the current locations of Colvocoresses Reef, Speakers Bank and Blenheim Reef. Image courtesy: Charts from U.S. Defense Mapping Agency, Landsat image by Allison Nussbaum.*

movement and the Landsat programme was propitious. The Earth Resources Technology Satellite (ERTS), later named Landsat 1, was a proof-of-concept experiment to demonstrate that space-based remote sensing data could improve the management of our environment and natural resources. The USA would use the practical experience and evidence gathered from these early instruments to decide whether to pursue an operational land remote sensing programme.

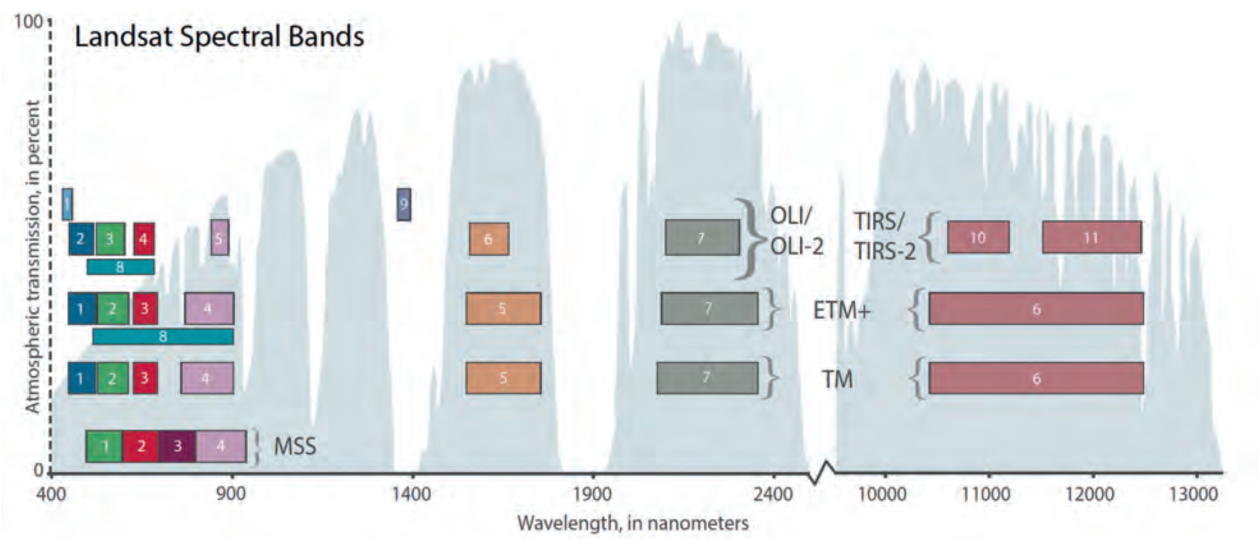
RE-CHARTING THE PLANET

More than half of the Earth had yet to be accurately mapped at the time of Landsat 1's launch in 1972. From the first downloads of data, many revelations appeared in the synoptic view of Landsat. Among these revelations, 1,200 miles of Antarctic coastline were redrawn, navigation charts were improved, a baseline map of the world's glaciers was created and the positions and courses of many Amazon tributaries were amended. The repeat coverage of remote regions also helped to map sea ice to aid shipping navigation routes around the Arctic. Landsat's medium resolution and large field-of-view made it easier for scientists to discern geological lineaments and identify fault lines in remote locations, the latter of which made contributions to the then-nascent theory of plate tectonics.

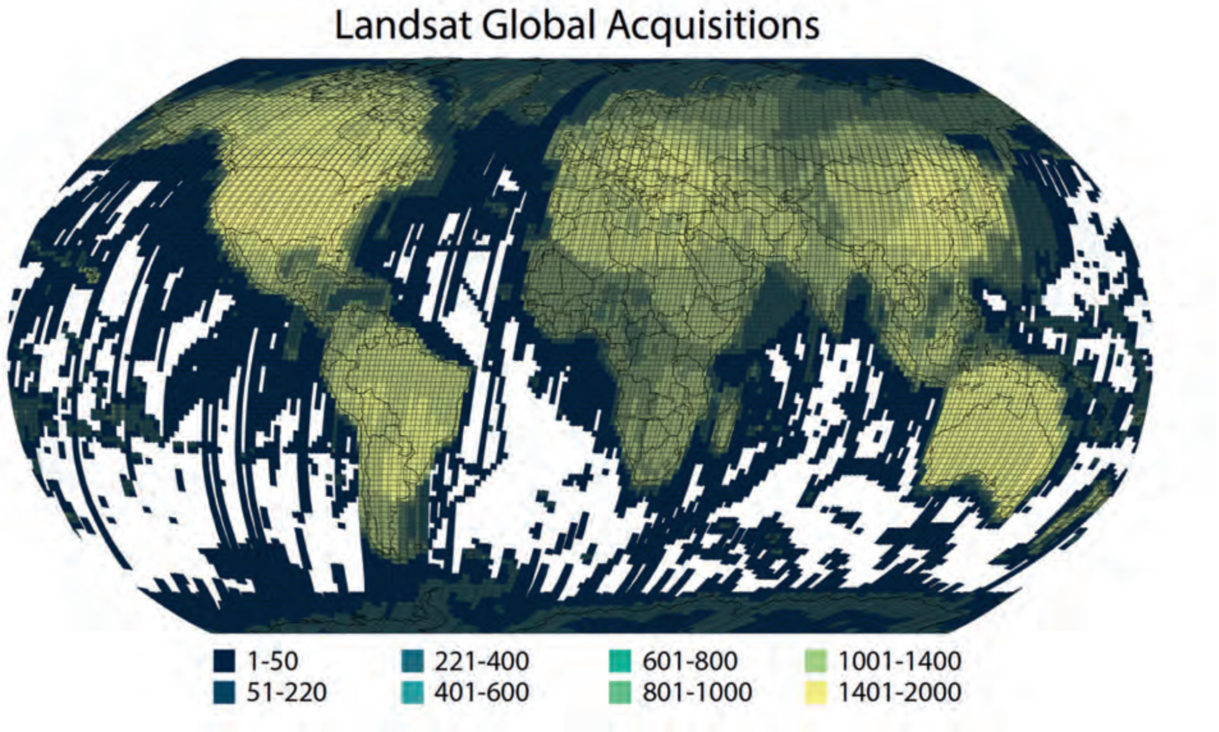
REALIZING SOCIETAL BENEFITS

Practical applications held the most promise for social and financial benefits from Landsat data. Satellite data is a relatively low-cost alternative to aerial surveys, offering the potential to survey large areas for applications such as crop reporting, range management, forest management and soil surveying. Within Landsat's first year, catastrophic flooding occurred along the Mississippi and Missouri rivers. Landsat data was used to map the extent of areas inundated by floodwaters. When the same areas flooded again in 1975, the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Centre used the rapidly relayed satellite data from NASA to create a flood damage map to help support the case for disaster relief funds.

Landsat's synoptic view also proved its worth as a resource for monitoring global crop production. In the early 1970s, the United States accounted for about 50% of worldwide grain exports and had large stockpiles of wheat. In July 1972, initially unaware of a growing global shortage in wheat harvests, the USA sold 15 million tons of wheat at a subsidized low price to Soviet traders. Shortly after, the US grain supply plummeted and grain prices soon reached 125-year highs in Chicago. Over the next year, food prices around the world rose by 50%. The Department of Agriculture's Foreign Agricultural Service was instructed to establish a global crop surveillance and reporting system to prevent such major commodity losses in the future. Landsat data quickly became an essential part



▲ *The evolution of sensors onboard each successive Landsat satellite continued to improve the use of Landsat data for multiple applications. Image courtesy: Laura Rocchio and Julia Barsi*



▲ *Landsat 1-8 path/row density map of the over eight million Landsat acquisitions from 25 July 1972 to 31 October 2018 that are available for download at the USGS EROS Center's Landsat archive (www.earthexplorer.com). Image courtesy: Matt Radcliff*

of this solution and a new emphasis was placed on the use of satellite observations for agricultural objectives and resource monitoring. To effectively forecast crops on a global scale, however, advances in automated processing and quantitative image processing were required.

EVOLVING FROM ANALOGUE TO DIGITAL

Early Landsat satellites (1-3) carried a Return-beam Vidicon (RBV) instrument based on proven television-based technology and a newly developed multispectral scanner system (MSS). The MSS was the first space-based instrument to digitally encode Earth data, to obtain calibration data in orbit and to measure data in multiple spectral channels with sufficient geometric fidelity to allow meaningful comparisons between those channels. While images can be processed from the MSS's digital data to conduct qualitative analysis like aerial photos, the potential to analyse satellite data quantitatively – i.e. quantitative remote sensing – was revolutionary. The MSS quickly proved itself in applications such as classification of vegetation types and boosted the adoption of digital satellite data for Earth observation, leading to the development of more advanced multispectral instruments. This process of digital image processing and statistical analysis of data would redefine modern passive remote sensing from space.

Technical characteristics for the next generation of multispectral scanner instruments were defined based on applications – specifically agriculture and geologic exploration for the new Thematic Mapper (TM) requirements. The TM instrument would be much more sophisticated, with 30m resolution, seven spectral bands including a thermal infrared band, and continuation of onboard calibration. Optimally, the next mission would include two satellites for an eight-day repeat coverage. Landsats 4 and 5 launched in 1982 and 1984, respectively.

With each new generation of sensors, the needs of the Landsat user community continued to drive requirements for improved spatial and radiometric resolution, spectral and temporal coverage, geolocation and calibration. Landsat 7 launched in 1999 with the Enhanced Thematic Plus (ETM+) that added a panchromatic band for increased spatial resolution and increased thermal band resolution from 120m to 60m. In 2013, Landsat 8 was launched capturing around 750 scenes a day, an increase from the around 450 scenes a day on Landsat 7.

The Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) instruments on Landsat 8 have improved signal-to-noise ratio and radiometric performance enabling 12-bit quantization of data, thus allowing for more bits for better Earth surface land characterization. While all Landsat satellites have collected calibration data onboard, Landsat 8 added a lunar calibrator to conduct onboard calibration using the moon like a photographer's 'grey card'. The evolution of Landsat sensors has consistently improved data quality while maintaining precise calibration and backward compatibility within the archive. The data in the U.S. Geological Survey archive from 1972 to the present can be confidently inter-compared, both spatially and radiometrically, thus the archive has confirmed Landsat as the cornerstone of global land imaging.

GROWTH OF EARTH SCIENCE RESEARCH FROM SPACE

Studies and applications of Landsat data continued to expand as this meticulously calibrated archive continued to grow. In June 1988, New England's sugar maple forests were devastated by pear thrip damage. By the time authorities figured out what was happening, the trees were putting out their second round of leaves. Access to archived

Landsat data was the only way scientists were able to accurately map the extent of the defoliation. In the late 1980s, scientists set out to assess global deforestation rates in the tropics using approximately 2,700 Landsat scenes from the archive and a geographic information system (GIS) to classify pixels into various land cover types and analyse spatial structures. Their results calculated the first credible and verifiable Amazon deforestation rates – a near-impossible task with previous labour-intensive and error-prone field sampling campaigns. These are just two of the many studies that emphasize the importance of a robust worldwide Landsat data archive.

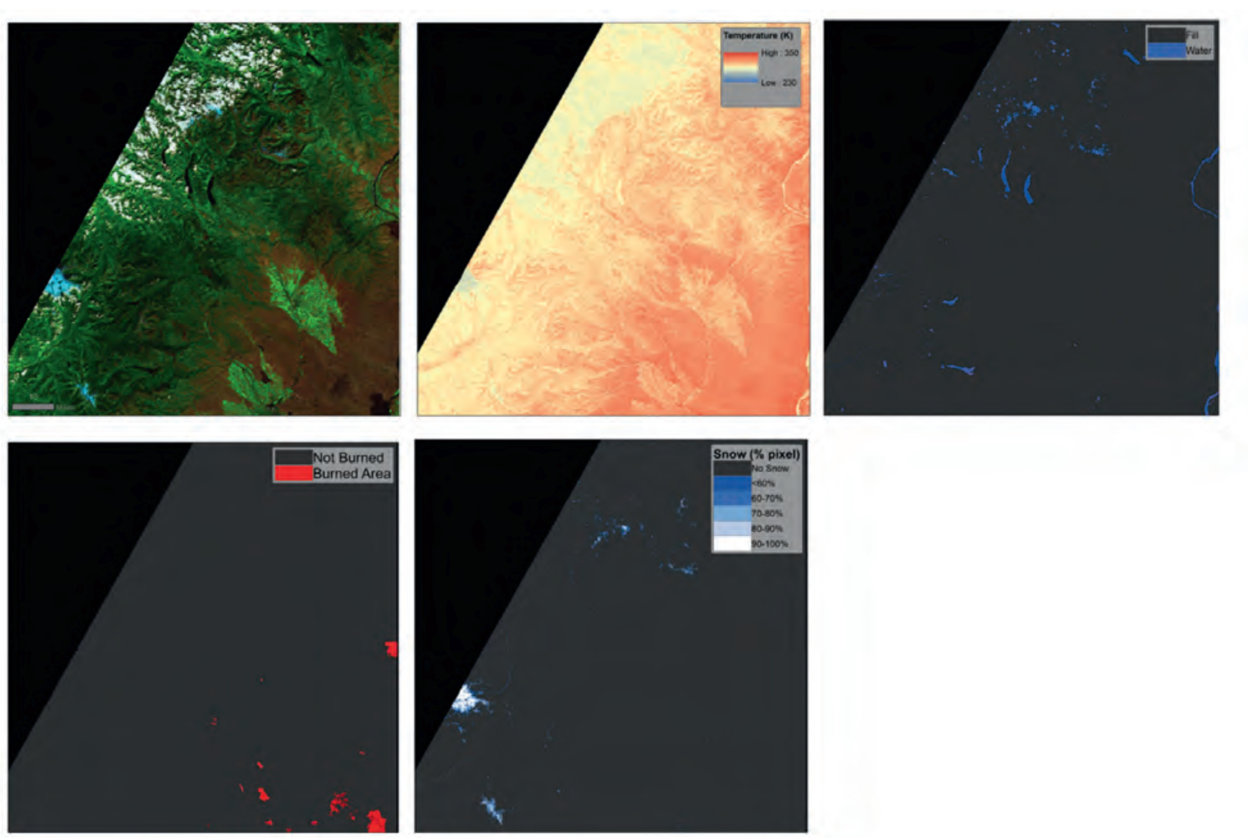
In an effort to privatize and recoup the costs of this national investment, the US government passed the Land Remote-Sensing Commercialization Act of 1984. This resulted in exponential cost increases for Landsat data, with digital TM scenes costing up to US$4,400 each. At a time when computing power was increasing and the new field of GIS was budding, orders for Landsat imagery were decreasing – primarily due to the higher costs. These costs put Landsat data largely out of the hands of scientists working on large-scale or long-term studies, prompting some scientists to migrate to other coarser resolution datasets, like NOAA's Advanced Very High Resolution Radiometer (AVHRR).

FREE AND OPEN DATA POLICY UNLEASHES FULL POTENTIAL

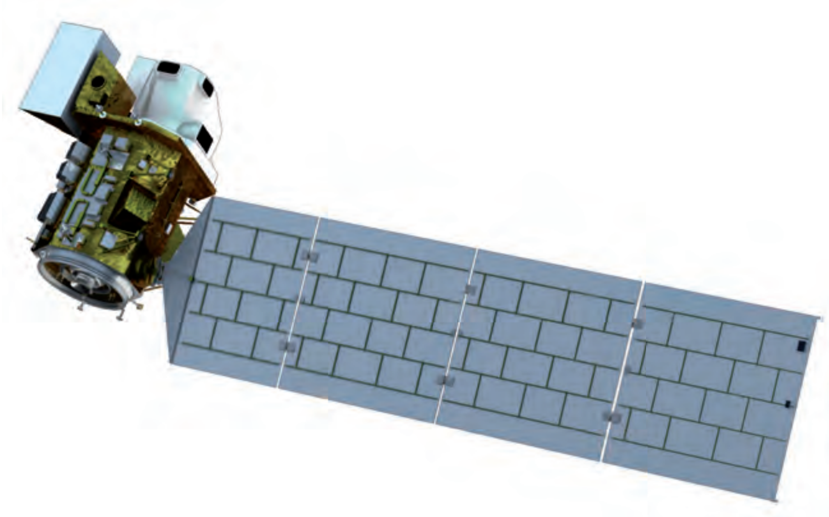
In 2008, the USGS officially announced no-charge electronic access to any Landsat scene held in the USGS-managed national archive. This was a pivotal decision that removed financial barriers for institutions and researchers and opened up new and previously unimaginable Landsat applications. Prior to the free and open data policy, research was restricted to the data that institutions and researchers could afford, rather than the data they really needed to solve a problem. Since 2008, there has been a significant increase in the use of Landsat, especially in global multi-temporal applications such as the World Resources Institute Global Forest Watch web application that monitors global forests in near real time. Geoscience Australia Water Observations from Space uses Landsat data to better understand where water is usually present, for instance. The archive is also used by the Global Food Security-support Analysis Data Croplands database to provide the highest spatial resolution (30m) global cropland map to date. As of 31 October 2018, users had downloaded almost 90 million Landsat scenes from the USGS archive.

LANDSAT GLOBAL ARCHIVE CONSOLIDATION INITIATIVE

With the constrained onboard storage capabilities of older Landsat satellites, numerous ground stations around the world paid a fee for the right to receive and distribute Landsat data. These 'international cooperators' (ICs) received Landsat data of their coverage areas downlinked to their local antennas. Each IC applied processing parameters specific to their data usage and placed the data onto distinctive media storage formats. Over time, more Landsat data was held outside the USGS archive, much of it unique. Recognizing the critical value of this data, the USGS began the Landsat Global Archive Consolidation (LGAC) initiative in 2010 to bring the data into a centralized global archive at the EROS Center. To date,



▲ *An example of a Landsat 8 analysis-ready data tile h004v002 Level-2 surface reflectance (top left), provisional surface temperature (top centre), Level-3 dynamic surface water extent (top right), burned area (lower left) and fractional snow-covered area (lower right) science products acquired on 23 July 2017. Image courtesy: Chris Barnes.*



▲ *The Landsat 8 satellite images the entire Earth every 16 days in an 8-day offset from Landsat 7. Next in the series, Landsat 9, is scheduled to launch in late 2020.*

over five million scenes have been received from IC stations around the world, with just over 3.5 million of them being unique additions to the Landsat archive. As of mid-2018, the LGAC effort was estimated to be almost 80% complete.

NEXT GENERATION OF DATADELIVERY AND ANALYSIS-READY PRODUCTS

In 2016, the USGS reprocessed the entire global Landsat archive into a tiered 'Collection' inventory structure. This structure ensures that all Landsat Level-1 products provide a consistent archive of known data quality to support time-series analyses and data stacking, while controlling continuous improvement of the archive and access to all data as it is acquired. The implementation of Collections represents a substantial change in the management of the Landsat archive by ensuring consistent quality through time and across all instruments.

With a Collection inventory structure in place, the USGS released research-quality, applications-ready, Level-2 science products commonly referred to as Landsat Analysis Ready Data (ARD) in 2017. Landsat ARD consists of top-of-atmosphere reflectance and brightness temperature, surface reflectance and provisional surface temperature. A fundamental goal of ARD is to significantly reduce the preprocessing burden of Landsat data, allowing users to easily produce regional and continental-scale Landsat-based maps of land cover, land cover changes and other derived geophysical and biophysical products. In early 2019 the USGS will release a suite of US ARD Level-3 science products. These products span the USGS Landsat archive from 1982 to present and include burned area (representing per-pixel burn classification and burn probability), fractional snow-covered area (indicating the percentage of a pixel covered by snow), and dynamic surface water extent (describing the existence and condition of surface water). Not only do these Landsat science products significantly reduce preprocessing tasks, they also provide a significant advantage to scientists and land resource managers who monitor changes in the USA's land cover state and condition.

TOWARDS 50 YEARS OF OBSERVATIONS AND BEYOND

In 2020, NASA is launching Landsat 9, the successor to the still-operational Landsat 8 satellite, to continue the mission of unrivalled space-based Earth observation and lead the Landsat programme into a half-century of Earth imagery provided to users worldwide at no charge. Together, both satellites will acquire around 1,500 high-quality daily images of the Earth that will advance research applications, including our ability to map global surface temperature and continuously track and characterize changes in land cover, use and condition. A joint NASA-USGS Landsat Architecture Study Team was established in 2017 to understand how the capabilities of future Landsat missions should look beyond Landsat 9. As with previous Landsats, the team will take into account data user needs as well as new technologies, relevant government policies and commercial and international capabilities.

The success of the Landsat programme has inspired the European Space Agency (ESA) Copernicus Programme Sentinel-2 satellite constellation, and a new generation of commercial satellite constellations like the RapidEye small-sats, SkyBox small-sats and Dove cube-sats. While these small-sat constellations provide higher spatial resolution and better temporal coverage than Landsat, they have a reduced spatial coverage per image and reduced spectral capability. There will continue to be a need for science-grade, rigorously calibrated satellites like Landsat, but there is an untapped potential to leverage the integration between Landsat and these new emerging technologies.

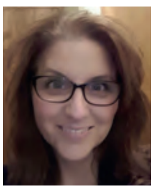
Current monitoring, assessment and projection initiatives provide scientifically accurate land cover and land change records. Today, it is necessary to use both big data and data cubes and to harmonize Landsat with other international and commercial datasets in order to advance our understanding of the causes – and effects – of natural disasters, urban growth and glacial ice changes for future generations. Landsat's long-term data record provides an unrivalled resource for observing land cover and land use change over a time scale of decades. Evolving technology, free data and robust calibration have helped make Landsat the cornerstone of global land imaging. ◀

ABOUT THE AUTHORS

Ginger Butcher leads communications (Science Systems and Applications, Inc.) efforts for the Landsat mission at NASA's Goddard Space Flight Center, managing communications channels and coordinating communications strategies, campaigns and products to promote the science and societal benefits from Landsat.

✉ ginger.butcher-1@nasa.gov

Dr Chris Barnes is the Landsat Science communications (SGT, Inc.) team lead at the U.S. Geological Survey EROS Center in Sioux Falls, SD, USA. Chris manages a team of scientists and communications specialists responsible for discovering, validating and promoting the characteristics of Landsat Science products.



Linda Owen is a Landsat Science communications (SGT, Inc.) specialist at the U.S. Geological Survey EROS Center, Sioux Falls, SD, USA. She currently coordinates and supports outreach and communication strategies relating to all aspects of the USGS Landsat Missions programme.

FIRST EUROPEAN AERIAL SURVEYING SUMMIT

Generating **Sustainable Business** for an Innovative Industry

Today's digital societies require a continuous supply of updated, reliable and correct geodata, and new technologies are arriving with increasing speed. The manned aerial survey is by far the main source of high-resolution geographical data in the geoinformation ecosystem. This article looks back on the first edition of the European Aerial Surveying Summit, which was held in Denmark in December 2018.

When people talk about geographical data and its creation, then satellites or unmanned aerial vehicles (UAVs or 'drones') – ubiquitous in the daily media stream – often spring to mind. Lately, mobile surveying systems have started to take on a growing role in data capture, especially in urban areas. While all these sources are playing an important part in the geoinformation ecosystem, the main source of high-resolution geographical information remains, overwhelmingly, the manned aerial survey.

Many critical governmental planning processes at any level of authority, whether for fair distribution of subsidies, transport infrastructure planning or flood protection, require a coherent geographical dataset in the accuracy and resolution band of better than 25cm (and for engineering processes down to under 3cm). Many processes are already migrating to three-dimensional data. A specific example is the area of flood prediction and protection measures, where an increase in geometrical accuracy can help to prevent catastrophic events. Additionally, flood events are subject to regional influences, and updated high-resolution height models are scarce and inconsistent across national and state borders. Other areas that are increasingly dependent on high-resolution height information include 5G network planning and power transmission, both of which are crucial elements of digital societies.

Today, over 90% of such data originates from manned aerial survey. The reasons are simple: satellites do not provide the required geometrical resolution and accuracy, drone applications are not yet suited for wide-area surveys, and mobile mapping systems are restricted to movement along roads or rails and provide only the horizontal perspective.

AERIAL IMAGERY MARKET SIZE

In terms of the size of the market, most sources agree that the global aerial imagery market currently has a value of between US$1.5 billion and US$2.3 billion, and a compound annual growth rate (CAGR) of between 11.5% and 14%. The global airborne Lidar market is estimated to generate US$1.3 billion to US$1.8 billion at a CAGR of 16-22%. With North America being responsible for 35-45% of the global share, Asia 20-30%, and Europe 15-25%, the value generation is considerable.

At the same time, and despite this impressive market size, the European aerial survey industry is facing challenges: a new wave of market protectionism and isolationism, prices spiralling downwards, tighter airspace regulations, a lack of standardization, and the more restrictive purchase behaviour of public and large private customers.

▲ *Intense networking during joint Christmas dinner at COWI headquarters.*

▲ *On a mission: gathering the data from the air.*

▲ *Strong interest at technology sessions.*

▲ *Leaders of the European aerial surveying industry under Nordic skies.*

THE STATE OF THE AERIAL SURVEYING INDUSTRY

From 5-7 December 2018, representatives of the European Aerial Surveying Industry gathered in Elsinore/Helsingør, just north of Copenhagen in Denmark, at the first European Aerial Surveying Summit to address market opportunities and challenges. The Danish engineering company COWI, which with its mapping division is one of Europe's major geodata suppliers, hosted the meeting, supported by the sponsorship of Hexagon, RIEGL, CAEAviation and Teledyne Optech. Exclusively dedicated to discussing the state of the aerial surveying industry, the event was the first of its kind in Europe in a long time.

Simon Musaeus, SVP of COWI's mapping division, stated: "Originally, we aspired to give a platform for communication across the sector to inform and understand the options for improving collaboration and businesses. After announcing the summit, the response from the industry was overwhelming, which indicated that we all – acquisition companies, industry suppliers and public agencies – felt a strong need to address the same issues jointly."

The agenda was designed to give a holistic view of the environment and room for open discussion on all relevant aspects of today's aerial surveying industry in Europe. Denmark counts among the countries with the best-developed geodata infrastructure in Europe. Adam Lebech, representative of the Danish Agency for Digitization, opened the conference with a warm welcome note and underscored the increasing relevance of data in general to the rapidly digitizing Danish society. From The Netherlands, another leading country in the use of 3D geoinformation and a long-standing benchmark for NSDI, Erik Nobbe, manager in charge of the national imagery and 3D programme at HWS, shed light on the reality of present-day aerial surveying data capture.

AERIAL MAPPING OF THE NETHERLANDS

Every year, a full aerial survey of The Netherlands is conducted two to three times to satisfy the needs of a growing number of users for relevant information. On the other hand, the rapidly growing demand creates considerable challenges: the data capture is often limited to a particular season (e.g. 'leaves on' or 'leaves off') and, within this time window, can only be carried out in cloud-free conditions. Imagery capture additionally requires a minimum sun angle to avoid shadows, which means operating during the busiest hours of the day. With three very active international airports, Dutch airspace is one of the densest and most strictly regulated in the world, which makes it very difficult to gain access for survey purposes. Despite the importance of geodata collection for the government, it has become clear that the air traffic control authorities and regulations are not willing to prioritize the operations. Unfortunately, this is no exception in Europe.

KEY REQUIREMENTS

The discussion on general topics that the industry perceives as crucial to resolve led to the highlight of the summit – a workshop at which all 50 participants identified the most prominent needs facing society and the industry today. When discussing proposals for change, the attendees identified several key requirements for action which would strongly support the digital societies of the future and generate sustainable business for an innovative industry in Europe:

1. European funding for a large-scale data acquisition programme for high-resolution and high-accuracy 3D data. A good example is the North-American 3DEP
2. Cooperation with and support from the civil aviation authorities to better prioritize aerial survey for the capture of geoinformation that is crucial for governmental planning processes
3. To define, maintain and promote quality, safety, ethical and business requirements for the aerial surveying industry and provide certifications that are acknowledged Europe-wide to ensure a predictable quality and delivery of the data generated in a sustainable way
4. Education of the decision-makers and the general public about the important role that high-resolution geodata from aerial survey plays on the route to digitalization.

The group of participants agreed unanimously to start the formation of an industry association. This body shall act as a professional counterpart to national and supranational funding agencies, promote the use of aerial surveying data, ensure sustainability of the services by certification, and serve as a platform for communication and cooperation among the industry stakeholders to enact positive change. The working group to prepare the formation of the association consists of Simon Musaeus (COWI), André Jadot (Eurosense), Rachel Tidmarsh (Bluesky), Giovanni Banchini (CGR), Florian Romanowski (Opegieka), Aicke Damrau (Geofly) and Klaus Legat (AVT). The target is to incorporate the association before the end of 2019.
The summit was brought to a positive close with words from Søren Reeberg of SDFE, who welcomed the decision and commented that positive cooperation with the industry is also expected from the public sector. The organizers and participants are now looking forward to the next European Aerial Surveying Summit later this year. ◀

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FIG Commissions and Their Work Plans 2019-2022

On 1 January 2019, ten new FIG Commission chairs started their term of office. A kick-off meeting was held from 9-10 January in Copenhagen to discuss their work plans. During November/December 2018 they had already worked on the technical programme for the FIG Working Week 2019 (22-26 April in Hanoi, Vietnam). The programme was also discussed and fine-tuned at a creative workshop.

The work plans will be presented in Hanoi but we can already reveal their overall ideas here:

- Commission 1 (Professional Standards and Practice) will engage surveyors in all member associations with the importance of acting ethically around the world, augment the FIG publication on international boundary making with reference to unstable ground and climate change as well as maritime boundaries, and build the Women in Surveying network for promoting gender equality.
- Commission 2 (Professional Education) will focus on developing academic networks for knowledge sharing, innovative learning and teaching/'Curriculum on the Move' and learning styles in surveying education.
- Commission 3 (Spatial Information Management) will focus on geospatial information infrastructures for smart cities, the collection, processing and presentation of geospatial big data, user-generated spatial content, and 3D cadastres.
- Commission 4 (Hydrography) will focus on development and recognition of standards of competency, development of technical standards and guidelines, developing and promoting the need to manage our oceans and seas in a sustainable manner, and a comprehensive investigation of plastic pollution at source that is concerning global environmental problem ('Mapping the Plastic').
- Commission 5 (Positioning and Measurement) will continue to arrange and develop the Reference Frame in Practice seminars as well as continuously address important issues concerning geodetic reference systems, geodetic positioning and measurement.
- Commission 6 (Engineering Survey) will support and accompany the development of projects in several domains of civil engineering, and promote the adaptation of innovative and advanced methodologies and technologies to projects, construction and structure monitoring.
- Commission 7 (Cadastre and Land Management) will focus on providing a discussion platform for ideas and tools to improve land tenure security around the world. Public-private partnerships in land administration and 'fit for purpose' are topics of particular interest.
- Commission 8 (Spatial Planning and Development): land is a scarce resource. In pursuit of a sustainable development, it is key to balance the various, sometimes conflicting, interests in spatial planning and to acknowledge the voice of all stakeholders. Themes that will be addressed are urban challenges, urban-rural dependencies, and GIS and land policy tools for implementation.
- Commission 9 (Valuation and the Management of Real Estate) will focus on the economic strand of surveying and specifically the valuation/appraisal of real estate. It will also look at compulsory acquisition, sustainable land and property taxation, new technology such as AVMs, informal land markets, new sectors such as natural-ecosystem value and international standards such ILMS and IVSC valuation standards and methodology. Commission 9 is also engaged with numerous agencies such as World Bank, UN FAO, GLTN and IFC.
- Commission 10 (Construction Economics and Management) will focus upon collaborative international standards in this discipline (ICMS), digital construction (including BIM) and differing approaches to the financial management of construction around the world.

Young Surveyors Network: the vision for the next two years is to inspire the next generation of surveyors based on five key initiatives – partnerships, communication, events, development and outreach.

You can meet the commissions and commission chairs from 22-26 April 2019 in Hanoi, Vietnam.

More information
www.fig.net/fig2019

Commission chairs working on the technical programme for the FIG Working Week.

Review of IX Hotine-Marussi Symposium on Mathematical Geodesy

The series of Hotine-Marussi symposia on mathematical geodesy are important for theoretically oriented geodesists. The tradition of these symposia started in 1959 with the first Symposium on Mathematical Geodesy organized by Antonio Marussi in Venice, Italy. After Marussi's death in 1984, the series were renamed the Hotine-Marussi symposia, also in honour of Martine Hotine who had died in 1968. The Inter-Commission Committee on Theory (ICCT) of IAG has been responsible for their organization since 2006.

The IX Hotine-Marussi Symposium on Mathematical Geodesy was held from 18-22 June 2018. The symposium took place at the Faculty of Civil and Industrial Engineering of the Sapienza University of Rome, Italy, in the ancient Chiostro of the Basilica of S. Pietro in Vincoli. The symposium was attended by 119 participants from 30 countries who contributed 120 papers (83 oral presentations and 37 posters). The symposium's scientific programme was grouped into ten sessions that were mainly thematically related to ICCT study group topics:

I. Geodetic methods in Earth system science (N. Sneeuw)
II. Theory of multi-GNSS parameter estimation (A. Khodabandeh, M. Crespi)
III. Digital terrain modelling (R. Barzaghi)
IV. Space weather and atmospheric modelling (K. Börger, M. Schmidt)
V. Global gravity field modelling and height systems (D. Tsoulis, S. Claessens)
VI. Theory of modern geodetic reference frames and Earth's rotation (Z. Altamimi)
VII. Deformation and gravity field modelling at regional scales (J. Huang, Y. Tanaka)
VIII. Estimation theory and inverse problems in geodesy (A. Dermanis)
IX. Advanced numerical methods in geodesy (R. Čunderlík)
X. Multi-sensor and time series data analysis (W. Kosek, K. Sosnica)

The symposium's scientific programme was complemented by a social programme including a night tour of the Vatican Museum and the Sistine Chapel.

More information
https://sites.google.com/uniroma1.it/hotinemarussi2018.

Participants of the IX Hotine-Marussi Symposium, 18-22 June 2018, in the Chiostro of the Basilica of S. Pietro in Vincoli, Rome, Italy.

ICA and the Rising Sun

The world reputation of Japanese cartography has been high and longstanding. A sea-going nation with a unique landscape at home, with contemporary environmental awareness, population pressures, industrial strength and an innovative culture, Japan's dedication to cartography and geographic information handling is second to none. Japanese cartographers are recognized in current advanced research in many aspects of cartography – notably in maps for ubiquitous/wearable/mobile devices, public information map displays, graphic design, mountain and topographic mapping, and location-based and navigational map systems.

Having previously visited Japan in 1980 for its 10th International Cartographic Conference (ICC), ICA has been invited back for the 29th ICC. This will take place in Tokyo from 15-20 July 2019. This major biennial global conference allows for 1,500 cartographers from academia, government and industry around the world to join in fellowship and share the latest innovations and developments in mapping techniques, technological advancements and current research in cartography and GIScience. Participants are invited to submit papers and abstracts on the latest scientific and social developments in these fields, on themes and topics listed on the conference website. The breadth of our contemporary discipline is reflected in the scope of contributions and participation.
ICCs are characterized by a significant

number of associated workshop meetings organized by the ICA Commissions, vibrant social events, extensive map and technical exhibitions, and the highlighting of children's cartography. Participation is encouraged from young researchers, and ICA scholarships are available.

The fascinating country of Japan, with many tourist attractions in urban, rural, mountain and coastal regions, provides many memorable destinations. The conference location, Japan's capital and largest city Tokyo, is itself well worth a visit. One of many appealing sites is the National Museum of Emerging Science and Innovation (Miraikan), which is also the well-equipped venue for ICC2019. The Geo-Cosmos, the symbol exhibit of Miraikan, produces a range of representations of Earth shining brightly in space with ultra-high precision. It is the world's first globe-like display using organic LED panels.

The Geo-Cosmos digital globe in the Miraikan museum, Tokyo.

The conference will take advantage of the newly adopted ICA Publications Policy, giving all contributors the opportunity to have widespread exposure of their input, research and activity. All geoscientists from around the world are encouraged to contribute to, participate in, and learn from this valuable meeting in July.

More information
www.icc2019.org
www.icc2019.org/papers.html
icaci.org/scholarship/
icaci.org/publications/
www.icc2019.org/papers.html
icaci.org/scholarship/
icaci.org/publications/

Reviewing – Nuisance or Necessity?

Many of us are receiving review requests for submitted manuscripts almost on a daily basis. This creates a lot of work, but the scientific merit of a contribution can only be evaluated by scientists. Thus, nobody else can do the job. Nevertheless, contributions for conferences used to be well accepted without any review; The ISPRS Archives are a very good example. Today, The Archives are indexed in the Web of Science, SCOPUS, Google Scholar, etc. In 2012, ISPRS introduced a full-paper double-blind proceedings series called ISPRS Annals. To improve the reviewing procedure, ISPRS recently published reviewing guidelines. Such an additional review procedure creates more work for everybody involved. So why did we do this?

Here are a few answers:

- Many fields recently started overlapping, e.g. photogrammetry, remote sensing, computer vision and robotics, as well as mapping and geospatial information sciences. Many of the other groups are larger than our community. Thus, in order to remain relevant and visible, we need to produce excellent scientific results. While a review process of course has its own pitfalls, a rigorous and constructive reviewing process improves the scientific quality of publications.
- The publications are a core currency of the scientific world. There is a clear trend that in particular the best of our younger colleagues present their work in meetings outside our community. They believe that in neighbouring fields, which typically have peer-reviewed and high-quality conferences with many participants, they earn more credits for their career. If we don't want to lose them (and thus risk losing our own future), we need to organize similarly high-quality meetings. The success of the *ISPRS Journal of Photogrammetry and Remote Sensing* proves that we are capable of doing so.
- Some people argue that the time-consuming task of writing a 'real' paper should be reserved for journal submissions, as journals are more highly regarded than proceedings. However, for someone with little experience, trying to publish a journal paper from scratch is a tremendous challenge. Adequately extending a good proceedings paper can be a more successful way to reach the goal.

There are, of course, counterarguments: in a number of research organizations, proceedings publications also indexed are not considered of any value. This is one of the reasons why ISPRS also provides The Archives series, so the authors have the choice.

IF THE PAPER TO BE REVIEWED IS GOOD, WE CAN ALSO ADVANCE OUR OWN KNOWLEDGE

In summary, I am convinced that in order to maintain our role in the scientific community, we must produce first-class scientific works. Reviewing helps in doing so. And if the paper to be reviewed is good, we can also advance our own knowledge. What more is there for a dedicated scientist?

By Christian Heipke

More information
www.isprs-ann-photogramm-remote-sens-spatial-inf-sci.net/IV-5/53/2018/
https://bit.ly/2SQ4ARy

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