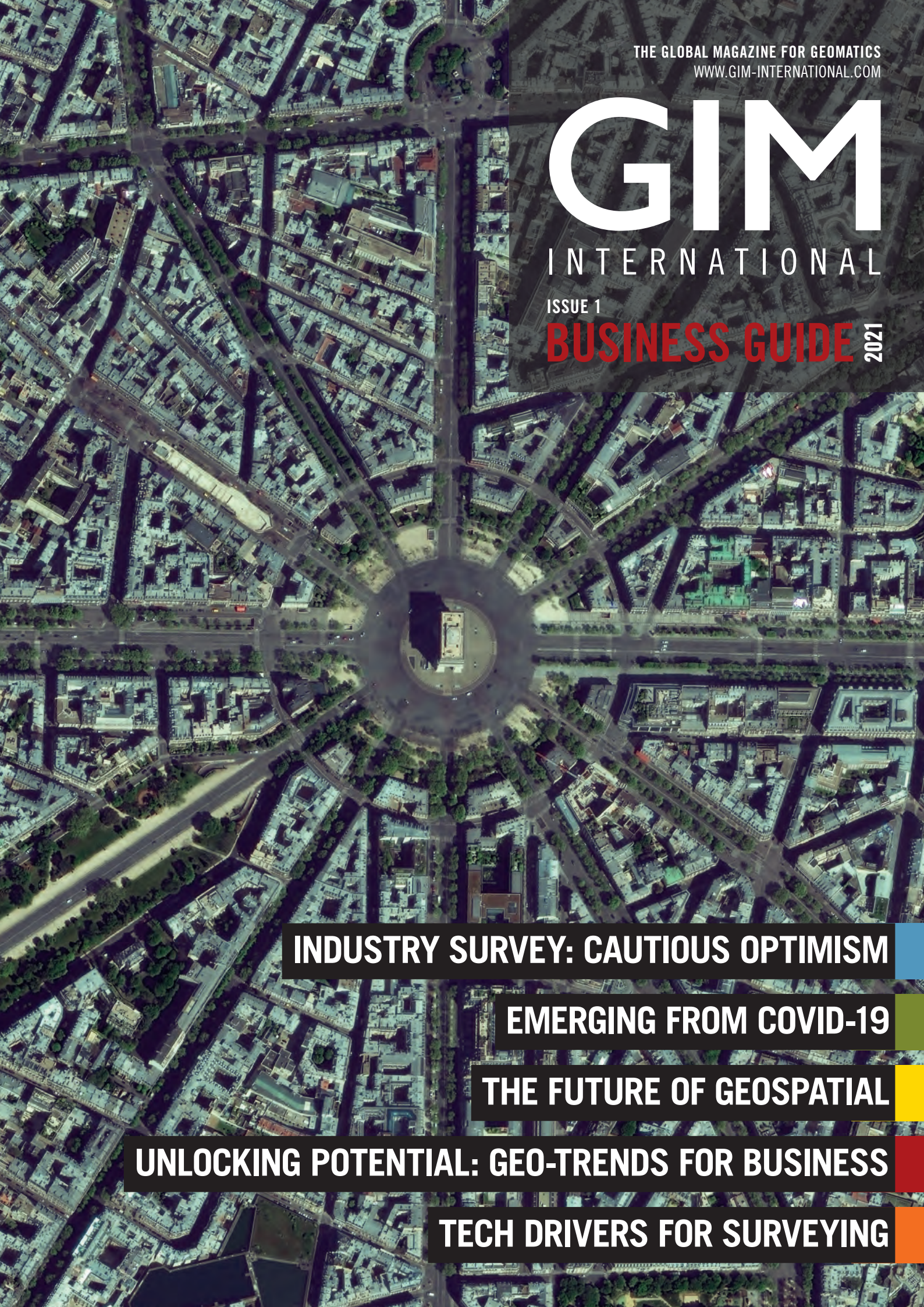

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GIM INTERNATIONAL

ISSUE 1

BUSINESS GUIDE 2021

INDUSTRY SURVEY: CAUTIOUS OPTIMISM

EMERGING FROM COVID-19

THE FUTURE OF GEOSPATIAL

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COVER STORY

European Space Imaging captured this image over Paris, France, with WorldView-3 in April 2020 during the first phase of COVID-19 lockdowns. The image was acquired in the effort to assist EU public institutions and media outlets with visual overviews of deserted tourist hotspots, airports and highways to assist decision-making aimed at addressing the economic and logistical impacts of the pandemic.

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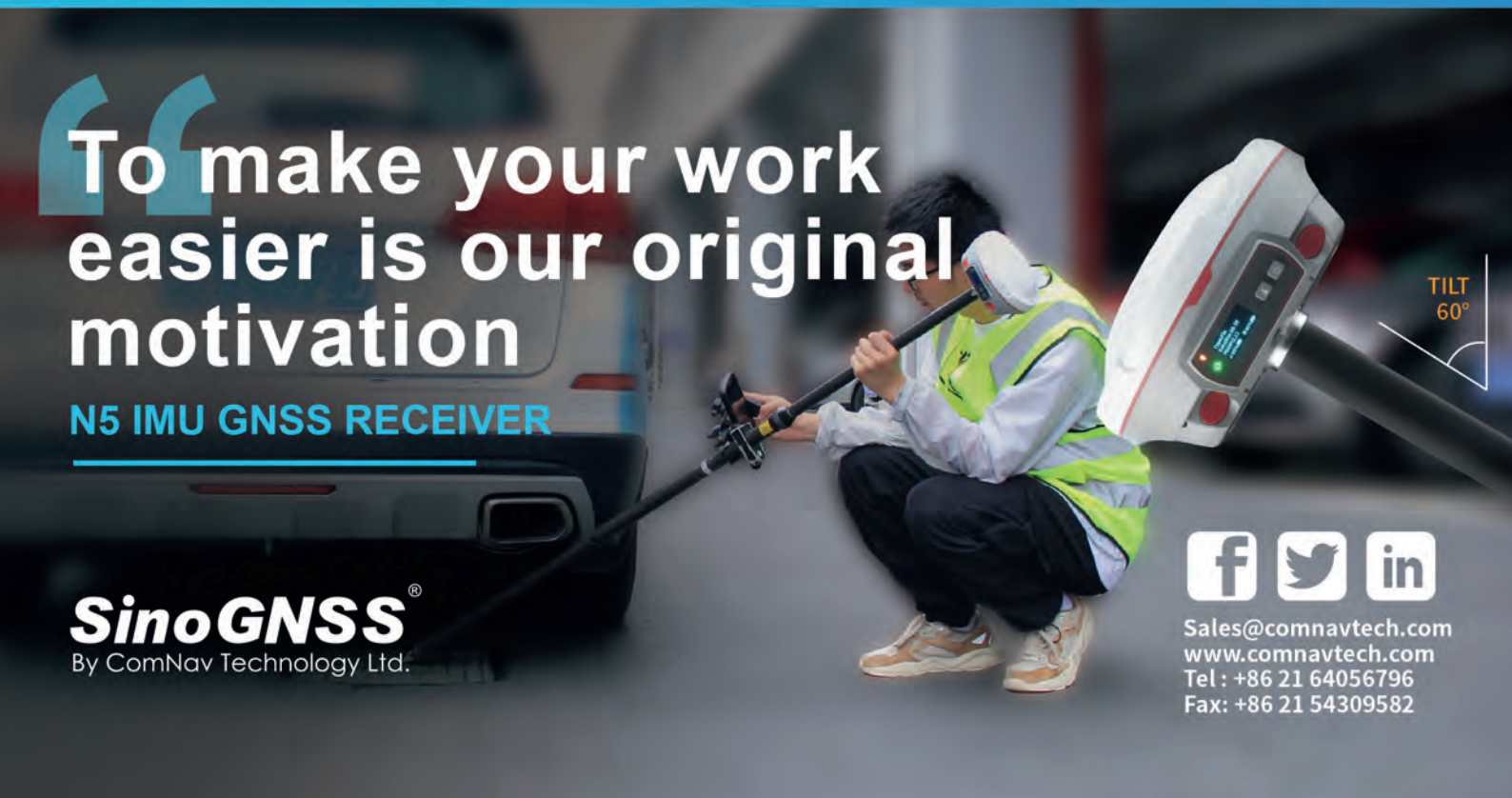

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Looking beyond

Our aim with this year's *GIM International* Business Guide is to give you a glimpse of tomorrow's geospatial industry. Needless to say, this is a very difficult time to be trying to predict the future, and yet we are all eager to know when we will be able to visit our friends and family again, eat out at a restaurant, attend a concert or festival and travel wherever we want. For many of us, professional life has almost come to a standstill due to the COVID-19 pandemic – or at the very least our world has shrunk as we are restricted to working from home, with no tradeshows or business trips and contact with colleagues and business contacts limited to videoconferencing at best.

'Forewarned is forearmed' as the saying goes, and that is fully in line with what we try to accomplish at *GIM International*. By keeping you – our readers – informed, we aim to give you a head start in preparing for the future… whatever it may bring. So in this Business Guide we attempt to look beyond the end of the pandemic, to paint a picture of where the industry is heading and what the longer-term consequences of this crisis might be. Based on the responses in our yearly reader survey, we can conclude that cautious optimism prevails over pessimism about the coronavirus crisis thanks to some bright spots keeping spirits high (see page 7). David Henderson and James Norris from the UK's Ordnance Survey have written about one of UN-GGIM's most important reports in their article titled 'Unlocking Potential: Emerging Geospatial Trends for Business' (page 21). Additionally, Andrew Coote has envisaged the geospatial industry after COVID-19 (page 13) and Vanessa Lawrence shares her predictions for the future of geospatial data (page 17). After reading this edition, you should have a clearer – and well-founded – idea of what probably lies ahead.

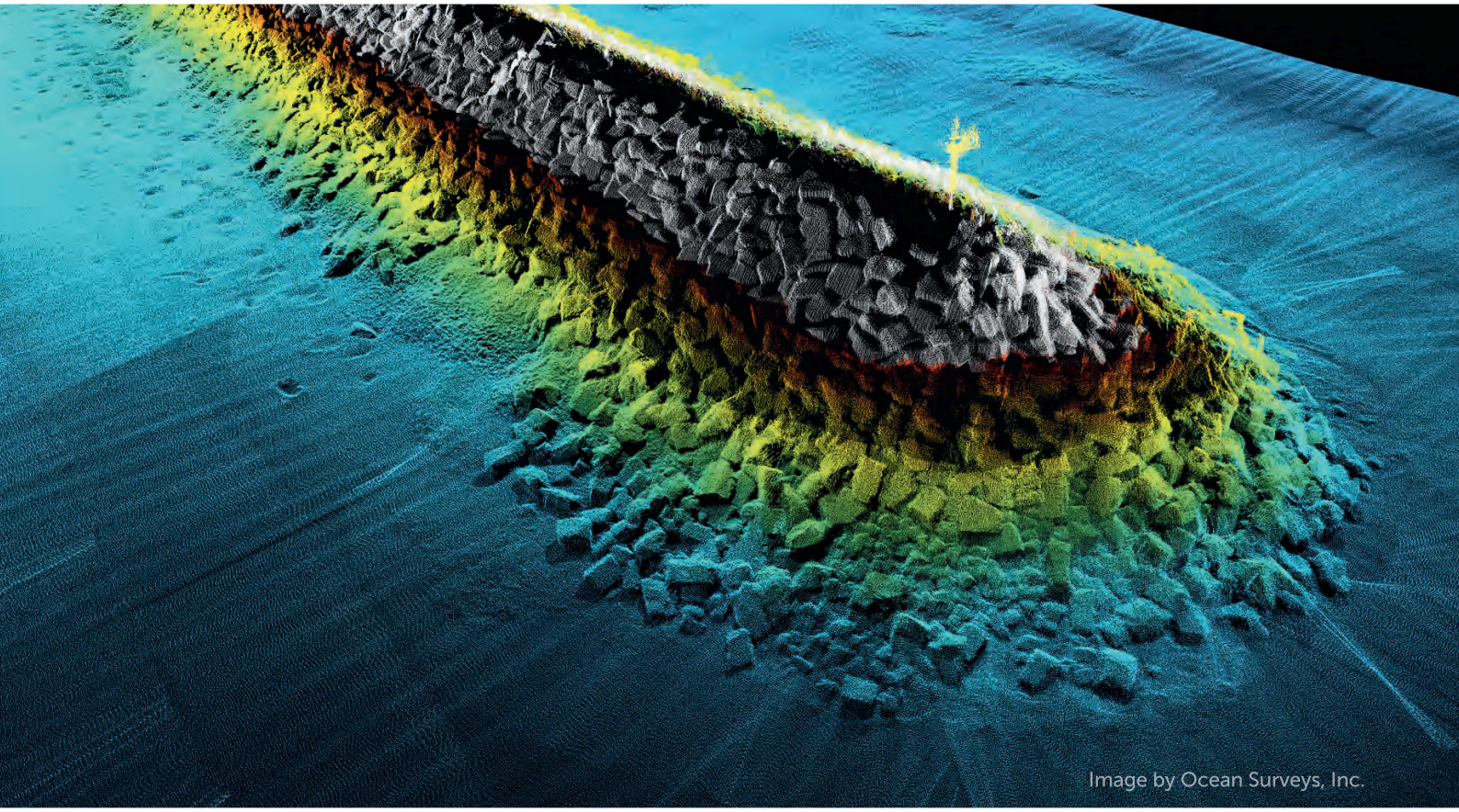
This is a good opportunity for me to proudly introduce our new technical editor, Huibert-Jan Lekkerkerk, who is a trained professional with extensive experience in both geomatics and hydrography. In fact, Huibert-Jan is a teacher, an analyst and a consultant all rolled into one and he has been a member of our editorial board for several years. Following the retirement of our senior editor Tjeu Lemmens last year, Huibert-Jan has agreed to join us in supporting our readers in their professional lives by bringing them the latest news and developments in geomatics technology. Huibert-Jan will be a regular contributor to *GIM International* from now on, so if you want to suggest ideas for articles, you can contact him on info@hydrografie.info. I wish Huibert-Jan all the best in his new role!

In the context of looking beyond, I would like to conclude by wishing you all the best for 2021 – both personally and professionally – from everybody here at *GIM International*. May health and prosperity go hand in hand as we leave the challenging times behind us and seize new opportunities that lie ahead!

Durk Haarsma,
director strategy & business development

durk.haarsma@geomares.nl

TELEDYNE OPTECH AND TELEDYNE CARIS



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Harxon TS112

Harxon's TS112 smart antenna family adopts Harxon's latest positioning technology and offers scalable positioning solutions with increased GNSS availability, reliability and accuracy for demanding applications such as agricultural machine autosteering, even in harsh environments. Each model of the TS112 family embeds a Harxon X-Survey technology 4in1 multifunctional GNSS antenna that integrates 4G, Bluetooth and Wi-Fi in one compact unit. This high-gain GNSS antenna features multi-point feeding technology, ensuring ultimate RTK centimetre-level positioning accuracy. The TS112SE, as the most affordable solution of the three, provides flexible positioning solutions via standalone positioning or dual-frequency precise point positioning (PPP) with accuracy from sub-metre to centimetre level while using the SAPA precise augmentation service. The SAPA precise augmentation service works as a reliable and economical alternative positioning option with wide service coverage in application environments that have poor LTE network coverage. The TS112 integrates a high-precision GNSS module with multi-band GNSS receiver and delivers RTK-level positioning accuracy for precision agriculture equipment and machine control. It also integrates 4G and a UHF radio modem for flexible correction transmission in the field. The TS112 PRO employs a future-ready NovAtel OEM GNSS module, offering global centimetre-level positioning utilizing TerraStar satellite-delivered correction services without the need for network infrastructure. Harxon's TS112 PRO also supports NTRIP service, so in application environments where it is not feasible to use a base station, the NTRIP differential corrections could be transmitted to a rover using 4G networks and enable users to achieve ultimate centimetre-level positioning accuracy.

ImpulseRadar

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Pentax G7N

The Pentax G7N is a GNSS smart antenna that will debut in spring 2021 as the latest model in the Pentax GNSS receiver family. Based on a powerful GNSS engine with precise point positioning (PPP) capability, the G7N integrates an inertial measurement unit (IMU), wireless datalinks and web UI system management for a complete field solution. The G7N has 555 channels for full tracking of all major satellite constellations for fast fixed RTK initialization. The IMU complements the position solution with full 3D orientation that provides tilt and azimuth for more efficient and accurate surveying. The integrated wireless datalinks include a global cellular modem, a full-band UHF radio, Bluetooth and Wi-Fi for cable-free operations. Two hot-swappable batteries provide continuous operation and an SD card provides additional memory up to 32GB. Traditional serial communication, external power and UHF antenna are included with ports on the bottom of the G7N. The innovative mechanical design of the G7N features a small and lightweight magnesium alloy housing, certified to IP67 standards for all-weather use. Furthermore, the product design facilitates superior access to the battery ports, SIM card and SD card slots for easy insertion or removal in the field. Configuration and status can be easily reviewed and changed from the on-board web UI that is accessible from any PC, tablet or smartphone via Wi-Fi. The web UI also allows wireless firmware upgrade and data transfer. Overall, the G7N combines multiple sensors for a robust and accurate RTK solution for the land survey and GIS markets, with easy wireless access and flexibility as a base, rover or repeater.

Zoller + Fröhlich LaserControl 9.2

Zoller + Fröhlich (Z+F) is one of the world's leaders in 2D and 3D laser measurement technology and continues to develop innovative solutions for the surveying industry. Z+F LaserControl Office and Scout are the optimal solution to work efficiently and fully with the laser scanners of Z+F. A range of filters, measurement and registration tools enable high-differentiate processing of scan data and are the key to filter, register and colour 3D point clouds. Thanks to the large selection of export formats provided by Z+F LaserControl, data can be imported and further processed in all common 3D software applications. Just as important as very high-accuracy measurements is the precise registration of point clouds and thus the avoidance of gaps in projects. In Z+F LaserControl, users have several registration options. In addition to classic target registration, point cloud algorithms can also be registered together with Cloud-to-Cloud and Plan-to-Plan (with the Scantra plug-in). These registration options are included in Z+F LaserControl Office (Premium) and Z+F LaserControl Scout. The new version of Z+F LaserControl 9.2 ensures a whole range of optimizations. In addition to the new light scatter compensation, there are many new tools in Scout and Office that increase the workflow efficiency with the point clouds.

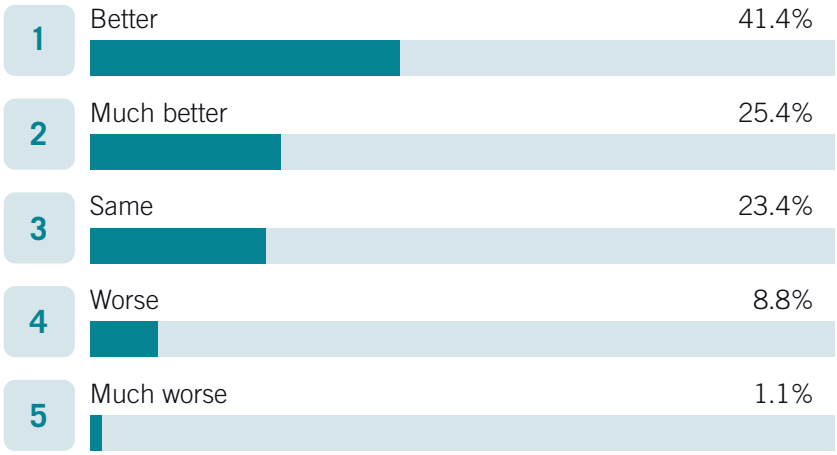
Geospatial Industry Cautiously Optimistic Despite Pandemic

This year's annual *GIM International* industry survey was conducted the twilight of 2020. After a year in which the COVID-19 pandemic turned everyday life upside down in many parts of the world, it seems more important than ever to gauge the mood of the geospatial business. Encouragingly, despite all the trials and tribulations caused by coronavirus, there are plenty of bright spots helping to keep spirits high in the mapping and surveying profession. This article outlines the key findings from the survey.

While some industries soared to new heights due to behavioural shifts caused by the pandemic, other sectors have taken a severe hit. The global outlook is unclear, although financial analysts state that governmental stimulus measures – for instance in the USA and European Union – together with the expected upturns once the pandemic has passed its peak will lead to new prosperity. "Vaccines will bring economy near recovery by end of 2021" was the headline in *Forbes* magazine in December 2020. Let's hope it comes true.

IMPACT OF COVID-19

This year's industry survey received responses from professionals in no less than 115 countries and with a wide variety of job titles, including consultant (31.3%), researcher/academic (17.8%), manager (16.5%), government official (9.7%) and technician (7.8%). They also covered the broad spectrum of sectors in which geospatial applications are used: 49.7% of the respondents are involved in land management, 39.6% in building & construction, 35.4% in infrastructure, 27.3% in urban planning and 14.3% in agriculture.



▲ *What are the expectations of the prospects in the surveying market in 2021 compared with the past couple of years?*

Unsurprisingly, the survey shows that the pandemic is affecting the business of almost all mapping and surveying companies across all verticals worldwide. Many surveyors have experienced a decrease in activity due to a reduced volume of work. Projects have been delayed, postponed or even cancelled. Revenues have fallen by 20%, 30% or even more due to the coronavirus restrictions. One respondent states that their business has been brought to a standstill.

Similar challenges are being experienced around the world. Remote working is difficult when much of the activities involve field work, such as to collect spatial data. A survey engineer from Hong Kong echoes this: "In the construction industry it is hard to work from home. You can't pour the concrete at home to 'remote construct' a project." "It has been pretty bad for us in the UK," comments another respondent. "We don't have any projects in our area because of the pandemic, so many people are leaving and resources are going to waste." A consultant from Bolivia states: "There are a lot of delayed or cancelled projects. We have seen a shift in the allocation of funds, from land administration to COVID-19." A land survey professional from India sums up his position as follows: "Being confined to home has turned me in a keyboard consultant."

Meanwhile, many companies are struggling to find a balance between productivity and employee well-being, as indicated by a manager from a survey company in the USA: "It has been hard to keep the crews on track and productive; we are all scared we may be causing harm by being exposed and then taking the virus home with us." Other effects being felt by geospatial professionals include longer stints away from home due to travel restrictions, quarantine both onshore and offshore, and uncertainty of contract work.

WIDE RANGE OF EXPECTATIONS

While it can be difficult to remain optimistic during such challenging times, a positive mindset always helps. A considerable number of survey participants are doing their best to see the upside of the current temporary lull in activity. As a geospatial consultant from Bulgaria puts it: "We now have time to think about innovation. On the edge of crisis, throughout the history of humankind there have been a lot of good examples of innovations that change directions to success." A consultant from South Africa takes a similar view: "COVID-19 has made me rethink and refocus my business." A software developer from Ireland states that his company has used the opportunity to make a positive shift to new technology and smarter working. Likewise, a consultant from Canada has seen positive change at his company: "The circumstances favour changes and have pushed the adoption of new technologies." These and other positive responses from the survey participants provide a ray of hope in the short term.

Although a considerable number of respondents are only cautiously optimistic about the future and prefer to take a 'wait-and-see' approach, many other industry professionals seem to already be focusing on the brighter future that will follow when the pandemic is finally over. In fact, the mood among some matches the same positive vibe reflected in last year's industry survey. This optimism is supported by the fact that various governments are initiating major national infrastructure projects, in effect investing their way out of the crisis rather than intensifying it by making cutbacks. For example, during the first wave of the pandemic the UK government announced a multi-billion-pound road and railway investment plan to stimulate the nation's economic recovery. Meanwhile, in the Netherlands, the government has launched a €20 billion national growth fund to invest in infrastructure and research & development projects. Although that initiative is not directly linked to the coronavirus pandemic, it nevertheless offers interesting opportunities for mapping and surveying companies.

▲ *Governments across the world are initiating major national infrastructure projects. (Image courtesy: Züblin Spezialtiefbau)*

▲ *GIS is increasingly shifting towards apps on mobile devices which enable faster data capture and information processing.*

WORLDWIDE NEED FOR GEODATA

Geospatial data already forms the essential information layer for many public services, but the rapid spread of the pandemic and the high number of cross-border initiatives to monitor and contain the spread of the virus have further highlighted its importance. For example, governments require highly detailed maps to be able to organize the nationwide programmes. A survey consultant from Indonesia experts this to drive the demand for reliable geodata, creating excellent opportunities for companies specialized in data capture, processing and visualization.

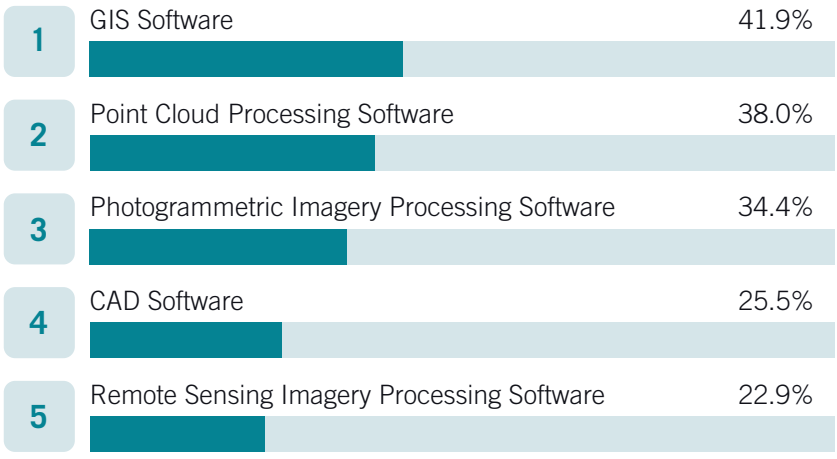
Moreover, the pandemic has put our industry firmly in the public eye. Hence, one US-based surveying manager involved in the autonomous driving business foresees a post-pandemic realization of how important spatial data is for various other markets and industries. A geomatics academic draws the same conclusion, commenting: "There are so many challenges facing different parts of the world which can be solved by our profession, thus presenting opportunities to show our relevance and importance."

Digitalization will play an important role in helping the industry to make the most of the brighter future that lies ahead, as a surveyor from Canada points out: "Once the pandemic is over and there is a return to near normal, I believe the industry will continue to grow through the increasing adoption of technology." A researcher from Croatia sees the current circumstances as fuelling new initiatives and opportunities: "The pandemic has shown that spatial information is essential for so many human activities. The ongoing development of technology and new concepts (digital twins) will boost development and business." A researcher from Malaysia agrees: "I expect that the integration of BIM and surveying applications will mature."

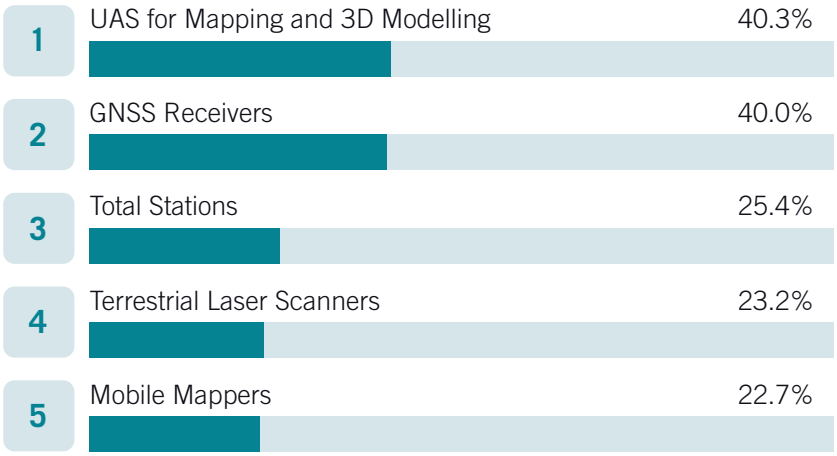
ROBOTICS

The survey confirms that developments in the field of autonomous systems are expected to continue to drive progress in scanning technologies, including processing. For example, the miniaturization trend in advanced sensor technology means that high-performance scanning equipment is getting smaller all the time, which is opening up new applications related to autonomous vehicles and mobile mapping systems. As this year's industry survey reveals, such solutions are high up on the wish list of a significant number of mapping and survey companies.

It is a relatively small step from autonomous vehicles to robots. There are already examples of robots being used in construction and mining, among other applications, as part of a complete surveying workflow or an as-built reality-capture workflow with a high degree of autonomy. Therefore, the robotization trend is generally expected to accelerate. Not everyone sees this as a positive development, however. An academic from Malawi makes the following prediction: "Surveying will increasingly be controlled by robots. One day, a person will only be required for verification, and eventually verification will be done by robots too. With machine learning/artificial intelligence/computer vision coupled with robotics, the number of workers in the companies will greatly reduce. The money will be invested in buying equipment rather than paying salaries."



▲ *In what type of software do organizations plan to invest in 2021?*



▲ *In what type of hardware systems do organizations plan to invest in 2021?*

MOBILE CONNECTIVITY

According to the respondents, mobile connectivity is another of the technological developments having the greatest impact on today's surveying profession. Several professionals point out that GIS as an end product is increasingly shifting towards apps on mobile devices which enable faster data capture and information processing. Needless to say, the key benefit of app-based mobile mapping is convenience; such solutions support easier and more user-friendly surveying, especially in hard-to-reach areas and when accuracy demands are not too high. "Mobile is king for getting geospatial into the hands of users," states a New Zealand government official, summarizing the popularity of such apps. However, a surveying manager from the United Arab Emirates sees this as posing a potential threat to the reputation of the profession: "Although the technologies will get better, the quality of the end products will deteriorate since more and more individuals without solid technical/theoretical surveying background will get involved (for cost-saving reasons) by the decision-makers who don't possess the technical knowledge to properly support decision-making on these issues." On the upside, a Belgian respondent working for a large manufacturer of survey equipment and software states: "I see parallels with the iPhone… the iPhone hardware gets better, but it is the app ecosystem that drives adoption and value-add. We will see the same in surveying. The ever-improving sensors will bring new applications."

ARTIFICIAL INTELLIGENCE

A survey company manager from Romania sees a strong connection between the rise

of mobile devices and artificial intelligence (AI): "More and more on-board artificial intelligence is embedded in these devices and the 5G technology will allow them to collect and process files data and provide the basic deliverables from the field." Judging by the frequency with which AI is mentioned in this year's survey, many others agree with him that this is an important development in the surveying profession. "The automated processing of collected data simply offers so many opportunities," observes one professional from the Netherlands. In a broader software and IT context, several respondents believe that the innovations made in software for mass data processing will lead to large-scale adoption of photogrammetric and remote sensing processes. Again, AI plays a key role here.

GROWTH OPPORTUNITIES AND INVESTMENT

In terms of hardware trends and investment plans for 2021, the respondents' answers indicate that many organizations are keen to invest in mobile mapping systems, whether as unmanned aerial vehicles (UAVs or 'drones') or ground-based systems. Total stations – the surveyor's workhorse – and GNSS receivers are also part of many investment plans, so it seems that these classics remain indispensable tools. On the software side, the top-ranking purchases lined up for 2021 are GIS software, photogrammetric imagery processing software and point-cloud processing software.

While many companies still intend to invest in new survey equipment and software systems this year, some of them have understandably put their purchasing plans on hold due to the economic impact of COVID-19. This has somewhat hampered the preparedness to invest compared with a year ago. However, based on the respondents' feedback in the survey, it is likely that the situation will return to pre-COVID-19 levels once the economy has bounced back.

CONCLUSION

The overall industry mood can perhaps best be illustrated by a consultant from Nepal who, despite having lost his job due to the economic effects of the coronavirus pandemic, nevertheless remains optimistic: "A geospatial component is being added to every part of technology. So there is increasing usage in a variety of fields beyond just disaster management and infrastructure. Hence, I strongly believe that future is very geospatial." A researcher from India is likewise positive about the longer term: "Geospatial technology is being recognized as an efficient, accurate and cost-effective technology by administrators, planners and decision-makers, so we can expect its use to increase."

While there is no denying that the COVID-19 pandemic is currently creating economic headwinds for many of us, we can conclude that the outlook for the geospatial industry remains very promising. ◀

ABOUT THE AUTHOR

Wim van Wegen is head of content of *GIM International*. In his role, he is responsible for the print and online publications of one of the world's leading geomatics trade media brands. He is also a contributor of columns and feature articles, and often interviews renowned experts in the geospatial industry. Van Wegen has a bachelor degree in European studies from the NHL University of Applied Sciences in Leeuwarden, The Netherlands.

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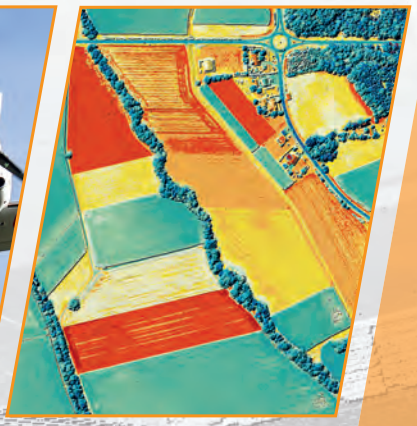

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5 Questions to... Hansjörg Kutterer, DVW

Innovative developments based on quantum physics will lead to further disruption of our professional field over the coming decade, predicts Hansjörg Kutterer who, besides being president of DVW, is also a professor of geodetic Earth system science. *GIM International* asked him five questions relating to the challenges and opportunities in the geospatial industry, now and in the future.

2020 was an extraordinary year. How has the COVID-19 pandemic changed the way the industry operates, and which other factors are influencing the geospatial business?

The pandemic was and is extremely influential on our professional life. At very short notice, we had to considerably change our approaches from on-site and immediate to remote and fully virtual settings. Fortunately, we could benefit from the ongoing digital transformation. The existing digital infrastructure and established procedures based on digital communication and collaboration tools could be used in order to overcome obstacles caused by the pandemic. Thus, it was possible to provide effective substitutes in the given situation, such as digital meetings, digital conferences or digital teaching. Nevertheless, both technical capacities and personal capabilities needed rapid upgrades. Actually, the accelerated digitalization is both an opportunity and an obligation for the geospatial business, as work can generally be continued on a digital basis but very often relies on digital geospatial data.

Which new technologies do you foresee becoming important to your work?

This is going to be the decade of continuous Earth observation based on a sustainably maintained infrastructure and a comprehensive open-data policy. The European Copernicus system may serve as an example. Rapidly increasing amounts of heterogeneous geospatial data are obtained within very short time spans. These new opportunities are accompanied by the strong need for effective data management using integrated research data infrastructures, for example. Moreover, advanced data processing is required which comprises things like deep learning techniques. I also expect that innovative developments based on quantum physics will lead to further disruption of our professional field over the coming decade. Quantum sensors such as optical clocks will provide accurate height differences over large distances, and quantum computers will further speed up time-consuming computations.

Is the surveying profession able to attract enough qualified personnel?

The number of qualified personnel is becoming increasingly crucial for the further development of the surveying profession. Despite the broad appeal of our professional field and the high number of vacancies, there is still a lack of public visibility and thus limited awareness among potential candidates. For this reason, there have been various activities in Germany over the years aimed at reaching and attracting more young people to the industry. For example, the Instagram campaign #weltvermesserer has been launched in 2021 by a consortium consisting of all national stakeholders, including the private sector, administration, science and all relevant professional organizations. Both the expected impact of this campaign and the increasing interdisciplinary nature of our professional community will provide a good basis for tackling this sizeable challenge successfully.

What is your policy on crowdsourcing and open data?

Due to my academic role and my volunteer position within DVW, my answer is twofold. Open data policies are mandatory for a more comprehensive scientific, administrative or private exploitation of existing and newly incoming data. This definitely refers to all stakeholders who rely on geospatial data. Data generated and used in science and education must be open and available through efficient digital data infrastructures. Sustainable open-data initiatives and programmes are highly appreciated. Crowdsourcing offers the opportunity to collect data that is either outside the scope of public agencies or could offer an alternative to existing administrative data that is only available with a licence. The DVW organization encourages any initiative that advances the fields of geodesy, geoinformation and land management.

In terms of meeting your goals, what is the biggest challenge for your organization in the next five years?

As a university professor I am very aware of the increasing need of the professional community for enhanced capabilities in the digital transformation, in smart and integrated systems, in the widespread application of our contributions, and in interdisciplinary work. This needs to be further implemented in the curricula over the coming years, including effective digital settings and dedicated competence-oriented techniques. Actually, this is also linked to DVW's activities, albeit from the perspective of a non-profit organization. As DVW, we offer professional expertise, conferences, post-graduate training, highly skilled working groups, and – last but not least – an attractive networking platform for our members, essentially based on volunteering. This needs to be sustainably maintained and further developed. ◀

Hansjörg Kutterer has been president of the German Society for Geodesy, Geoinformation and Land Management (DVW) since 2016. He has strong expertise and long-term high-level experience in various fields of geodesy and geo-information, both in academia and administration. Since 2018, he has been a university professor of geodetic Earth system science at Karlsruhe Institute of Technology (KIT). Prior to that, one of his roles was as director general of the German Federal Agency for Cartography and Geodesy (BKG).

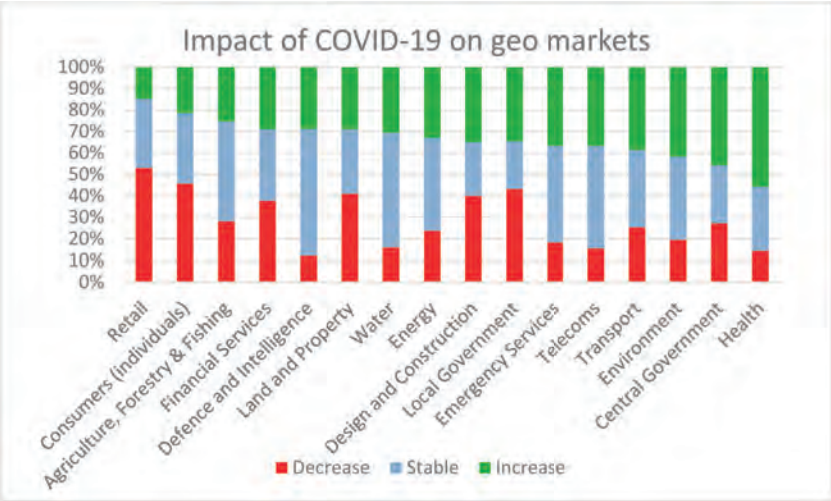
Emerging from COVID-19

The geospatial industry has been more fortunate than others – such as hospitality and tourism – during the COVID-19 pandemic. In fact, there are some exciting opportunities relating to accelerating the digital transformation so that businesses can adapt to the 'new normal', as well as economic stimulus packages with a greater emphasis on green growth. Furthermore, the health sector, which has long failed to exploit the potential of geospatial, has started to recognize its value. This article examines these and other influences that are likely to shape the future of the geospatial industry.

The COVID-19 pandemic has provided a warning about the very real risk of new crises of an unforeseen nature emerging in the future. At a time when healthcare systems are under unprecedented pressure, geospatial solutions have proved essential in crisis management by supporting analysis of how the virus is being spread and by whom, as well as logistical challenges such as where personal protective equipment (PPE) is being manufactured and what supply chain is required to get it to where it is needed.

PERSONAL PRIVACY VS PUBLIC HEALTH

As various public inquiries look at what their own nations could have done better, they will look to the Far East. Countries such as South Korea enacted legislation allowing government use of data from smartphones, social media and ride-sharing apps to help understand and control the spread of infection. Experience with SARS and, more recently, MERS led to democratic governments in the region overcoming privacy concerns and enacting laws to authorize emergency use of such data for public health purposes. In the West, we already trust our governments to collect and use – in strictly protected ways – vast amounts of our personal data during population censuses. The way they anonymize such data is well established and effective. So why, in the developed democracies of Europe, can we not trust our legislators to put in place such temporary measures for health emergencies?



▲ *Figure 1: Three-year forward growth by sector. (Source: ConsultingWhere)*

DIGITAL TRANSFORMATION

The most profound long-term change is likely to be the acceleration of the digital transformation, not only as underpinned by European Union declarations, but recognized globally. The rise of Zoom seems to have made companies more accepting of remote working almost overnight, resulting in a significant structural impact on the configuration of cities and public transport networks. The increasingly pervasive use of the term 'artificial intelligence' (AI) to underpin all use of advanced software engineering, whilst a troubling misappropriation of the term, does point to where geospatial can contribute to adapting to such change. An increasing interest in geoAI in the finance sector, for instance, will be part of a move to make better use of alternative sources of data for 'decisioning' on investment options. Another facet of digital transformation will be the increased use of drones. Surveyors may not be allowed to visit sites to undertake their work and crews cannot travel to a site together, but sending up a drone is OK. With less air traffic, aerial surveys around the busiest airports have also become easier.

SOCIAL AND ECONOMIC DAMAGE

As the world emerges from the pandemic, the huge social and economic costs will start to

hit individual businesses and their employees. It has clearly been necessary for governments to substantially increase sovereign debt for job retention and other business support schemes, but that money will have to be paid back. Interest rates are currently low and the repayment periods for strong economies are relatively long. However, the danger is that inflationary pressures will grow as suppliers rack up prices to recover losses suffered during the pandemic.

Recent announcements of pay freezes for public-sector workers are a foretaste of cuts in public investment and tax rises. With public-sector organizations accounting for an estimated 50% of supply-side geospatial companies' sales, this will affect revenues. For instance, there will probably be a slowdown in digital twin projects, which are often sponsored by city authorities, as discretionary spending is cut with the diversion of resources to social care. The situation is likely to be exacerbated by a reduction in new, large construction projects because of changes to living patterns. People's desire for more outside living space will see the depopulation of cities over the next decade and the rise of smaller developments in satellite towns. The office-space needs will change for most geospatial companies due to the shift towards the 'WeWork' model to preserve community spirit and as face-to-face meetings are held less frequently and closer to home. This change will be accompanied by the conversion of large swathes of office space for residential or other uses.

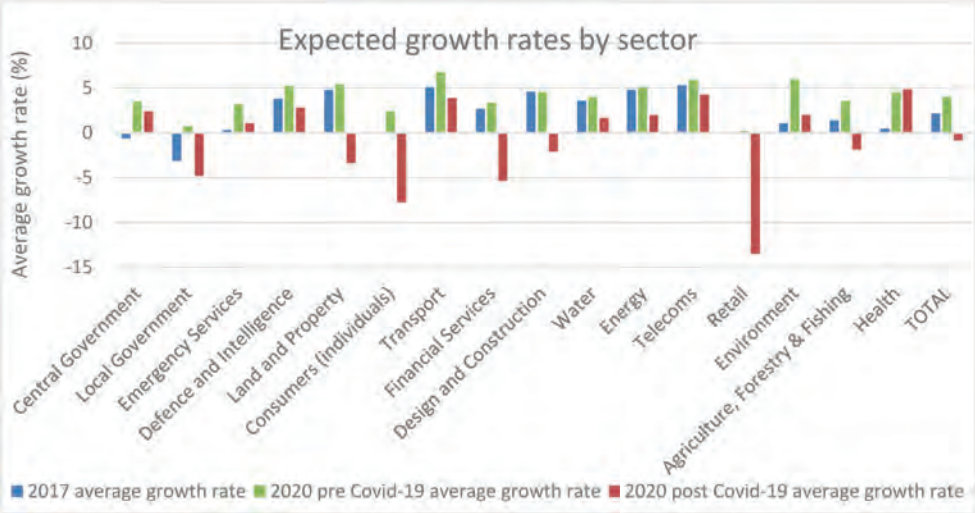
SILVER LININGS

Nevertheless, the clouds hanging over the infrastructure sector have a silver lining. The European Union Green Deal will drive massive investment in projects that have a positive environmental profile. This is not only good for the planet, but is also likely to stimulate the need for wide-ranging environmental impact assessments. The greening of agriculture will create the need for ever-more precise Earth observation data. Alongside this, the implementation of the global Financial Action Task Force (FATF) recommendations will mean financial institutions will have to report on climate-related risks as part of the stress tests imposed by regulators. In general, there is currently a relatively poor understanding of the location of the assets invested in by financial institutions. This will need to improve to meet these requirements. The Spatial Finance Initiative is a good source of further information on this potentially huge market for geospatial companies. It will require complex integration of Earth observation and human geography (statistics, mobility, address) and the application of machine learning to huge quantities of data. ConsultingWhere is currently authoring a joint report with the Satellite Application Catapult on this subject due for release in early 2021.

MARKET OPINION

In the summer of 2020, ConsultingWhere conducted an opinion survey to test sentiment

in the industry on prospects over the next few years. The respondents were mostly UK-based and represented about 100 separate organizations with a reasonably even spread, from small and medium-sized enterprises (SMEs) to large multinationals. This was the third in a series of surveys and revealed some interesting results. COVID-19 is currently having a significant impact on the markets in which the respondents operate. Only 33% expected revenue growth in 2020, compared to 47% expecting their revenues to grow in 2021 and 70% in 2022. In the pre-COVID-19 survey in early 2020, 62% were expecting substantive growth over each of the following three years.



▲ *Figure 2: Changes in predicted growth between 2017 and mid-2020. (Source: ConsultingWhere)*

SECTORAL CONTRASTS

Based on the survey, there has also been a sharp change in the patterns of expected growth by sector. The survey indicates that more stable private sectors such as energy, telecoms and water are still expected to expand, as are central government, health and emergency services. On the other hand, sectors which are typically more sensitive to consumer behaviour are expected to contract – particularly retail but also construction, property and consumer mapping. Figure 1 summarizes the findings, organized from left to right in increasing confidence in future growth. Sectors with relatively high sensitivity to consumer behaviour predominate on the left of the chart, whilst those markets with lower reliance on consumer disposable incomes are shown on the right.

TIMELINE COMPARISON

When the three recent surveys are viewed together, signs of the disruption to the upward trend in confidence become more clearly visible. Figure 2 compares the average expected growth rate by sector across the three surveys. In the 2017 survey, only two sectors were expected to contract – central government and local government – whereas a broad array of sectors are now expecting to suffer reduced demand over the next three years, some of which had high growth expectations in 2020.

PRIVATE SECTOR

This data throws new light on the prospects for the more stable private sectors. Water, energy, transport and telecoms all show that growth levels have been cut from their pre-COVID-19 levels but by much less than their more cyclical counterparts. Each expects to remain positive in terms of overall market opportunity. Even within this seemingly homogenous grouping, there are subtle differences in the underlying responses. More respondents indicated that growth in transport was likely to be greater than 10%, better than in any of the other three sectors. This may reflect the potential for increased geospatial involvement in the growing market of delivery and collection businesses resulting from the move towards online shopping.

PUBLIC SECTOR

Only the health sector has a higher average growth rate post-COVID-19 than before it. The central government sector has held onto some of the gains that had been accrued since 2017 but is down on the pre-COVID-19 expected growth rate. This is likely to reflect similar factors as healthcare in terms of increased focus on well-being outcomes. Pessimism on local government expenditure endures.

CONCLUSION

In summary, it is likely that the geospatial industry will prosper from the changes – both temporary and permanent – that are occurring as the world emerges from the pandemic. To use the current jargon, many businesses will need to 'pivot' their business models to focus on different sectors. This will involve moving out of their comfort zone to engage customers in new sectors and exploit the wide range of new technological advances coming out of the research community. If the industry does not adapt quickly, for sure others will move in to 'eat our lunch'. ◀

FURTHER READING

https://ec.europa.eu/isa2/news/eu-member-states-sign-berlin-declaration-digital-society_en
https://www.fatf-gafi.org/
https://spatialfinanceinitiative.com/
www.consultingwhere.com/lms20/

ABOUT THE AUTHOR

Andrew Coote is principal consultant for ConsultingWhere. He has over 30 years' experience in the development and use of information systems, specializing in the management of location-enabled applications. He has held senior management positions in both the public and private sector in the UK and Africa. His expertise lies in strategy development and implementation, return on investment and market assessment. Recent strategic assignments have taken him to East Asia, Eastern Europe, Southern Africa, Australasia, North and South America and the Middle East for customers including the World Bank, European Union, Esri, Land Information New Zealand and Ordnance Survey.

The Future of Geospatial: Are We Everyone's Friend or Do They Not Know We Exist?

The perspective the author brings to the 'future of geospatial' is taken from spending the last five years assisting senior government officials from both developing and developed countries and also briefing senior members of board rooms of some of the largest organizations in the world. They have all wished to think through how the added dimension of location could make a difference to their decision-making.

Whilst we in the sector use terms such as 'geospatial information', 'our geospatial community' or even 'the GIS team', most senior government officials and senior directors of organizations do not normally recognise these terms. They are looking at either enhancing the information infrastructure of their country or their organization, or they are looking at the competitive advantage to be gained from using extra data sources that other competing organizations have not yet discovered.

The boundaries between 'geospatial' and so many other disciplines, in most users' minds, are simply non-existent. We too may need to break down these boundaries more than we have done to date, in order to attract interest in what we do. And not just in the boardroom; young graduates around the globe are flocking to data science and space roles, but are they equally attracted to geospatial? The answer currently is 'no' as so many still do not understand the power of our work and the benefit to society it can bring.

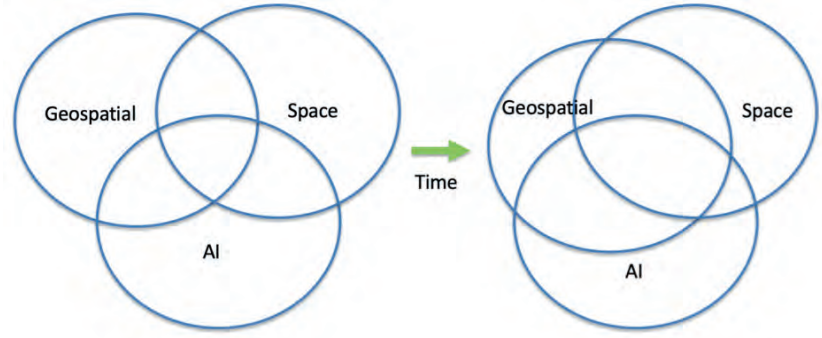
EVERYTHING HAPPENS SOMEWHERE

Talking to a professor of data science who 'zoomed' me recently, he had little knowledge of geospatial, let alone that it underpinned some of the biggest decisions taken each day. We discussed its use in government and their operations from managing resources, administering services, to tackling emergencies. We covered its role in industries, including construction, the property market, utilities, insurance, defence and security, navigation, waste and asset management, and logistics. Our discussion turned to its use at global scale, to assist understanding and to tackle some of the biggest issues facing the globe: environmental issues such as climate change, food security, identifying poverty and inequality and underpinning the measuring and monitoring of United Nations Sustainable Development Goals (SDGs).

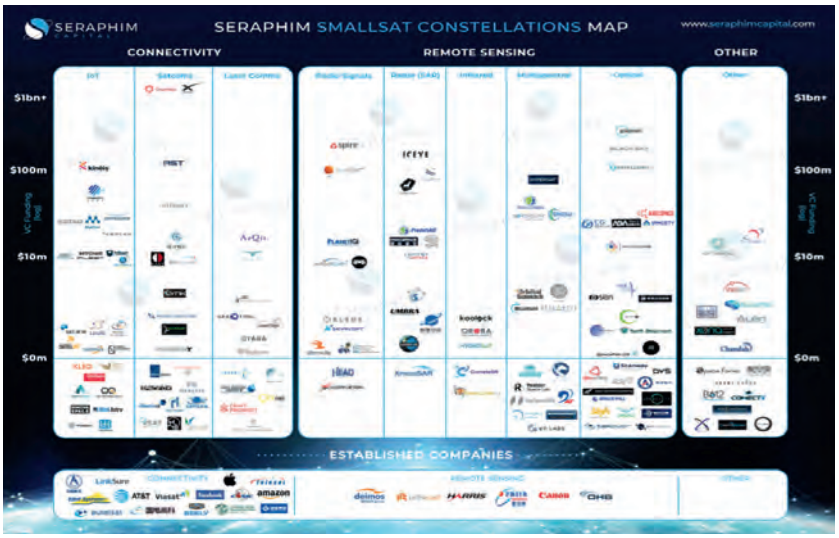
By the end of the conversation, the phrase that I first used when writing for *GIS Europe* magazine in 1993 – 'everything happens somewhere' – was ringing in his head together with the understanding that geospatial information is now seen as a vital part of a national and organizational information infrastructure.

FITTING IN

So where do we fit in the future? Firstly, we know geospatial is an economic contributor. The geospatial industry globally was valued at £300bn by GeoBuis Report (2019). According to recent economic research, an economic uplift can be expected to occur by organising geospatial information within a national spatial data infrastructure (NSDI) or a similar infrastructure. In a study undertaken by the Boston Consulting Group (BCG) and a report by the UK Geospatial Commission (2018), it was estimated that the fiscal uplift could total up to £14bn for the United Kingdom alone.



▲ *Figure 1. The changing symbiotic relationship of the geospatial, space and AI industries over time. (Image Courtesy: Location International Ltd 2020.)*



▲ *Figure 2: The Seraphim Capital Small Satellite Constellation Map. (Image Courtesy: Seraphim Capital 2020)*

We also know that we overlap considerably with the space industry as well as the data science and AI industry (Figure 1). Each year, we become more beneficial to them as the interoperability and open systems approach around the globe is being increasingly adopted across our industry.

The space industry is seeing significant growth in the Earth observation sector often backed by venture capital investment (Figure 2). The ever-increasing number of and the move to smaller sized-satellites, downloading not only traditional bandwidths but now also small-sat radar and video imagery together with the introduction of high-altitude platforms (HAPs) that not only use solar energy but now also hydrogen fuel, is revolutionizing the remote sensing community. But irrespective of how versatile these platforms are, they generally still only generate data that is not 'in context'.

It is only the combination of their outputs with multiple other pieces of locational information from 'other providers' which makes the space-based data become useful information for the decision-maker. These 'other providers' may, at one end of the spectrum, be humans using their mobile phones in a passive locational sense or, at the other end, highly accurate, authoritative geospatial data from either a government or the private sector.

With the addition of AI algorithms to geospatial decision-making processes, millions of calculations can be made per second, assisting the terabytes of data within any locational data stack to be easily analysed – and consistent results to be provided to the decision-maker.

▲ *Figure 3: The future focus of those working in geospatial measured by relative importance. (Image Courtesy: Location International Ltd 2020.)*

It can therefore be concluded that the geospatial community, the space community and the AI community have a symbiotic, mutually reinforcing relationship. Geospatial information provides the context to the work of the space and the AI industry and hence I predict the geospatial community will grow in importance as the benefits it brings to space and AI is increasingly recognised.

GEOSPATIAL INFORMATION IN A DIGITAL SOCIETY

The UK Geospatial Commission (2020) stated In 'Unlocking The Power of Location: the UK's Geospatial Strategy 2020 to 2025' that "by 2025, the UK will have a coherent national location data framework underpinning a flourishing digital society" which highlights the importance of geospatial information to a country; and many similar statements are referenced around the globe. Drawing on the recognition of this importance, together with the symbiotic relationship with other growth sectors and the fact that 'everything happens somewhere' is vital to solving some of the globe's biggest challenges. It is therefore necessary to consider how our community should evolve for it to prosper – and not be subsumed into adjoining communities.

Clearly, aligning ourselves with our neighbouring communities will ensure that we are recognised for the benefits we can bring. But there are many questions that need to be answered for us to be successful. These include such questions as: Should we promote our role more within the measuring and monitoring of the globe's grand challenges so that we are an attractive community to join? Should we consider perhaps using not only 'geospatial professional' but also 'geodata scientist' within our vocabulary? Should our graduate courses have greater intensity of focus on computer science than they do today? Should we simplify our messages, so more people understand that 'geospatial' underpins everyone's daily lives?

Over the past 10 years, geospatial has been successfully used to tackle serious decisions in many industries from manufacturing to the finance markets and, of course, more recently, underpinning much of the analysis

undertaken in the COVID-19 pandemic. However, the awareness of the impact geospatial makes has always been similar to 'Intel inside' our computers but without even a label to identify ourselves! This has to change for our identity not to be lost to other subject areas.

Due to our historical roots, technology has often been the lead focus for the geospatial community. Today, we need to ensure that the focus is changed to one that emphasises the impact we can have organizationally, using globally adopted standards and ensuring our people have the skills to meet the growth of geospatial, as more data becomes available from so many sources (Figure 3).

With a subject area measuring and monitoring the biggest issues facing the globe which is no longer hampered by being 'technology led', that already adopts international protocols and standards and is needed by adjacent growth industries, it is clear that the community will continue to thrive.

However, our success is conditional on us all being able to express and rationalise what we do, why we do it, for whom we do it and how we do it. This has to be in language that everyone understands and is simple to grasp, starting perhaps always with the phrase that is now 27 years old, 'everything happens somewhere'.

FURTHER READING

- GeoBuis Report (2019), https://geoguiz.com/geobuiz-report-2019.
- UK Geospatial Commission (2018), https://www.gov.uk/government/publications/geospatial-commisssion-annual-plan-2019-2020.
- UK Geospatial Commission (2020), Unlocking the power of location: the UK's geospatial strategy 2020 to 2025.

ABOUT THE AUTHOR

Dr Vanessa Lawrence CB FRICS is working internationally as a senior advisor to governments, inter-governmental organizations including the World Bank and large private-sector organizations. She is a non-executive director of several major scientific organizations in the UK and abroad. From 2000-2014, she was the director general and CEO of Ordnance Survey, Britain's national mapping authority and from 2011-2015, she was a founding co-chair of the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM).

INSIGHTS FROM THE UN'S FUTURE TRENDS *REPORT*

Unlocking Potential: Emerging Geospatial Trends for Business

How can organizations and businesses advance their geospatial maturity in the coming years? The latest version of the *Future Trends in Geospatial Information Management* report by UN-GGIM captures technological and non-technological developments and signposts opportunities for change.

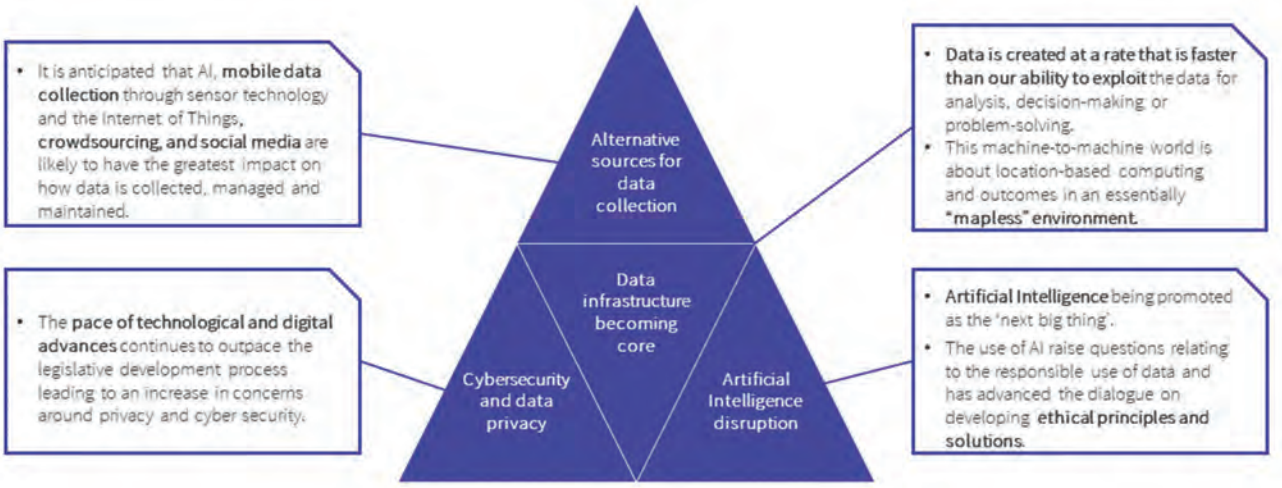
In 2020, the United Nations Committee of Experts in Global Geospatial Information Management (UN-GGIM) approved the publication of a periodic review of the third edition of the *Future Trends* report, led by Ordnance Survey (OS) on behalf of the UK and with contributions from over 100 experts and organizations. Since first being published in 2013, *Future Trends in Geospatial Information Management: The Five to Ten Year Vision* continues to provide strategic insight on the mid-to-long-term developments in geospatial information. This latest version captures changes and developments across both the technological and non-technological environments and signposts opportunities for organizations and businesses to adapt and advance their geospatial maturity in the coming years.

▲ *Figure 1: Increase of topics covered by each of the* Future Trends *reports, 2013-2020.*

REPORT FINDINGS AND STRUCTURE

As expected, the increasing rate of change within the industry is one of the main findings in the report. Alongside emerging themes, the latest version showcases how geospatial information and technology solutions underpin economic growth and can act as a blueprint for business development. Figure 1 shows the growing number of themes and trends that have been covered in the report since it was first published.

The report recognizes the increase in adoption of data-centric technologies rather than 'traditional' IT technologies that handle data, the evolution of user demands and requirements, and the significance of partnerships and collaborations between the governmental, private and academic corners of the industry. It also documents the increasing role that geospatial information plays as part of the 2030 Agenda for Sustainable Development.



▲ *Figure 2: New sources of data and the rapid pace of technological advancements are providing new opportunities.*

Its strength comes through the collaborative and global nature of the report's contributions from across the globe, with 124 UN Member States, public and private-sector organizations and experts providing their input. A global consultation took place on the report in early 2020, with the findings presented and adopted at the Tenth Session of UN-GGIM in mid-2020.

FIVE DRIVERS FOR FUTURE CHANGE IN GEOSPATIAL

For ease of reference, the report's findings are grouped around five overarching industry drivers: industry structural shift, the rise of new data sources and analytical methods, technological advancements, user requirements, and policy and legal. Each driver is supported by a series of trends that provide a more detailed explanation of the topic and allow businesses to be aware of these evolving industry drivers.

The report is certainly relevant for emerging businesses, established organizations, entrepreneurs and individual geographic professionals alike. The key takeaways for many will be the opportunities provided by new sources of data, the rapid pace of technological advancements and the need for the appropriate skills and data privacy considerations to deliver against evolving user requirements.

1) Industry structural shift

The structural shift demonstrates the change in focus towards new expertise in consolidating large numbers of data sources whilst meeting a new generation of user requirements. This shift will impact the way of working together, necessitating great collaboration amongst data providers and users. The rise of smartphones and other mobile devices has increased expectation and user demand for higher accuracy, currency, and detail, so organizations will need to adapt their offering. Developments show that the data collected in GPS-assisted tracking systems by commercial parties in the automotive sector may be of subsequent real-time value to government agencies concerned with car tracking, traffic control and alternative road selection, reducing risk, road-based crime and the number or severity of traffic accidents. The market for such dynamic mobility data is predicted to be one of the fastest growing markets of the future.

2) Rise of new data sources & analytical methods

With 'data everywhere', the demand for analytical-ready data that reveals immediate insights is increasing beyond that of traditional geospatial datasets for visualization and analysis. The concept of big data analytics has been a constant theme since the first report in 2013. The volume, size, speed, diversity and complexities with which geospatial data is generated have already led to changes in organizations and businesses across the world. Findings have shown that change has taken place both in the infrastructure and processes used to collect, store, analyse and use data, as well as in the skills and expertise of the workforce. Cloud-based processing and access to sources of new and richer data is already giving rise to new applications and business opportunities.

3) Technological advancements

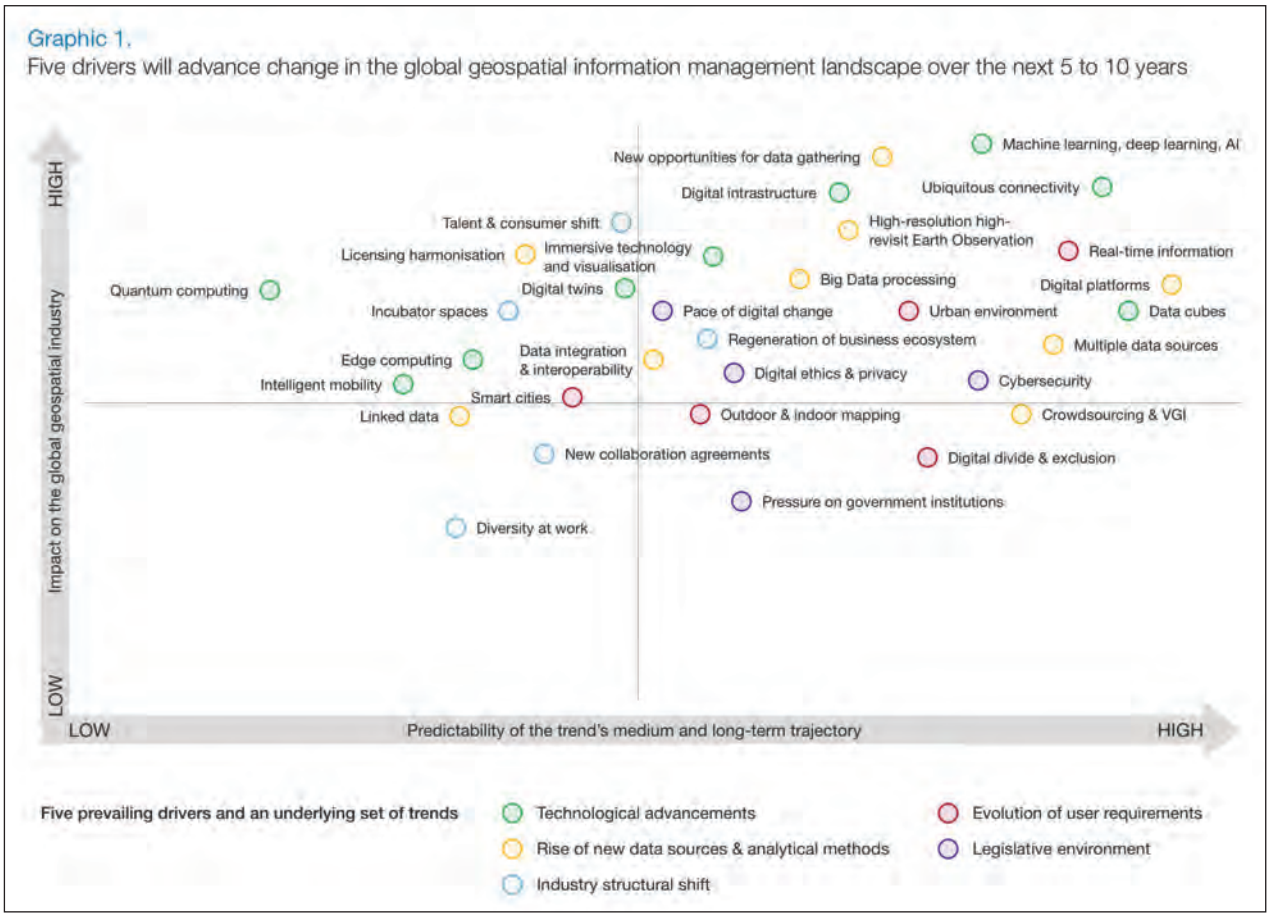
Some of the broadest and most powerful new geospatial trends continue to be associated with mainstream advancements in technology. The speed at which such innovation is occurring represents great opportunities, but it also challenges organizations and nations to keep pace. Advances in technology such as automation, artificial intelligence, sensor technology and the Internet of Things have created a shift towards a more machine-centric world. The continuous developments in technology call for accelerated training in future skillsets to keep up with technological capabilities whilst staying mindful of new questions of data privacy and cybersecurity.

4) User requirements

In recent years, the report has identified a notable shift in the requirements of users. At a citizen level this can be seen through growing numbers of location-based services, such as in transport or retail. This expectation of mobile, frictionless and convenient access to data increases the demand and opportunity for near-real-time data generation and analytics. At city level, the development of digital twins with associated citizen services is allowing local municipalities to simulate scenarios related to climate change and flooding events while mitigating risks and increasing infrastructure resilience. The popular rise of smart city infrastructures will serve as a platform for even greater engagement with citizens and planners.

5) Policy and legal

As is often the case, technology develops at a faster pace than the legal and policy frameworks that support it. Emergent



▲ *Figure 3: The potential and predictability of the key drivers and trends.*

technologies and disruptive business models are often at the forefront of these developments. The report recognizes that, as interdisciplinary collaborations are commonplace, this places even more emphasis on security, data privacy, ethics, trust and licensing requirements. There will be greater demand for governments and commercial organizations to consider these emerging legal and policy challenges as part of national frameworks for data and digital progression.

EVOLVING FUTURE TRENDS

Needless to say, the biggest disruptions, biggest impacts and biggest opportunities for the geospatial industry will arise when one or more of these innovations come together. The report recognizes that its readers are starting with different experiences, operate in different national policy contexts and have different levels of geomaturity. There is therefore an opportunity for businesses to promote the use and affordability of technology and analytical methods in the short-to-medium term. Entrepreneurs in the geospatial sector are well placed to leverage the rapid pace of change and create tools and services that can be used for economic and societal growth.

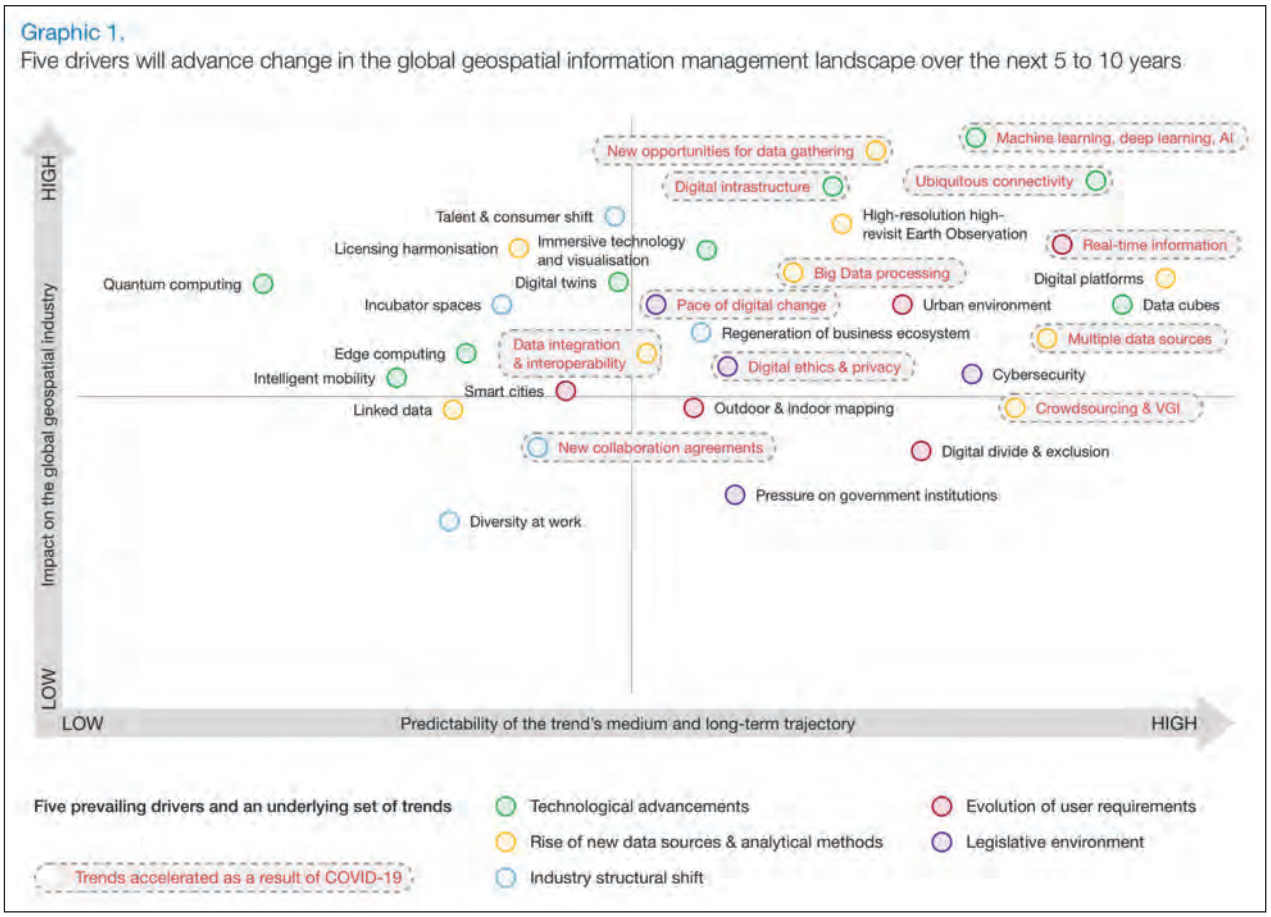
Figure 3 visualizes the drivers and the trends discussed in the report. The majority of these drivers and individual trends are classed as both 'high impact' and 'high predictability'. The future of geospatial is clearly approaching very quickly and these trends bring a huge amount of opportunity as well as responsibility.

The capability of the geospatial community to deliver insightful data to meet key challenges is vital. It requires collaboration and strong leadership to help realize and communicate how high-quality, timely data can enable decision-making. It is clear that the increasing availability and decreasing costs of geospatial technology and new analytical methods have the potential to significantly reduce the global geospatial digital divide over the next decade.

IMPACT OF THE PANDEMIC

During 2020, COVID-19 accelerated the application of many of the trends in the report in ways that could not have previously been imagined – from the temporary halt in on-the-ground data collection which required the rapid identification and use of alternative data sources, to the need to integrate data from multiple sources whist maintaining its provenance and trust. In the post-COVID-19 world, it is likely that a number of trends will be accelerated to an even higher status of both 'high impact' and 'high predictability' sooner than expected.

The pandemic has underlined how geospatial infrastructures have become an essential component of disease prediction, prevention and response. From analysis of spatial big data to trace people's movements to using contextualized data, digital maps and technologies to predict behaviour, and from visualizations that make data more easily accessible to machine learning techniques using aerial and satellite data, all of these techniques support the assessment of how environmental changes may impact infectious disease transmission. Several trends – such as data interoperability and real-time information and connectivity – have only gained in momentum, reinforcing how interconnected our world is and improving the global understanding of the interactions between people and places. The global response to



▲ *Figure 4: Trends that have been accelerated by the pandemic.*

COVID-19 has reminded the geospatial sector of the importance of both human and physical geographies working alongside one another.

CONCLUSION

The third edition of the *Future Trends in Geospatial Information Management* report reveals the speed at which the geospatial industry has evolved and is still evolving influenced by factors inside and outside the industry. This pace of change brings unprecedented opportunities to accelerate the development of a new generation of geospatial capabilities in response to demands being voiced by users and society as a whole. Although the geospatial trends identified in the report are focused on new technological developments, new data sources and a better understanding of user needs, the real value in this report comes from the encouragement of new ways of working, collaboration and the possibilities of new partnerships. The industry as a whole has a responsibility to use these new capabilities in pursuit of better outcomes – globally, nationally and locally. The lessons of 2020 have provided a clear demonstration of how important the geospatial industry is to a sustainable and better future. ◀

FURTHER READING

Third edition of the Future Trends report, http://ggim.un.org/meetings/GGIM-committee/10th-Session/documents/Future_Trends_Report_THIRD_EDITION_digital_accessible.pdf

A significant year for the UK on the global geospatial scene - Geospatial Commission (blog.gov.uk) https://geospatialcommission.blog.gov.uk/2020/11/13/a-significant-year-for-the-uk-on-the-global-geospatial-scene/

ABOUT THE AUTHORS

David Henderson is the chief geospatial officer and member of the Ordnance Survey executive team where he leads the continuous development of Ordnance Survey's geospatial strategy and location data framework. Focusing on the longer-term progression of Ordnance Survey's core strategic strengths, technical capabilities and geospatial assets, David's team works to ensure Ordnance Survey remains at the forefront of the global geospatial industry. A geospatial professional and Honorary Fellow of the Royal Scottish Geographical Society, David joined Ordnance Survey in 2003 and has fulfilled a variety of technical and leadership roles. David has led the UK's delegation to the UN's Committee of Experts on Global Geographic Information Management (UN-GGIM) since 2016 and is a vice-chair of the UN-GGIM Europe Regional Group.

James Norris is international policy advisor at Ordnance Survey where he works to promote the vital role that geography and geospatial data has in transforming economies, sustaining the environment, and making the world a better place. He is a Fellow of the Royal Geographic Society, and works across several domains in the geospatial information sector. Most recently contributing to and promoting the work of UN-GGIM. James has written several international policy documents including the UN-GGIM's *Future Trends in Geospatial Information Management: 5-10 Year Vision,* Second Ed. and is a contributing author to the UNDRR *Global Assessment Report on Disaster Risk Reduction 2019* where he wrote about changes in technology and data sharing.

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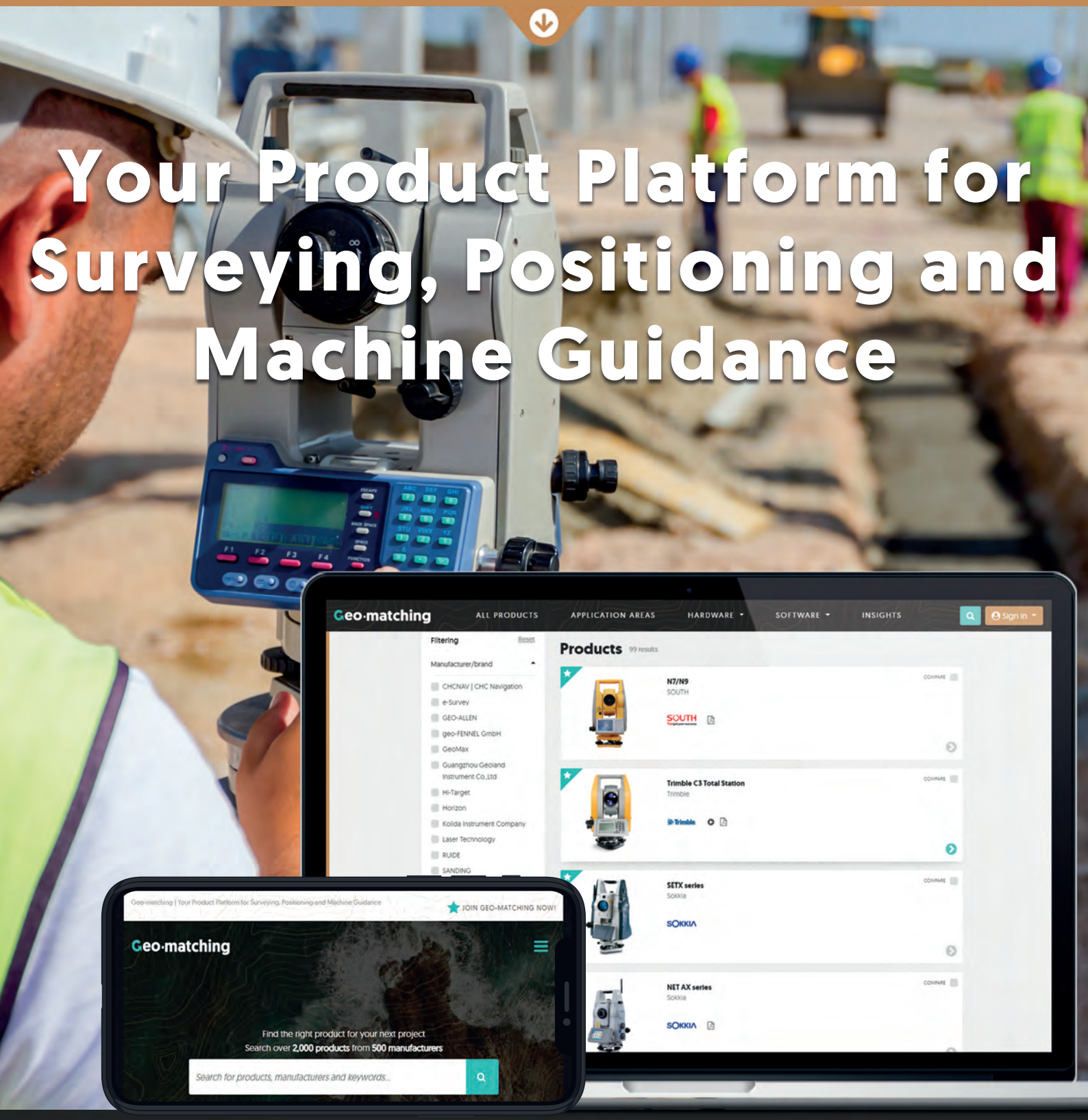

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Key Global and Technology Drivers Impacting Surveying

As the FIG commission chairs near the halfway point in their terms, they reflect on the global and technological drivers influencing their work. This article outlines how the work across the FIG commissions supports the SDGs. The discussion is also informed by global reports such as the UN-GGIM's *Future Trends in Geospatial Information Management* and the *RICS Futures Report 2020*.

A major global driver for FIG is the '2030 Agenda for Sustainable Development' and the association is committed to supporting the UN member nations in meeting the 17 Sustainable Development Goals (SDGs) and 169 targets. Key global challenges include climate change, natural and other disasters, urbanization and food and water insecurity. Climate change increases the risk of natural disasters leading to displacement of people, environmental impacts and economic losses. It also impacts food and water security, making access to arable land and drinking water a global challenge. Mitigation and adaptation strategies are a key focus for spatial planning and development and cadastre and land management. Positioning and measurement as well as spatial information management play a role in improving data accuracy, data modelling and reporting against SDG 13 (Climate action), SDG 14 (Life below water) and SDG 15 (Life on land).

GLOBAL DRIVERS

Urbanization is an important driver of the global development agenda, posing significant challenges for governments. Approximately 15% of the world's population live in urban informal settlements and slums lacking access to safe water, sanitation and other needs (Satterthwaite and Mitlin 2014). Pro-poor spatial planning and development as well as land administration (relevant for cadastre and land management) systems are needed to support sustainable development and land markets and to enhance the urban/rural interface.

▲ *Figure 1: The 17 Sustainable Development Goals. (Source: United Nations, 2015)*

Participatory cadastre and land management combined with spatial planning and development supports responses to SDG 1 (No poverty), SDG 2 (Zero hunger), SDG 5 (Gender equality) and SDG 11 (Sustainable cities and communities) aiming for equal land rights for all. These issues are evident in global land governance frameworks such as the *Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security* (CFS and FAO, 2012).

The valuation and the management of real estate as well as construction economics and management provide expert information to the market to support decisions on managing scarce resources. Environmental, social and governance (ESG) thinking in response to the SDG targets supports construction project initiation, engineering surveys, procurement, carbon accounting and environmental resilience.

Professional standards and practices underpin these responses and support SDG 16 (Peace, justice and strong institutions) and SDG 5 (Gender equality) through professional ethics and standards. Professional education supports SDG 4 targets related to equal access to education, increased participation and literacy levels, and ensuring that all learners acquire the knowledge and skills needed to promote sustainable development. The surveying education curriculum needs to keep abreast of the current global challenges, as well as the advances in technology and new approaches of the profession. Professional education also has a role in preparing graduates who can develop mechanisms and processes that will help to meet those needs. Advances in ICT and learning management systems mean that professional education can be more accessible than ever before.

COVID-19 restrictions since 2020 have impacted the way of working, space requirements and consumer demand. There is also a rising demand for geospatial information and more rapid adoption of technology. Global construction will be critical in the economic recovery, and spatial planning and development, cadastre and land management, valuation and the management of real estate, hydrography, engineering surveys, and construction economics and management will all play an important role. This will not be possible without effective positioning and measurement and spatial information management, underpinned by professional standards and practice and professional education.

TECHNOLOGICAL DRIVERS

Looking ahead to a post-COVID world, the key technological drivers are likely to include smart cities, BIM, digital twins, autonomous surveying techniques, artificial intelligence (AI),

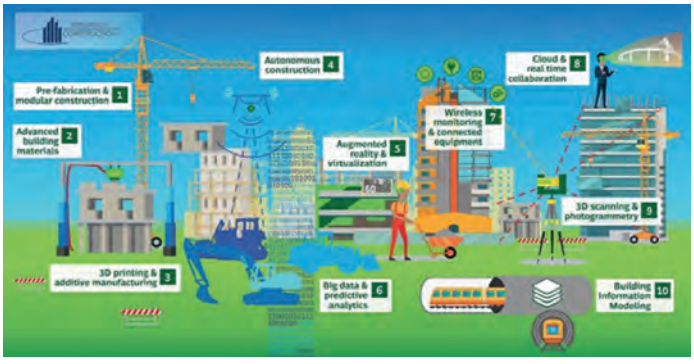
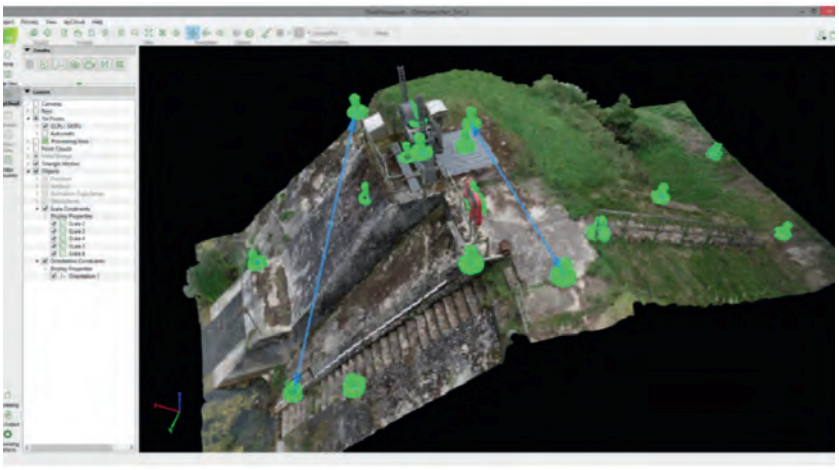


Figure 2: Surveying in Construction 4.0.



▲ *Figure 3: Dam monitoring and inspection – photogrammetry model of a dam within Pix4D.*

machine learning and big data, blockchain, augmented reality, automated feature extraction and change detection. While these are having a big impact in the Global North, they also are driving advancement in the Global South.

SMART CITIES, BIM AND DIGITAL TWINS

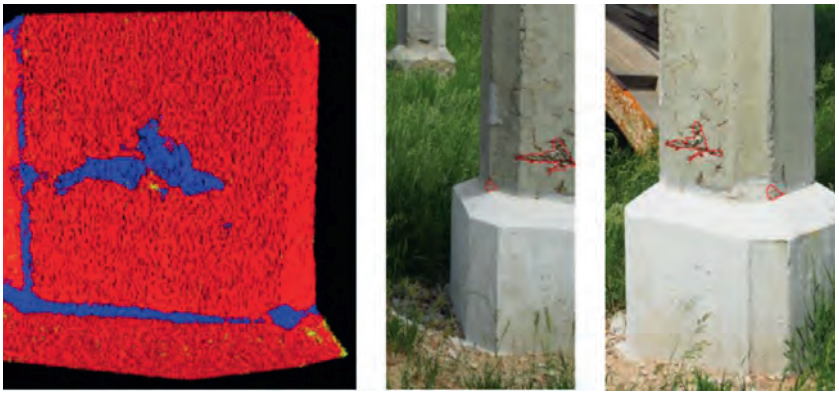
Smart cities provide solutions to urbanization problems through better managing complex surroundings creating opportunities for smart technologies and efficient governance models (UN-GGIM, 2015). BIM, GIS, smart cities and digital twins all require precise positioning and measurement of the buildings and critical infrastructure ensuring better integration into smart city design. The construction economics and management notion of 'whole-life thinking' is being applied to construction and infrastructure projects, connecting building operations, asset management and construction into integrated management and information frameworks.

ARTIFICIAL INTELLIGENCE, MACHINE LEARNING, BIG DATA AND CLOUD COMPUTING

The Internet of Things and information processing technologies support intelligent sensing and machine learning processes across a range of devices (UN-GGIM, 2015). The amount of data collected brings challenges for data management and is driving developments in spatial information management and positioning and measurement, including big data, cloud computing, AI and machine learning, that allow the data to be processed more efficiently (UN-GGIM, 2020). While these technologies bring huge benefits, they also result in privacy (RICS, 2020) and digital divide challenges, with professional standards and practice becoming ever-more important.

AUGMENTED REALITY

Augmented reality (AR) approaches involve adding digital elements to a live view, often by using technology such as the camera on a smartphone. This provides interesting opportunities for spatial information management and positioning and measurement. The implementation of AR can also facilitate assessment to provide data for land registration and spatial planning decision-making, cadastral and engineering surveys and hydrography.



▲ *Figure 4: Concrete damage detection based on machine learning classification of terrestrial laser scanner point clouds. (Source: Hadavandsiri and Lichti, 2020)*

AUTOMATED FEATURE EXTRACTION AND CHANGE DETECTION

Automated feature extraction (AFE) tools can help spatial information management in the extraction of geospatial features in large datasets, allowing object detection for change detection purposes. These tools can be used for a range of applications including feature extraction of parcels to support cadastre and land management, and automation of the identification of parties (e.g. landholders).

AUTONOMOUS SURVEYING TECHNIQUES

Autonomous surveying techniques can be used in cadastral surveys, hydrography and engineering surveys for construction and monitoring purposes. Autonomous vehicles for aerial, maritime and terrestrial surveys provide a cost-effective tool that is easily deployed for monitoring infrastructure. Having an accurate reference frame helps positioning and measurement work undertaken for engineering surveys to be linked to data from diverse sources.

BLOCKCHAIN

Blockchain technology and tools introduced into cadastre and land management and the valuation and the management of real estate can bring certainty and clarity to investment decisions, making them simpler and faster. By linking existing title and valuation documents and other forms of information with property data from AI and machine learning, blockchain provides more transparent digital data and more data points.

MORE ACCESSIBLE GEOSPATIAL INFORMATION

Spatial planning and development views the world as land-use layers, within the landscape and its use. New geospatial technologies, AI, big data and cloud computing all make it easier to perform complex analysis to support decisions. Accurate and accessible geospatial information is at the heart of the inclusive decision-making necessary for sustainable urban development, especially for SDG 11 (Dijkstra et al, 2010).

RISE OF NEW DATA SOURCES AND ANALYTICS

New positioning and measurement techniques are primarily based on GNSS technology but include various means of reducing collection times (RTN) or providing augmented signals from ground-based or space-based augmentation systems (GBAS/SBAS). Remote sensing is now accomplished from drones much more cost-effectively than from satellites. Thanks to cost-effective positioning and measurement through cheaper GNSS receivers and the fusion of data from multiple sensors and techniques, more users can accurately access geospatial data. This broadens and strengthens spatial information management and enables crowdsourcing to support the assessment of progress against the SDG targets.

FUSION OF DATA FROM DIFFERENT SENSORS

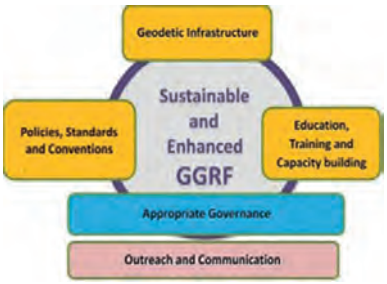
To develop smart cities, geospatial information must be integrated into the evolving architecture, standards and best practices. Every sensor and device connected to the internet has location information that sets the context for the information transmitted. Geospatial information becomes particularly important when the sensor or device is moving (UN-GGIM, 2020). In terms of positioning and measurement, geospatial coordinates can be provided by SBAS, GBAS, imagery, Lidar, IMUs and/or total stations, offering benefits beyond simply GNSS. Use of GNSS helps to orient all the different sensor data into a common reference frame for ease of combining the data. Moreover, new instruments allow cadastral and engineering surveys to be undertaken very close to the object or from afar, including aerial or subterranean and underwater environments. Fusion of datasets offers many alternative ways for obtaining geospatial coordinates in difficult circumstances and gives a more complete status of the object being studied in real or near-real time.

CROWDSOURCING AND VOLUNTEERED GEOGRAPHIC INFORMATION SYSTEMS

One response to the increased demand for geospatial information is crowdsourcing and volunteered geographic information (VGI) systems to complement existing data. The sheer volume of crowdsourced geospatial data makes up for its lack of accuracy. This data can 'learn' and 'adapt to' changes in the environment, such as when traffic flows are detoured based on data crowdsourced from GPS users. While individual observations of geospatial coordinates might be inaccurate using handheld GNSS, statistical distribution will eventually reveal an accurate estimate of the true value. Positioning and measurement can help to ensure correct datums, and spatial information and management ensures that standards are applied to ensure metadata and programming consistency exists in the crowdsourced data.

CONCLUSIONS

The geospatial profession needs to continually evolve to respond to global challenges, social impacts and the rapid evolution of technology. The drivers mentioned in this article are having a profound impact on this work. It is important to ensure that the professional standards and practices, including the valuation, construction and other global standards the industry operates under, are still relevant. It is also essential that the next generation of professionals are educated and competent and able to contribute responsibly to the global challenges. ◀



▲ *Figure 5: The UN SCoG WG on ETCB is a critical component in the Global Geodetic Reference Frame (GGRF) Roadmap. (Source: Roman, 2020)*

FURTHER READING

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Hadavandsiri and Lichti (2020) Concrete Damage Detection based on Machine Learning Classification of Terrestrial Laser Scanner Point Clouds, FIG Working Week 2020 proceedings, 10-14 May 2020.

FIG COMMISSION CHAIRS:

Winnie Shiu, Professional Standards and Practice (Commission 1)
David Mitchell, Professional Education (Commission 2)
Hartmut Muller, Spatial Information Management (Commission 3)
Mohd Razali Mahmud, Hydrography (Commission 4)
Daniel Roman, Positioning and Measurement (Commission 5)
Maria Joao Henriques, Engineering Surveys (Commission 6)
Daniel Paez, Cadastre and Land Management (Commission 7)
Marije Louwsma, Spatial Planning and Development (Commission 8)
Ben Elder, Valuation and the Management of Real Estate (Commission 9)
Alan Muse, Construction Economics and Management (Commission 10)

ABOUT FIG

The International Federation of Surveyors (FIG) is the premier international organization representing the interests of surveyors worldwide. It is a federation of the national member associations and covers the whole range of professional fields within the global surveying, geomatics, geodesy and geoinformation community. It provides an international forum for discussion and development aiming to promote professional practice and standards.
For more details, see https://fig.net/about/index.asp

A Commercial PPK Solution for Phantom 4 RTK

As the first consumer model with a professional GNSS receiver integrated on board, the DJI Phantom 4 RTK (P4R) has been applied in aerial mapping since its release and helps surveyors save time and money. In this article, the authors propose a commercial PPK solution for the P4R drone to bring an easy, affordable and precise solution to the mapping industry. They also explain the workflow and validate the accuracy of the results.

The biggest advantage of the P4R is its integrated GNSS receiver, which enables the unmanned aerial vehicle (UAV or 'drone') to directly tag the positioning coordinates and accuracy factors into the imagery attributes (EXIF) after accessing the NTRIP network differential sources. In turn, it can be easily read by photogrammetry and 3D modelling software and applied to optimized aerotriangulation.

This is an idealized effect in practice, as the quality of RTK positioning is influenced by the correction interruptions that frequently occur in shaded urban and areas with poor mobile signal coverage. Also, the corrected GNSS error is proportional to the distance from the base station to the drone. Therefore, PPK technology without real-time communication between base stations and drones can ensure a more stable and reliable mapping performance. A base set a few hundred metres from the drone provides significantly higher-quality position fixes compared to a network base station (CORS) potentially a few kilometres away.

▲ *Figure 1: The P4R and base station used for flight testing.*

THE PPK SOLUTION

The PPK solution consists of the following three main components:

1) Drone: A P4R drone with all the accessories needed to perform the flight mission and record the raw photos and static observations for PPK processing.

2) GNSS base station: A Hi-Target inno1 portable base is used to collect checkpoints on site and provide stable and reliable static observations.

3) PPK post-processing software: The authors used PPK Go which is turnkey software that enables P4R to achieve the most accurate and reliable camera positioning data in any coordinate system without measure targets or ground control points (GCPs). With 2cm accuracies on X, Y, Z dimensions, the output text file with position information or geotagged images can then be used directly in common photogrammetric or 3D modelling software.

WORKFLOW AND ACCURACY VALIDATION

To validate the performance, the authors selected an industrial park in a typical urban environment as the site and compared the accuracy of the digital ortho map (DOM)

using RTK and PPK methods, respectively. The steps are outlined below.

1) Checkpoint acquisition and mission planning

As shown in Figure 2, eight points were placed evenly inside and outside the area. P1, P3, P7 were planned as control points, and the rest were checkpoints. The coordinates were acquired using the inno1 portable RTK when the error of the fixed solution converged to the millimetre level. Each point was observed independently 30 times and the average value was taken as the measurement result.

2) Data acquisition

The base station was set up on a known point, the instrument height was measured and then the static recording was started at a 1Hz interval before the flight. The mapping area was selected in the GS RTK app installed on the remote control and the mission was planned according to the parameters in Table 1. To compare the difference in the accuracy of RTK and PPK, the RTK geotagging function (NTRIP) was simultaneously activated.

The flight mission took about 18 minutes and a total of 267 images were collected, all of which were geotagged RTK fixed coordinates.

3) PPK processing

The next step was to run the PPK Go post-processing software, create new projects and import the base station and flight project data separately. The software automatically checked the dataset integrity and matched the imagery, raw observations and the timestamp file in the folder. After configuring the ellipsoid and projection and entering the known coordinates of the base station, clicking the process button started the processing. The waypoint with the fixed solution was marked in green on the graph of the interface. Finally, clicking on 'Export' geotagged the processed high-precision coordinates into the imagery and saved the result as a new dataset.

4) Image processing and DOM generation

There are numerous data processing software solutions available for drones, such

▲ *Figure 2: Distribution of GCPs and checkpoints.*

Table 1: Flight Mission Parameters			
Flight altitude	100m AGL	Weather	Sunny
Flight speed	7m/s	Overlap/side lap	80%/70%
Photo scale	3:2	PTZ angle	-90°
Built-in distortion correction	Off	Central meridian	114°
Coordinate system	WGS-84 UTM 49N	Wind speed	Breeze
GSD	3.9cm	Planning area	0.427km²

Table 2: Statistical Table of Point Mean Square Error_Geotagged NTRIP RTK_noGCP									
Point name	Coordinate deviation			Point RMS	Point name	Coordinate deviation			Point RMS
	dX_a	dY_a	dZ_a	dS_a		dX_a	dY_a	dZ_a	dS_a
P1	0.009	-0.016	-0.122	0.018	P5	-0.036	-0.052	-0.139	0.063
P2	-0.029	-0.006	-0.108	0.030	P6	0.026	0.094	-0.112	0.098
P3	-0.027	0.006	-0.142	0.028	P7	-0.026	0.026	-0.178	0.037
P4	-0.044	-0.185	-0.159	0.190	P8	0.025	0.026	-0.199	0.036

Table 3: Statistical Table of Point Mean Square Error_PPK_noGCP									
Point name	Coordinate deviation			Point RMS	Point name	Coordinate deviation			Point RMS
	dX_b	dY_b	dZ_b	dS_b		dX_b	dX_b	dY_b	dZ_b
P1	0.039	-0.016	-0.052	0.042	P5	0.014	-0.042	-0.069	0.044
P2	-0.029	-0.006	-0.018	0.030	P6	0.046	0.094	-0.042	0.105
P3	0.003	-0.004	-0.072	0.005	P7	0.024	0.036	-0.038	0.043
P4	-0.034	-0.205	-0.069	0.208	P8	0.015	0.046	0.081	0.048

▲ *Figure 3: DOM produced by Pix4Dmapper software.*

as Pix4Dmapper, MetaShape, Inpho, Context Capture, Dronedeploy, etc. The authors used the more familiar Pix4Dmapper software to perform aerial triangulation and generate three sets of DOM data corresponding to different configurations.

5) Accuracy validation

Once the data had been processed, the coordinates of each checkpoint were queried on the map and then compared to the corresponding RTK measured coordinates to calculate the variances dX, dY, dZ. The results are shown in Tables 2, 3 and 4.

As shown in the above charts, analysis reveals that the horizontal accuracy of NTRIP RTK and PPK are both within 5cm without control point correction, which is the ideal accuracy for the topographic survey. In the elevation dimension, RTK accuracy needs to be corrected with a small number of control points to reach the same level as PPK. The elevation precision is more susceptible to the control points correction relative to that of horizontal. When taking account of NTRIP RTK that may be affected by the quality of communication and the working environment, PPK provides more reliable and stable accuracy optimization and is less dependent on control points.

The accuracy of points P4 and P6 is lower than the rest, both in RTK and PPK mode. When corrected by the control point, the accuracy is greatly improved. For points outside the route coverage zone, the accuracy is relatively poor under the condition of zero GCP. It is necessary to optimize this by expanding the route area accordingly or placing a small number of control points.

CONCLUSION

From the above experimental analysis, it can be concluded that the PPK solution consistently delivers accuracy down to 5cm or below (depending on the ground sampling distance) across the entire survey. Compared with the traditional drone mapping method, this greatly reduces the reliance on control points, eases the fieldwork workload, improves both efficiency and safety, and provides a reliable, cost-effective commercial solution for drone mapping.

Table 4: Statistical Table of Point Mean Square Error_NTRIP RTK_3 GCPs adjusted

Point name	Coordinate deviation			Point RMS	Point name	Coordinate deviation			Point RMS
	dX_c	dY_c	dZ_c	dS_c		dX_c	dX_c	dY_c	dZ_c
P1	-0.010	-0.026	0.008	0.028	P5	-0.026	-0.042	0.051	0.049
P2	-0.039	-0.016	0.032	0.042	P6	0.026	0.094	0.038	0.098
P3	-0.037	-0.034	0.018	0.050	P7	-0.026	0.036	-0.028	0.044
P4	-0.044	-0.185	-0.019	0.190	P8	-0.005	0.036	-0.049	0.036

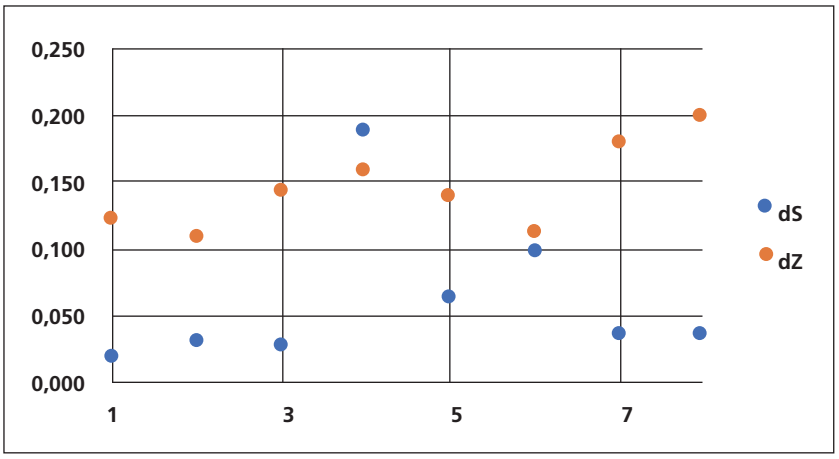

Figure 4: Distribution of checkpoint accuracy_Geotagged NTRIP RTK_noGCP

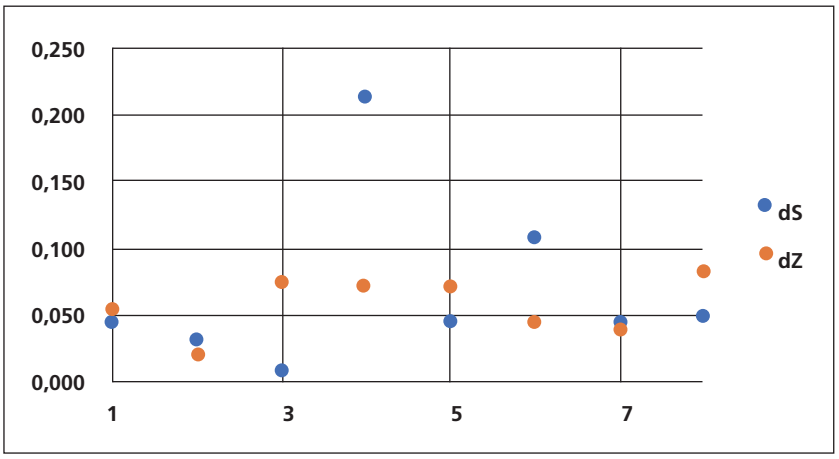

Figure 5: Distribution of checkpoint accuracy_PPK_noGCP

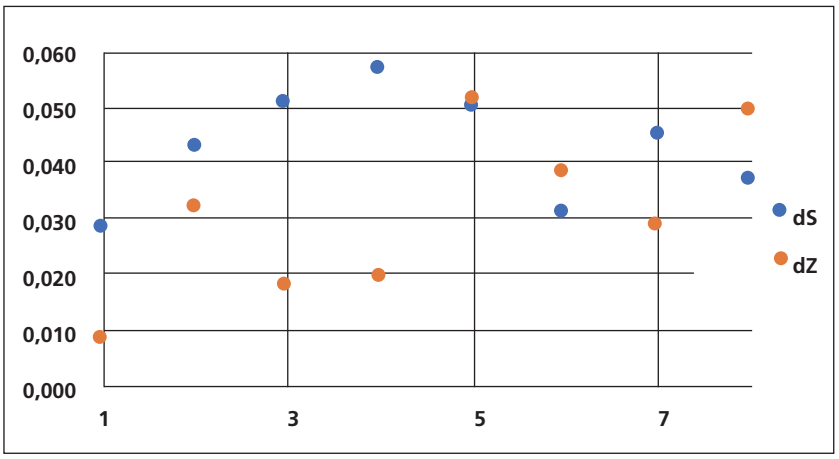

Figure 6: Distribution of checkpoint accuracy_ NTRIP RTK_3 GCPs adjusted

5 Questions to... Paul Digney, President of SSSI

How are technological developments, skills shortages and – of course – the pandemic affecting the broader geospatial community in Australia? To find out, *GIM International* spoke to Paul Digney, president of the Surveying and Spatial Sciences Institute (SSSI), which is the peak Australian body for all professionals and custodians of quality geospatial data creation, storage, maintenance and use.

2020 was an extraordinary year. How has the COVID-19 pandemic changed the way your organization operates, and which other factors are influencing the geospatial business?

The events of the last year have had a significant impact on all of us in many ways in terms of how we live and work, and many of those changes are likely here to stay. SSSI has taken a very proactive approach to managing the challenges of COVID-19 to support our members, profession and the broader geospatial community. The main effect has been our pivot towards delivering events and continual professional development via webinars that have attracted enormous interest throughout Australia and beyond. With many of our programmed face-to-face events cancelled, we provided more than 60 webinars between March and December 2020. A good example of this agile approach will be the delivery of our national spatial industry conference – Locate 2021 – as our first hybrid event. This will offer delegates who may not be able to travel the opportunity to attend Australia's premier geospatial event either online or through local hubs in their respective cities across Australia and New Zealand.

Overall, whilst the broader geospatial industry within Australia has been affected by the pandemic, we have fared much better than other sectors. In fact, we have an important role to play as the pandemic continues to unfold with governments and authorities relying on measures that are inherently spatial in nature, such as quarantining, contact tracing and social distancing. As governments work to reopen economies, they will rely increasingly on granular location information. To detect and extinguish new hotspots, public health officials will need to know the location of homes, the routes people take to work, and the parks and restaurants they visit, all of which hinges on geospatial information.

Which new technologies do you foresee becoming important to your work?

Many current and emerging technologies are highly relevant to SSSI and our members, but there is particular interest in spatial digital twins, satellite-based augmentation systems (SBASs) for GNSS positioning, artificial intelligence (AI) and machine learning. As the world has moved from data to models, there has also been an evolution occurring with digital twins. The early application of digital twins was moving to a 3D model as an improved design tool for the building of assets. More recently we have seen the advent of spatial digital twins applied to both the built and natural environment, from single buildings to parts of – or even whole – cities. There is now a global push to contribute to the concept of 'digital twin Earth' – an AI-driven digital replica of our planet that converts the full power of AI, Earth science and modelling, cloud computing and Earth-scale data about the environment, society and the economy into actionable insights for scientific, political and financial decision-makers.

Whilst SBASs have been available for users in regions such as the US, Japan and Europe for several years, the introduction of a Southern Hemisphere system will have a significant impact in Australia. The Southern Positioning Augmentation Network which is being jointly developed by the Australian and New Zealand governments has recently completed an 18-month trial and will become fully operational in 2023. Its introduction will significantly improve the accuracy of positioning from 5-10 metres to 10 centimetres without the need for mobile or internet coverage and will provide significant economic efficiencies and safety improvements to sectors such as agriculture, construction and transport through better location-based data and mapping.

Are you able to attract enough qualified personnel?

In Australia, as in many countries, there is a widespread shortage of skilled personnel in the surveying/ geospatial science professions. This is being acutely felt in sectors such as transport infrastructure and resources which are currently seeing significant investment occurring in many regions of the country. The current capability deficiency is likely to continue until the mid-2020s before starting to swing back towards a surplus. Whilst there is a large demand for geospatial professionals, there have been some welcome developments on the supply side which have helped the profession meet some of the shortages. Notably, enrolments in undergraduate geomatics engineering degrees (incorporating surveying and geospatial science degrees) have been rising steadily over the last ten years. This is one area that SSSI and other associations have worked collaboratively with the broader industry. Initiatives such as 'A Life Without Limits' have helped to foster greater interest in surveying as a career amongst young people and provide clearer guidance regarding pathways into the profession.

Diversity remains a challenge for our sector in Australia; studying surveying and geospatial sciences is still very much a male-oriented activity. The increase in enrolments in geomatic engineering courses is almost exclusively male, and the share of women in undergraduate geomatic engineering degrees has actually fallen. So there is much to be done to improve diversity and inclusion within our professions. In this context, SSSI has played a significant role in the Space, Spatial and Surveying Diversity Leadership Network (SSS-DLN): a sector-wide group of businesses, governmental and educational organizations aimed at providing visible advocacy for diversity and inclusion within the profession.

What is your policy on crowdsourcing and open data?

Australia has broadly adopted a policy of open data and was largely championed by ANZLIC, which is the peak government representative body in Australia and New Zealand responsible for geospatial information. It comprises the geospatial agencies from all states and national governments. Geoscience Australia, Australia's pre-eminent public sector

geoscience organization and Australia's national government member of ANZLIC, has been committed to open data since 2008 when it began applying Creative Commons By Attribution (CC-BY) licensing to its data and products as the default. SSSI is highly supportive of the use and application of open data. Open-access licensing permits the innovative use of data and information so that research, industry and the community can generate economic, social or other outcomes of benefit. To maximize re-use of information and enable uptake by the broadest range of potential users, however, government data and information needs to be free, discoverable, based on open standards and accessible online in machine-readable formats. SSSI has led the way in community engagement in the use of crowd-sourced and open data. The catastrophic bushfires which caused devastation to many parts of Australia in early 2020 affected all Australians, and those in the surveying and spatial profession were keen to provide assistance in some way. This resulted in the coordination of the SSSI National Bushfire Recovery Map-a-thon, where over 600 surveying and geospatial professionals from 25 countries volunteered and worked together to map burnt infrastructures in seven different project areas affected by bushfires. This was followed up with a second even more successful Map-a-thon on 31 October 2020 that focused on bushfire preparedness for the upcoming bushfire season. Participants collected data on static water infrastructures (such as dams, water tanks and swimming pools). Once again, the OpenStreetMap (OSM) platform and Hot Tasker Manager were used to coordinate the mapping effort.

In terms of meeting your goals, what is the biggest single challenge for your organization in the next five years?

The greatest challenge for SSSI is to remain relevant and continue to grow our membership base by meeting both the professional and personal development requirements of existing and new members with a broader range of services. This will require the ability to adapt and align with the changing needs of the industry and the members. Whilst we are currently seeing growth, there is still a trend for people to move away from professional organizations due to the increase in the availability of content online and the use of social platforms for networking. ◀

Paul Digney is the survey technical director for Jacobs Australia and president of Australia's Surveying and Spatial Sciences Institute (SSSI). He is a licensed surveyor in Tasmania and Victoria with over 25 years' experience in the surveying/spatial profession.

COMPANY PROFILES

ComNav Technology

Founded in 2012, ComNav Technology is a world-leading high-tech company focused on high-precision GNSS technologies. ComNav Technology engages in R&D, manufacturing, sales and services, aiming to provide worldwide customers with high-precision GNSS chips, modules, terminals, software and solutions across industries. ComNav Technology is dedicated to be an innovator and leader in high-precision GNSS technologies and applications. As of the end of 2020, ComNav Technology had sold its products and solutions to more than 120 countries with a total quantity of more than 440,000 units of modules (receivers) in over ten different industries, including land survey, machine control, UAV, UGV, deformation monitoring, personnel positioning, precision agriculture and marine. It is an R&D-driven company and nearly half of the employees have extensive experience in high-precision GNSS or engineering. Owning more than 40 technology patents and more than 50 software copyrights, ComNav Technology continues to invest at least 20% of annual revenue into R&D every year to pursue the best of GNSS technologies and solutions for global users. ComNav Technology believes that quality, performance and reliability make a difference. Every ComNav Technology product is subject to strict quality control and has been certified by international authoritative certification bodies. Located in Shanghai, the 26,000m^2 ComNav Technology GNSS Industrial Park accommodates more than 400 employees for daily work. With a dedicated team of people who are passionate about GNSS technology, ComNav Technology is committed to providing best-in-class positioning solutions for various applications to delight engineers and users with high-precision requirements.

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e-Compass

Founded in 2005, Shanghai e-Compass Science & Technology Co., Ltd is affiliated with the Unistrong Group. Located in Shanghai, e-Compass is specialized in the surveying and GIS industry, integrating R&D, manufacturing and sales. The main products include data acquisition and positioning equipment such as high-precision GNSS receivers, GIS data collectors, combined inertial navigation products, UAV positioning products and data application solutions such as displacement monitoring systems, intelligent driving test systems and precision positioning service systems.

www.esurvey-gnss.com | +86 21 54467213 | info@esurvey-gnss.com

CHC Navigation

CHC Navigation (CHCNAV) is a publicly listed company creating innovative GNSS navigation and positioning solutions. With a global presence – including distributors in over 100 countries – and more than 1,300 employees, CHC Navigation is today recognized as one of the fastest-growing companies in geomatics technologies. CHC Navigation develops advanced geospatial technologies and provides a wide range of state-of-the-art solutions, including for land surveying, construction, GIS, hydrography and bathymetric survey, deformation monitoring, precision farming and 3D mobile mapping for mass data acquisition. The company's surveying and engineering solutions include the i73 GNSS, a versatile pocket-sized IMU-RTK GNSS rover combining best-in-class performance and integrated inertial module to automatically compensate for pole tilt. The i90 GNSS receiver offers integrated IMU-RTK technology to provide robust and accurate positioning in any circumstances. Its automatic pole-tilt compensation boosts survey and stakeout speed by up to 30%. The P5E GNSS reference receiver guarantees outstanding performance for all geodetic and scientific applications. The CHCNAV slogan, 'Make Your Work More Efficient', perfectly summarizes how the company's GNSS positioning and integrated navigation solutions are designed to dramatically improve productivity and provide an outstanding return on investment for customers and business partners.

www.chcnav.com | +86 21 5426 0273 | sales@chcnav.com

European Space Imaging

Since the launch of the first very high-resolution (VHR) commercial satellite, European Space Imaging has been providing the best possible spatial resolution to the European market. From its inception in 2002, the company has established and maintained strong relationships with the industry's premium satellite imagery leaders and this has allowed European Space Imaging to ensure that it stays at the forefront of the geospatial industry. Through innovative partnerships, European Space Imaging now has access to 25 orbiting satellites at resolutions of between 30cm and 1m and with a combined daily revisit of close to ten times per day. In addition, it has access to an extensive imagery archive incorporating billions of square kilometres of data from all over the world, dating back as far as 2000. With almost 20 years' experience, European Space Imaging has developed a reputation for expert and personalized customer service and an unbeatable track record for supplying tailored very high-resolution imagery solutions to meet the diverse project needs and requirements of its customers. Furthermore, European Space Imaging is the only European satellite data provider to supply imagery at true 30cm resolution and which owns and operates its own multi-mission ground station for direct satellite tasking and local data downlink.

www.euspaceimaging.com | +49 (0)89 130 142 0 | sales@euspaceimaging.com

Geo-allen

Geo-allen Co. Ltd. was founded in 2002, in Suzhou, Jiangsu Province, 80km away from Shanghai. Over the years, Geo-allen has grown to be a world-famous company with an R&D team, a trading department, manufacturing workshops and an after-sales-service team. With the DNV's ISO9001 certificate and policies of best service/best quality/best prices, Geo-allen is gaining more and more industry recognition. Geo-allen is continuously expanding and developing. Its products now include UAVs, GNSS devices, total stations, theodolites, auto levels, laser instruments and almost all kinds of accessories including tripods, staffs, poles, bipods/tripods and reflecting systems as well as different kinds of adapters for GNSS controllers, different bags for instruments and accessories and more. Geo-allen also holds several approved patents for products that it has designed and is in the process of applying for more. With its values of Punctuality, Quality, Rigour and Service (P/Q/R/S), the company is looking forward to contributing to the development of the Belt and Road initiative and envisions an even more beautiful future. Although the world changed in 2020, when COVID-19 caused a sudden global shutdown and business slowed down, Geo-allen adapted quickly and continues to grow. The company is confident that business will be even better in 2021.

https://www.geoallen.com/ | +86 512 6802 6320 | +86 512 6862 9776 | geoallen@vip.163.com

Gintec

Guangzhou Geosurv Information Technology Co., Ltd (Gintec) is a professional company specialized in high-accuracy surveying, measuring and monitoring solutions, especially focused on providing practical, cost-effective and innovative monitoring solutions for geotechnical engineering. As a high-tech company, it values technological innovation and encourages everyone within the organization to make technological breakthroughs in their fields. Based on practical applications and user requirements, Gintec continuously improves product performance with innovative approaches to support considerable efficiency gains. As a people-oriented company, Gintec values the cultivation of talents. Ongoing professional learning and training are aimed at strengthening the company's capabilities and expertise to enable it to offer customers ever-more professional technical support. To maintain its reputation as a reliable supplier to customers, the focus is on ensuring the quality of every product. From developing and producing to delivering, every process involves strict testing to guarantee that customers receive the best-quality products. The Gintec technical team is devoted to developing innovative instruments, data acquisition and related software for surveying and geotechnical & structural monitoring. Especially in software, Gintec can provide outstanding support to solve difficult technical problems. Nowadays, the company is increasingly focusing on producing innovative monitoring systems that are adapted to clients' project needs to measure deformation, movement, inclination, strain, convergence, etc. Gintec also continues to develop practical and cost-effective monitoring instruments that are easy to install, read and interpret, which automate manual processes and reduce overall monitoring costs. In the future, the focus will remain on researching and developing advanced geotechnical instrumentation systems in order to provide more innovative geotechnical engineering solutions for customers.

http://gintec.cn | +86-20-82514956 | overseas@gintec.cn

Harxon

Harxon Corporation, a company of BDStar, is committed to delivering advanced GNSS positioning solutions that are reliable, precise, affordable and easy to use. With dedicated customer service and innovative products, the company has grown to become one of the world's leading aftermarket suppliers of high-precision GNSS antennas, robust radio modems, high-performance smart antennas for mission-critical applications such as surveying and mapping, UAVs, precision agriculture, autonomous vehicles and more. Harxon is also an original positioning equipment manufacturer that designs, manufactures and sells high-precision GNSS positioning technology. Its OEM positioning products come in different designs for a wide range of applications that require accuracy, efficiency and rapid integration, even in harsh environments. Harxon's field-proven positioning technology offers system integrators tailored service with shorter development cycles and increased profits.

https://en.harxon.com | +86-755-26989948 | sales@harxon.com

ImpulseRadar

ImpulseRadar develops and builds ground penetrating radar (GPR) instruments and related software. As an industry leader, it is the only GPR manufacturer offering an entire product line that utilizes the latest real-time sampling technology. This design concept provides significant operational and performance benefits over older conventional GPR designs. ImpulseRadar supports its advanced hardware with excellent user interfaces and improved processing software, which are simple, clean, intuitive and reliable. When investigating and mapping subsurface features and structures, professionals often face complex challenges and they need tools with which they can overcome those challenges in a quick, straightforward and dependable way. Because of this, ImpulseRadar focuses its efforts on areas where it can make a clear difference in functionality, user-friendliness and system performance. Whether for GPR novices or experts, ImpulseRadar's instruments offer a quick, precise and dependable way to investigate the subsurface and maximize in-field productivity and decision-making capabilities. The company's thoroughly modern range offers industry-leading performance with real benefits that will drive results across a wide range of application areas. As an established company, ImpulseRadar has an international network for sales and support. It is also Triple-A (AAA) rated by Dun & Bradstreet, in recognition of the high creditworthiness and capacity for meeting payment liabilities. Contact ImpulseRadar to learn more about its state-of-the-art GPR solutions, including PinPointR, CrossOver and Raptor.

https://impulseradargpr.com | +46 953 100 08 | info@impulseradargpr.com

Phase One

Phase One A/S is a leading researcher, developer and manufacturer of medium-format and large-format digital cameras, software and imaging solutions. Founded in 1993, Phase One is a pioneer of digital photography. The company has developed core imaging technologies and a range of digital cameras and imaging modules. Phase One provides the world's highest image quality in terms of resolution, dynamic range, colour fidelity and geometric accuracy. As such, the company has grown to become the leading provider of high-end imaging technology across many business segments. This includes both hardware and software for aerial mapping, industrial inspection and cultural heritage digitization, as well as serving the world's most demanding photographers. Based in Copenhagen, Denmark, and with regional offices in New York, Denver, Cologne, Tel Aviv, Tokyo, Beijing, Shanghai and Hong Kong, Phase One nurtures long-term relationships with customers, technology partners and its global network of distributors, often playing the role of digital imaging partner to customers with special requirements. It is with this passion for service that Phase One continually exceeds expectations and drives the imaging industry forward.

https://industrial.phaseone.com/ | +45 36460111 | +45 36460222 | industrial@phaseone.com

Racurs

Racurs has a 28-year history of success on the Russian and worldwide geoinformatics markets. Since its foundation in 1993, the company has been developing innovative mapping software for processing aerial, space and terrestrial imagery. The flagship product, PHOTOMOD, was one of the first digital photogrammetric systems on the market that was designed for working on off-the-shelf PCs. Today PHOTOMOD is the most popular digital photogrammetric software in Russia and well known all over the world.

PHOTOMOD provides a closed production cycle, and involves the generation of many kinds of value-added products – such as digital maps, DEM, orthomosaics and 3D-vectors – without the use of third-party solutions.

The main Racurs business activities are:

- PHOTOMOD development and further integration into Russian and international markets.
- Photogrammetric production services using both airborne and satellite imagery.
- R&D in the field of RSD processing software, methods and algorithms.
- Remote-sensing data distribution in Russia and the CIS countries.

Racurs has been an ISPRS Sustaining Member since 1998 and Special Committee I2AC Member since 2016. Racurs also organizes the well-known International Scientific and Technical Conference 'From imagery to digital reality: ERS & Photogrammetry'.

https://racurs.ru | +7 (495) 720-51-27 | info@racurs.ru

RIEGL

RIEGL is a leading international provider of cutting-edge airborne, mobile, terrestrial, bathymetric and unmanned laser scanning technology for a wide range of applications in surveying. In addition to the company headquarters in Horn, Austria – where research & development as well as production are also located – RIEGL provides sales, support and service through its offices in Vienna and Salzburg, RIEGL subsidiaries in the USA, Japan, China, Australia, Canada and the UK, and its worldwide network of distribution partners. RIEGL has been producing Lidar systems commercially since 1978 and focuses on pulsed time-of-flight laser radar technology in multiple wavelengths. RIEGL's core 'smart waveform' technologies provide pure digital Lidar signal processing, unique methodologies for resolving range ambiguities, multiple targets per laser shots, optimum distribution of measurements, calibrated amplitudes and reflectance estimates, as well as the seamless integration and calibration of systems. RIEGL's various 3D scanners offer a wide array of performance characteristics. The professional advice of the RIEGL experts ensures that each customer finds the optimum solution for their specific applications. From initial purchase to system integration as well as training and support, RIEGL stands out as an industry leader.

http://www.riegl.com | +43 2982 4211 | office@riegl.com

Zoller & Fröhlich

Beyond being a leader in the fields of ferrules, wire harnessing technology and laser measurement technology, Zoller + Fröhlich (Z+F) is known worldwide as a manufacturer of innovative products in the areas of switch cabinets and special machinery. All products have been developed and produced exclusively in Germany, where the company employs more than 270 employees. Z+F is an internationally operating company and cooperates with dealers in more than 40 countries. There are also permanent subsidiaries in the United Kingdom and the United States. Besides the corporate success, human beings have always been a focus of the company's philosophy. This principle can be seen in the various social and cultural commitments of the company – always with the objective of regionality and strengthening the company's locations.

www.zf-laser.com | +49 (0) 7522 9308-0 | sales@zf-laser.com

Teledyne Optech & Teledyne Caris

For more than 45 years, Teledyne Optech has been providing world-class Lidar technology for airborne, mobile, bathymetric and most recently UAV with its compact Lidar. Teledyne CARIS has been a world leader in hydrographic software for more than 40 years. This year, the businesses are aligning to create holistic geospatial solutions for land and water. Learn more about solutions like the world's most powerful topo-bathy Lidar system, the CZMIL Supernova, now featuring the world-leading bathymetric processing and data management software CARIS Bathy Database (BDB) delivering a single workflow for acquisition, processing and analysis. Explore the leading Galaxy suite of airborne sensors including T2000, which boasts an effective two million points per second all on the ground, efficient and effective corridor mapper CM2000 and the bestselling Prime+. All Galaxy models now feature the CARIS Mira AI Lidar noise-classifying software, providing significant time-savings in Lidar data processing with 95% accuracy and reducing manual point-cloud processing times by 50-90%. There is no need to adjust parameters such as density and altitude, and the sensitivity of the tool can be adjusted to suit individual project needs with a few simple and understandable parameters.

https://www.teledyneoptech.com/ | https://www.teledynecaris.com/ | +1 905 6600 808 | inquiries@optech.com

SBG Systems

SBG Systems is a leading supplier of inertial motion sensing solutions, from miniature to high accuracy. Combined with cutting-edge calibration techniques and advanced embedded algorithms, SBG Systems' products are ideal solutions for surveying applications whether they are aerial, marine or land based. The company has renewed its popular line of miniature inertial navigation systems with high-end functionalities. The Ellipse-D 3rd Generation now embeds a dual-frequency and quad constellation GNSS for centimetric position and higher orientation accuracy. This lightweight dual-antenna RTK GNSS/INS brings high-end technology to the smallest factor, offering a cost-effective solution to surveyors. SBG Systems' in-house full-featured post-processing software Qinertia gives access to offline RTK corrections and processes inertial and GNSS raw data to enhance accuracy and secure the survey. Qinertia has recently been upgraded to support third-party IMUs and all GNSS receivers and now covers all surveyors' projects with its new GNSS licence to post-process both static and kinematic GNSS data. It now includes a brand-new Virtual Base Station (VBS) feature. The VBS consists of computing a virtual network around projects in which position accuracy is maximized, homogeneous and robust as for PPK short baselines. Surveyors can collect data far from base stations or over large areas, making it ideal for corridor mapping. SBG Systems also offers custom solutions to cover all surveying applications, like Quanta. It is a direct georeferencing solution that delivers precise orientation and centimetre-level position data in real time and for post-processing.

www.sbg-systems.com | +33 1 80 88 45 00 | sales@sbg-systems.com

Schneider Digital

Schneider Digital is a globally active, full-service provider for professional 3D-stereo, 4K/8K and VR/AR hardware solutions. Schneider Digital supplies the optimal monitor-related, workstation-related, graphics-related and peripheral devices for demanding applications in the geospatial sector, meeting the highest requirements for 3D-stereo and VR/AR systems. Hardware solutions by Schneider Digital are predominantly used in graphics-intense computer applications such as 3D city modelling, GIS, BIM, photogrammetry & remote sensing, Lidar 3D point-cloud editing, oil and gas exploration, geology, hydrology and hydraulic engineering, meteorology and weather modelling, geodata processing, data analytics and reporting, geoCAD applications, geoplanning, land survey, cartography & data visualization, navigation & telematics, etc. The company's portfolio includes desktop 3D-stereo and touch-enabled monitors up to 4K/8K resolution and screen diagonals from 27" to 98", VR/AR solutions, Powerwall & multi-screen displays, professional graphics cards by AMD and NVIDIA, high-performance workstations as well as innovative peripheral devices, such as head-tracking and gesture-tracking devices, 3D controllers, Z-mouse systems, 3D measurement devices and 3D glasses. Schneider Digital manufactures its own Powerwall display solution called smart VR-Wall and the 3D PluraView passive 3D-stereo monitor.

www.schneider-digital.com | www.pluraview.com | +49-8025-9930-0 | info@schneider-digital.com

South

Every technology revolution contains the immense power of changing the world. South, a national brand in the geoinformation industry, has created its own legacy over the past 30 years and presented a new picture of 'Mind in China'. In the air, the company helps to capture data of each part of the globe to digitize 3D spatial reconstruction; on the ground, it can position each location with high precision to digitize the living environment; indoors, it is striving for SLAM mobile mapping to bring new innovation; and in the water, it supports the collection of highly accurate data for environmental protection and ecological balance. South is changing the methodology of information exchange and data capture, and getting intelligence into daily life. The company provides professional turnkey solutions for a variety of industries, creating bigger values with expertise and vision and making surveys much easier than before. South is striving to realize every incredible idea and make dreams come true. It sees every step as a new advancement of the geospatial industry, as a way of shaping history and creating new opportunities. South Group is committed to becoming and remaining a world-class survey equipment manufacturer and geoinformation solution provider.

www.southinstrument.com | +86-20-23380888 | mail@southsurvey.com

Tersus GNSS

Tersus GNSS provides affordable, centimetre-precision GNSS solutions to improve the quality of life for everyone. Independent core technologies in surveying, automation and GNSS correction enable the company to broaden the application of its solutions. From Tersus GNSS RTK boards to integrated solutions, Tersus software, hardware and services make high-precision positioning more accessible. For example, the Tersus BX40C is a compact GNSS RTK board with full constellation tracking for providing centimetre-level accuracy positioning, and the Oscar is a new generation of tilt survey GNSS receivers with calibration-free tilt compensation. Founded in 2014, Tersus GNSS is rapidly expanding in the global market. The continuous investment in R&D is crucial to maintain its rapid growth in an extremely fast-changing environment. Tersus GNSS solutions are used all over the world. The company serves and supports its customers from its offices located in China, the US and Australia, coupled with a competent network of dealers and distribution partners.

www.tersus-gnss.com | +86 21-5080 3061 | Sales: sales@tersus-gnss.com | Technical support: support@tersus-gnss.com

TI Asahi

TI Asahi Co., Ltd. was established in 2009 and inherited the manufacturing business of Pentax-branded surveying instruments, whose origins can be traced back to 1933 when Fuji Seisakusho first started producing what has since become one of the oldest surveying products in Japan. As a leading company in developing and manufacturing state-of-the-art surveying instruments, TI Asahi has introduced various high-precision and high-quality product lineups. These include optical levels, total stations, GNSS receivers and 3D scanning systems, all of which have been used and appreciated by numerous professionals in worldwide surveying and construction projects. The company mission is to develop and provide the products that fully meet the needs of the world of surveying by focusing on true performance that customers desire in surveying instruments. TI Asahi believes that the products it provides must be able to offer substantial solutions to both technological and economical obstacles faced by users in their daily work. The company therefore regards it as essential to continuously learn what is actually required in real-time surveying and to reflect those needs in all levels of its business activity, from product development to aftersales service.

www.pentaxsurveying.com/en | +81 487930118 | international@tiasahi.com

Vexcel Imaging

Developing cutting-edge digital aerial cameras and photogrammetric processing software with constant product upgrades and world-class support has made Vexcel Imaging a market leader in the geospatial arena. The industry-leading UltraCam aerial sensor portfolio covers all applications in airborne photogrammetry, from nadir to oblique to wide-area data collection. Processing of the UltraCam data is handled by the UltraMap photogrammetric software suite that offers a processing workflow for highly automated generation of exceptional-quality point clouds, DSMs, DTMs, ortho imagery and 3D-textured TINs. This end-to-end technology is the basis for Vexcel's cloud-based aerial image library providing organizations with location-based insight and intelligence. Industry-leading UltraCam sensors provide up-to-date high-resolution vertical and oblique imagery along with other digital representations of the world, and precision geometry enabling AI and machine learning. The Vexcel Data Program (VDP) allows businesses and organizations to make better strategic decisions through intelligent imagery to uncover crucial location insights. VDP is already powering the Geospatial Insurance Consortium (GIC), an initiative launched by the National Insurance Crime Bureau (NICB) to provide its 1,100 members with best-of-breed aerial pre-disaster and post-disaster imagery.

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5 Questions to... James Kavanagh, RICS

Despite COVID-19 and Brexit, the UK geospatial sector has actually increased its operational capacity rather than suffering a downturn, according to James Kavanagh, director of global land & resources at RICS. We asked him five questions about his views on today's and tomorrow's surveying profession.

2020 was an extraordinary year. How has the COVID-19 pandemic changed the way your organization (and the industry) operates, and which other factors are influencing the geospatial business?

In 2020, we all suddenly found ourselves working in a very different environment – one in which health, safety and adherence to COVID-19 requirements/restrictions were paramount. If anything, it has made us much more aware of our impact on others, and RICS has been quick to provide practice-based advice to members. Within geospatial surveying, we have seen clients become more aware of not only the 'remote' and therefore coronavirus-safe nature of geospatial data capture, but also the increasingly critical need to be able to access up-to-date and accurate geoinformation for all kinds of asset management applications. The UK geospatial sector does not seem to have suffered a downturn during 2020, despite COVID-19 and Brexit; in fact, it appears to have increased its operational capacity. Governments seem to be using large infrastructure and construction projects to help kick-start the post- COVID economies and geospatial surveying has a key role to play.

Which new technologies do you foresee becoming important to your work?

Robotic indoor measurement, SLAM-enabled mobile laser/Lidar scanning and consumer-led technology with geospatial applications – for example, the Apple iPhone 12 with an in-built scanner – all have the potential to become important. We can also see the merging of geospatial technologies, with multiple data sources (scanning, imagery, etc.) being combined with other related tech such as augmented reality/virtual reality (AR/VR). We're also excited by the digital twin concept and the large-scale asset management potential of the 'holy grail' of full BIM/GIS integration. It really does feel that geospatial is on the cusp of a new age.

Is the surveying profession able to attract enough qualified personnel?

There is a growing professional and technical capacity crisis within surveying across all sectors, from engineering to land management to hydrographic surveying. I believe that the only nation on Earth producing a surplus of surveyors is Poland. There is a need to look at our academic and technical training capacity in a less parochial way and perhaps to better share capabilities. Initiatives like 'Get Kids into Survey' and its use of the GeoSquad comic format might be a solution (certainly in the anglophone world) but it is also important to ensure that young people are able to fulfil their professional, social and economic aspirations.

What is your policy on crowdsourcing and open data?

These approaches do have an important role to play, but issues of liability and accuracy need to be remembered. They can work if used for investigative and insight purposes or in regions where nothing definitive exists, but there are risks if used for decision-making and definitely in a legal (cadastral) context. There is no thread of assurance (or, more importantly, liability) and the data can also be 'gamed' or interfered with. Authoritative, definitive and consistent geospatial data provided by national agencies and/or professional surveyors will always be needed.

In terms of meeting your goals, what is the biggest challenge for your organization in the next five years?

Capacity issues, climate change, the sustainable development goals, training, new tech and the integration of geospatial technologies are all important challenges. Other issues that we as a profession need to deal with include career development, staff retention, economic and salary improvement and things like understanding mental health, because the construction sector had a serious problem with depression, anxiety and tragically suicide even before COVID-19. RICS is very keen to work with and help geospatial firms to become more holistic in understanding staff needs and to put in place the best processes to help the profession to grow – and to look after its professionals! ◂

James Kavanagh MRICS C.Geog is a Chartered Surveyor and Chartered Geographer. He studied at DIT Dublin, Ireland, and University of London. With over 25 years' experience in the global land and property sectors, James worked on some of the largest infrastructure projects in Europe before spending several years working on mapping, surveying and formal/informal land rights issues for the United Nations (UNRWA) around the world. He is currently director of global land & resources with the Royal Institution of Chartered Surveyors (RICS). He is also engaged on geospatial technologies and their application within BIM and the implementation of smart city policies. James is chair of the International Land Standard (ILMS) Coalition and is working on further research and output on issues of valuation within informal settlements, customary land issues and the process of land and property rights formalization.

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