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Future Trends in Geospatial Information

Future trends in geospatial information management: the five to ten year vision

Background Document Prepared by Ordnance Survey, Great Britain on behalf of UN-GGIM

**The secretariat acknowledges with thanks the substantive contributions from Jevon Snell and John
Carpenter of Ordnance Survey, Great Britain**



UN-GGIM

UNITED NATIONS INITIATIVE ON
GLOBAL GEOSPATIAL
INFORMATION MANAGEMENT

Future trends in geospatial information management: the five to ten year vision

Draft for consideration by the
UN-GGIM Committee of Experts,
July 2012



UN-GGIM

United Nations Initiative on
Global Geospatial Information Management

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Background

At the inaugural meeting of the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM), held in Korea in October 2011, the Committee decided that there was a need to document the thoughts of leaders in the geospatial world as to the future development of this industry over the next five years and then looking further out, to thoughts as to its development over the next 10 years.

A number of experts and visionaries across a wide range of disciplines of the geospatial community – from data collection experts, academics and major users of geospatial information, through to leading figures from the private sector and the volunteered geographic information (VGI) movement – have been invited to contribute their views on the emerging trends in the geospatial world. In addition, all member states were invited to input their views.

A number of written responses were received from individuals across the broad spectrum of the geospatial community, and a follow-up discussion forum was held in Amsterdam in April 2012 to elaborate on these contributions and to try to find consensus on major trends. This paper builds on both the written contributions received and on the discussions held in April 2012.



Acknowledgements and disclaimers

The views expressed in this paper are, at present, the considered views of the authors based on the contributions received in written form and the views expressed and trends identified at the forum held to discuss these issues in April 2012. Whilst different and, at times, conflicting views were inevitably expressed by contributors, consensus on a number of major trends were forthcoming.

This paper is being presented to the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) for its consideration and it is likely further editing may take place before it is approved by the Committee.

We are grateful to all those who have given up their time, either to provide written contributions or to attend the discussion forum held in April 2012. A full list of those who have contributed can be found at the end of this paper.

This paper has been authored on behalf of UN-GGIM by Jevon Snell and John Carpenter of Ordnance Survey, Great Britain, based entirely on the contributions of those listed at the end of this document. The document does not reflect the views of the authors or their employer.



Foreword

As a community, those involved in the geospatial world have seen significant change over the past decade. Understanding of the value of geospatial information among senior decision-makers in both governments and businesses around the world has increased significantly in recent years. The Internet, mobile devices and the explosion of location-based services which bring us and everyone directly into contact with location information on a daily basis have ensured that people, the world over, are beginning to appreciate the value of geospatial information.

At the first session of the Committee of Experts, it was agreed that it would be beneficial to document major trends we expect to impact on those of us involved in geospatial information management in the coming five to ten years.

The United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) was established to ensure that Member States can work together, share knowledge and support the development of strong geospatial information bases. The work is all based on a common recognition of the value geospatial information can play in developing our economies, in providing critical services, in underpinning sustainable development, and in doing so, in enhancing people's lives the world over.

A cross-section of recognised experts from all regions of the world were approached to provide initial written contributions and requests were made to all Member States to provide contributions also. As stated previously, this was then followed by a forum in Amsterdam in April 2012, which offered the chance to build on those contributions and seek to find consensus.

This draft paper is now being presented to the Committee of Experts for discussion and to seek, at this stage of the development of the paper, the valuable wider input of the complete spectrum of Member States represented on the Committee. We would welcome all input and contributions to this discussion in order to ensure the paper, when published in its final form, reflects the considered views of the Committee as a whole.

At this stage, we have not focused on future trends in uses of geospatial information; relatively few of the responses received focused on uses and, as such, the paper reflects this. Nevertheless, raising awareness of the many uses to which geospatial information can be applied, and the value of doing so, will be a critical activity of UN-GGIM. As such, we are hoping that all of you will consider providing case studies from your own countries which demonstrate how geospatial information can be used and the benefits that its use has brought. These can then be used to complement this paper, helping to demonstrate to senior decision-makers and stakeholders why location matters.

Whilst inevitably different Member States may face different challenges at different times, I am also confident that many of us will face a significant amount of similar challenges and opportunities in the coming five to ten years, many of which I hope are identified in this paper. The UN-GGIM will be a valuable forum where we can meet and discuss these shared challenges and opportunities and support each other, sharing the valuable experience and expertise that we all possess.

Dr Vanessa Lawrence CB

Director General and Chief Executive, Ordnance Survey and
Co-Chair, UN Committee of Experts on GGIM
July 2012



Executive summary

The use of geospatial information is increasing rapidly. There is a growing recognition amongst both governments and the private sector that an understanding of location and place is a vital component of effective decision making. Citizens with no recognised expertise in geospatial information and who are unlikely to even be familiar with the term, are also increasingly using and interacting with geospatial information; indeed in some cases they are contributing to its collection often in an involuntary way.

A number of important technology-driven trends are likely to have a major impact in the coming years, creating previously unimaginable amounts of location-referenced information and questioning our very understanding of what constitutes geospatial information. These developments offer significant opportunities, but also present challenges, both in terms of policy and in terms of law. Meeting these challenges will be important in order to ensure that the full value of geospatial information can be maximised in the coming five to ten years.

Ensuring that the full value of geospatial information is realised in the coming years will also rely on having the necessary training mechanisms in place. New and changing skills will be required to manage the increasing amount of geospatial information that is likely to be created and to ensure that the maximum value is secured from it.

The number of actors involved in generating, managing and providing geospatial information has increased significantly in the last ten years, and this proliferation will continue and indeed will likely accelerate in the coming five to ten years. The private sector and the Volunteered Geographic Information (VGI) community will continue to have a significant role to play in providing the technologies and information required to maximise the opportunities available. They are likely to provide valuable and in many cases unique elements of geospatial information and the technologies and services required to maximise it, in addition to offering a growing understanding of the end-user base for geospatial information.

Government's role in geospatial information management may well change in the coming five to ten years, but it will continue to be vital. Building bridges between organisations, collaborating with other areas of the geospatial information community and providing complete geospatial frameworks will be key to ensuring that users have access to reliable and trusted geospatial information. This information can be used to inform decision-making and to ensure that the potential benefits of a fully spatially-enabled society are realised.

As with all technology-driven sectors, the future is difficult to predict. However, this paper takes the views of a recognised group of experts from a wide range of fields related to the geospatial world together with valuable contributions from the National Mapping and Cadastral Authorities, and attempts to offer some vision of how this is likely to develop over the next five to ten years.

Based on contributions received, trends have been broken down into broad themes covering major aspects of the geospatial world. They are as follows: Technology trends, including the future direction of data creation, maintenance and management; legal and policy developments; skills requirements and training mechanisms; the role of the private and volunteered geographic information sectors; and the future role of governments in geospatial data provision and management.



1 Trends in technology and the future direction of data creation, maintenance and management

1.1 'Everything happens somewhere' – the new wave of data creation

1.1.1 We are witnessing an exponential growth in both the number of data capture methods and, perhaps more significantly, in the amount of data being generated and captured. Geography has long been 'mobile'; indeed, one of the most significant trends of the last five to ten years has been the number of devices in use that have Global Navigation Satellite System (GNSS) functionality and an Internet connection and that, as a result, both use and create location information.

1.1.2 This trend will continue over the next five to ten years – we can envisage a scenario in which many objects will be, in some sense, a geospatial beacon, referencing to or generating location information. The proliferation of low cost, low tech, network enabled sensors – be it in mobile phones, computers, energy meters or any other everyday device – will mean that previously unimaginable amounts of data will be created.

1.1.3 Data creation will be both active, but also, increasingly, passive. Users of social media such as Twitter and Facebook are likely to generate vast amounts of spatially-related information, without ever being particularly conscious of the fact they are doing so, as detailed information is collected as a by-product of everyday activities. Tweeting from a place where you have gathered with friends or posting a picture on Facebook from your phone may not be conscious efforts to create or provide geospatial information but this is still, in essence, what is taking place.



1.1.4 New layers of data will increasingly be generated as a result of these activities leading to what can be described as 'modelled geospatial actor data'¹, whereby information generated by individuals using websites and social media is overlaid on top of spatially accurate geospatial information. The information generated through use of social media and the use of everyday devices will further enable the detection of patterns and the prediction of behaviour. This is not a new trend - many online companies and resources already analyse and interpret information in this way and the proliferation of location based services (LBS) has been one of the major trends of the *last* five to ten years – but

¹ This phrase was used by one of the contributors in their submission to the GGIM Secretariat on *Future trends in geospatial information management*



the extent to which this takes place is likely to continue to grow over the next five to ten years as yet more and more data is generated through such channels.

- 1.1.5 There are a diverse range of existing demonstrable benefits that suggest this trend will continue – from life-critical information in the aftermath of a disaster to lifestyle information such as finding a restaurant. In the coming five to ten years, more are likely to emerge, from lowering insurance premiums, to being able to see on a mobile device the nearest source of fresh water or the owner of a parcel of land. Individuals will continue to ‘opt-in’ to a lifestyle which is enhanced by an ever-growing number of geospatial beacons and sensors, in turn providing ‘analytical superfood’² that can and will, if used effectively and appropriately, improve people’s lives across the globe.
- 1.1.6 Nevertheless, the significant growth in deployment of geospatially-enabled devices and the increasing use of geospatial information in everyday life will bring with it a need for stronger policy and legal frameworks to manage privacy concerns and protect the interests of those who are providing this data. The way the above information is used, and the privacy concerns which may manifest themselves as a consequence of this, will be discussed in greater detail later in this paper.

1.2 Managing a world of data

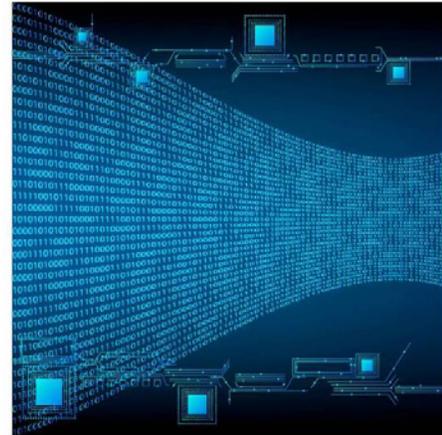
- 1.2.1 The creation of such huge amounts of data will bring with it a requirement for the ability to make sense of this data, which, in and of itself, will drive demand for geospatial information as people look to location to help make sense and identify patterns within the sea of data that is being created.
- 1.2.2 We are currently suffering from a data overload; our ability to create data is, in general, ahead of our ability to use that data effectively to solve problems. There is no doubt that there is a huge amount of value to be gained from the information contained within all this data that is being generated. However, the growth in the amount of data brings with it an ever-growing requirement to be able to find the *right* information at the *right* time.
- 1.2.3 The huge quantities of data now generated, and the increasing amounts of data that are likely to be created, will bring a requirement for enhanced data management systems. With approximately 2.5 quintillion bytes of data created every day³, a significant amount of which will have some kind of location reference, the challenges of data management moving forward will be significant.

² This phrase was used by a contributor in their submission to the GGIM Secretariat on *Future trends in geospatial information management*

³ <http://www-01.ibm.com/software/data/bigdata/>



1.2.4 The need to address this problem will drive one of the main trends in the next five to ten years – an increasing use of and reliance on *Big Data* technologies – technologies which enable the analysis of vast quantities of information within useable and practical timeframes. Currently, many of the Big Data solutions being generated are custom-crafted. Technology is already available to deal with ‘big data’, but the reliance on this kind of technology will grow in the next five to ten years.



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1.2.5 The demand for real-time information and real-time modelling seems certain to increase in the coming years and presents major challenges. Nevertheless, techniques such as Graphical Processing Units (GPUs), parallel processing and NoSQL⁴ databases are becoming available, which will meet the demand to generate the desired results within a matter of seconds instead of hours.

1.2.6 Looking outward over the next five to ten years, new massively scalable, distributed systems for processing unstructured and semi-structured data will emerge, and will become widely accepted and relied upon in the management and interpretation of geospatial information. Use of these technologies will facilitate the effective use of the reams of raw data being generated by the increasing number of geospatial sensors, eliminating ‘the white noise of excessive data’⁵ to locate the right information at the right time, thus driving effective and well-informed decision-making.

⁴ A new model of database, less reliant on data being structured and particularly designed for working with large volumes of data

⁵ This phrase was used in one of the submissions to the GGIM Secretariat on *Future trends in geospatial information management*



1.4.2 Use of, and reliance on the cloud by those in the geospatial community will continue to increase significantly to meet this demand in the coming five to ten years, particularly as volumes of data and demand for real-time, real-world data grows. Over the next five to ten years, Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS) and Data as a Service (DaaS) all offer technological opportunities to those in the geospatial management world that better meet the requirements of users.



Source: SCOTTCHAN/Shutterstock.com

1.4.3 As mentioned previously, users will want to receive the right information at the right time. In order to achieve this, and in light of the increase in the volumes of data available, the geospatial computation required to do this will increasingly be non-human in nature, with accurate results generated automatically and provided directly to end-users.

1.4.4 As well as expecting to receive the right information at the right time, users will increasingly expect to receive the desired information to their device of choice. Use of the cloud will also facilitate this and is likely to become the standard over the next five to ten years, making geoinformation resources accessible to anyone, anywhere, anytime.

1.5 Open Source

1.5.1 Open Source is likely to grow significantly as a viable alternative to commercial suppliers. The geospatial community already has a well-established 'infrastructure' in the Open Geospatial Consortium (OGC) and a vibrant and relatively tight-knit community who champion its potential. The wider drive in governments towards Open Source solutions will remove many of the perceived barriers to wider adoption and drive a virtuous circle, where the value will grow as more users adopt and feed back improvements. A number of National Mapping and Cadastral Authorities (NMCAs) have already adopted Open Source into some of their services.



- 1.5.2 Three trends seem likely to drive this adoption – in countries where resources are particularly scarce the availability of free-to-use software clearly has upfront economic benefits. Secondly, the ability to share and modify software relatively easily also helps to facilitate knowledge exchange and the building of common user communities. In countries where the development of geospatial infrastructures is in its early stages, the availability of Open Source information offers a genuine alternative to previous operating methods. Finally, the next generation of geospatial graduates will have been exposed to Open Source during their academic studies and potentially in their personal lives, and hence will be technically as well as culturally attuned to using it.

1.6 Trends in ‘professional’ data creation and maintenance

- 1.6.1 A number of primarily technology-driven trends in the professional world of geospatial data collection will continue to improve both the quality of data collected and the efficiency with which it is collected.
- 1.6.2 The trend of moving from two dimensional (2D) mapping through to three dimensional (3D) and on to four dimensional (4D) visualisations is technology driven and will accelerate in the next five years. Users are likely to increasingly expect more complex and realistic 3D models, particularly of cities, to enable effective planning and management and to optimise resources. Much of the influence for the developments in these areas comes from outside of the traditional geospatial sphere, with 3D software and developments in the gaming industry offering insights and possibilities which ‘maps’ cannot provide.
- 1.6.3 The use of the fourth dimension is also likely to increase over the coming five to ten years in geographic information systems (GIS), with GIS companies increasingly providing ‘time’ functionality as an additional dimension alongside conventional x, y and z coordinates. This is likely to provide the ability to view the past, in order to understand change that has already taken place, but will also enable predictive modelling of future trends. Effectively managing real-time information, but also effectively archiving time-referenced data, will become an increasingly important technique in the management of data over the coming years.
- 1.6.4 The quality of aerial imagery will continue to increase in the next five to ten years. However, with the existing availability in many areas of the globe of very high-resolution imagery at centimetre levels, focus in this area is likely to be more on the speed with which the imagery collected can be provided to users and what analysis can be undertaken with those images.
- 1.6.5 The proliferation of low cost launch systems and affordable satellites, with increasingly powerful multi-band sensors will both lower cost and greatly increase the volume of high-quality imagery. As well as providing greater coverage, increased frequency of data collection will allow more dynamic analysis of remote areas, for issues such as canopy loss and land use.

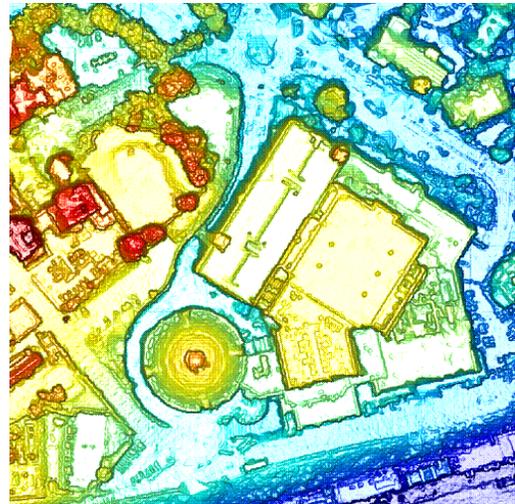


1.6.6 Unmanned Aerial Vehicles (UAVs) in the civilian sector are likely to be increasingly used as an additional method of data capture and will complement satellite remote sensing and aerial imagery. These devices will be useful to supplement both everyday data collection and in emergency response situations, where near real-time information is of particular value to those on the ground.



1.6.7 The ability of UAVs to access areas that would otherwise be inaccessible offers the chance to enhance the information available to decision makers on the ground, providing a more comprehensive operating picture to those involved in an emergency response. The use of this kind of near real-time data capture tool could be invaluable in an incident such as a fire on an industrial complex or when crowd control is required following an event, where additional information further increases effective command and control and analysis.

1.6.8 The accuracy of optical imaging sensors will continue to improve significantly over the coming years, bringing with it the ability to better identify features on the ground. Spatial, spectral and radiometric resolutions will drastically be improved enabling the better identification of features. In this regards, stereoscopic high-resolution hyper-spectral imagery could also become more widely available.



1.6.9 Mobile mapping systems will be upgraded for capturing and processing both street-level visual information, Points of Interest (POI) and attribute data in more detail. We are likely to see further use of 3D flash-Light Detection and Ranging (LiDAR) and optical sensors onboard, which will facilitate the generation of more comprehensive and complete data sets.



1.7 Positioning ourselves in the next five to ten years

1.7.1 Global Navigation Satellite System (GNSS) technology is now mainstream, but the major step-change across the spectrum of user equipment is likely to come within five years with the launch of both new and next-generation GNSS. By 2015, there will be over 100 GNSS satellites in orbit. This will enable faster data collection in very challenging environments, with higher accuracy and greater integrity. User equipment will see greater integration with other technologies to produce a more complete and ubiquitous positioning solution.



Source: eteimaging/Shutterstock.com

1.7.2 Improvements in satellite gravimetry missions are starting to challenge the way that vertical reference systems are defined. Some nations are already taking the step to move away from traditional schemes defined using large-scale terrestrial observations and base the national vertical reference system on purely gravimetric geoids instead.

1.7.3 Reference frames are becoming more accurately defined with each iteration as technology and techniques improve. This is further aided by long term GNSS and other space observation, for example, Satellite Laser Ranging (SLR), Very Long Baseline Interferometry (VLBI), Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) datasets. National reference frames are increasingly becoming more aligned to globally standardised geodetic reference frameworks – an example being International Terrestrial Reference Frame (ITRF) – as well as GNSS reference frames. This fosters interoperability and unification of geospatial information datasets across the globe and will be of increasing importance in the coming five to ten years.

1.7.4 Indoor positioning is also an emerging frontier, but one which still presents major challenges. Whilst a number of technologies exist that can be used to improve data in this area, including ultrawideband, accelerometers and Radio Frequency Identification (RFID), no single source is able, as of yet, to provide the widespread coverage that may be expected in years to come. Whilst solutions are likely to be forthcoming in time, it is more likely to be closer to ten years than five years when we see the greater availability and widespread use of indoor geospatial information.



- 2.1.5 Privacy issues are also considered in greater detail below, however, as data becomes more accurate and timely, there will be a desire in some countries to control access, or at least know who is accessing the data. The development of online access controls will evolve to enable this, but given the ease with which data can be hacked, these controls are likely to be easily circumvented, potentially raising questions, in those countries where such concerns exist, about who is accessing the information.

2.2 Funding in a changing world

- 2.2.1 Governments and governmental bodies involved in the collection and management of geospatial information have traditionally been reliant on public money to fund their activities. Whilst variations on this model have emerged in the last ten to twenty years, the majority of countries still are reliant, in one way or another, on funding from the public purse. The foundations of traditional funding models for geospatial information collection and maintenance have, however, been shaken in recent years. The emergence of the Internet and the creative dynamism this has brought with it has shaken the notion that content needs to be paid for at the point of use, whilst the financial crisis that has engulfed much of the world has placed increasing strains on public sources of funding. Both of these trends present major challenges.
- 2.2.2 Access to information free at the point of use that appears comparable to other sources of data, and indeed which meets the needs of certain user groups, inevitably leads to questions about the cost at the point of use for other sources of information.
- 2.2.3 Content is, in general, not cost-free, either to collect or to manage. In general, there are costs involved with collecting and managing geospatial information, even if it is provided to users free at the point of use. Private sector companies may choose to provide certain information free at the point of use, because the value they get from other information overlaid on that data and the revenues they can generate from other sources linked to that information make it economically worth their while, especially in areas of high economic activity. Conventional Volunteered Geographic Information (VGI), that is geographic information actively collected by members of the public and maintained through crowd-sourcing (the best known example being OpenStreetMap), may be provided free at the point of use, but is reliant on a significant amount of time and energy being spent by a relatively small number of individuals collecting and managing that information (or incorporating information from other sources). Governments may choose to provide information to its citizens free of charge, either out of principle, because it believes doing so will improve public life, or because it believes doing so will stimulate economic growth; nevertheless, there are costs involved in the creation and management of this content.
- 2.2.4 Of course, some government providers of geospatial information will already be in a position whereby all information they collect is provided free at the point of use. However, these countries are likely to still face challenges in terms of securing the funding required



to maintain the detailed, accurate geospatial information that can underpin social and economic development.

2.2.5 Most government providers of geospatial information today typically rely on funding either from the taxpayer or from mixed sources of income, including from the public sector. The funding of NMCAs to perform their task remains a controversial topic and will evolve over this period. One of the major challenges of the next five to ten years for governments in terms of the provision of geospatial information, will be demonstrating the value and securing the necessary funding to ensure that this information can be maintained. In a world where information, including geospatial information, can easily be accessed free-of-charge, this will be challenging. It is likely to be particularly so given the financial situation impacting most countries across the globe.

2.2.6 In countries with less developed mapping resources and Spatial Data Infrastructures (SDIs), the vital role of high-quality data to support economic and social development will become better understood and relatively higher proportions of national wealth are likely to be expended on capture and maintenance programmes.



2.2.7 Because of the fundamental nature of the data, funding will come from central government sources, supported in some cases by additional funding from global or national development funds. This is likely to be the predominant model in certain regions, particularly those where the process of establishing reliable geospatial information bases is in its early stages.

2.2.8 In many countries, the difficult economic climate has already seen reductions in central government funding. The accompanying increasing pressure for free availability of core data sets will provide a challenging environment. Undoubtedly this will cause some of the affected NMCAs to look closely at the sustainability of their business models.

2.2.9 Government providers of geospatial information are not alone in needing to respond to the disruptive impact of the Internet on the content industry or to the squeeze on public finances. One of the major challenges of the next five to ten years will be finding the new business models that will provide the funding to maintain accurate and quality-assured geospatial information required, whilst growing the user community for high-quality, accurate and maintained geospatial information.



2.3 Licensing, pricing and data ‘ownership’

- 2.3.1 Existing pricing and licensing models for those who do charge for access to geospatial information are often seen as too complex, costly and rigid for many users. Indeed, part of the motivation for the development of VGI was to provide data, which could be used relatively free of licensing restrictions. Nevertheless, for those who are required to licence data in order to fund collection and management activities, funding and the demand for access to geospatial information with less restrictions on its re-use will pose challenges.
- 2.3.2 The ongoing drive for cheaper access to information and the increasing richness of the information available, means that there may be increasing pressure to monitor and licence information at the feature level rather than at local, regional or national database level, bringing with it new challenges.
- 2.3.3 Data ownership issues will evolve in challenging ways in the coming years. At present, intellectual property issues around geospatial data are ‘relatively’ simple, as the role of data creator, processor and publisher are generally definable due to the discrete nature of these processes. The growth in the amount of data, the number of actors in the data creation processes and the interconnectivity of these parties will make ownership tracking a near-impossible task in years to come.
- 2.3.4 The licensing of data in an online world is proving very challenging. The entertainment industry has sought to protect its rights over content with mixed results. The issues in the geospatial world may well follow those in the entertainment industry, with many users assuming that all data is freely available and can be shared widely. There are attempts to provide simple machine-readable licences for valuable content – sometimes referred to as digital rights management – but these have not, as yet, resolved the problem. Data piracy and hacking will grow significantly over this period, to the extent that, combined with open data, *consumer* use of geospatial data may become effectively free at the point of use in virtually all circumstances.
- 2.3.5 Again the lack of a multi-national legal or policy framework in place to deal with these issues will need to be addressed as data acquired in one country will likely be processed in a second country by a corporate domiciled in a third country, while the data itself will be held ‘in the cloud’ – hence determining the legal framework, liabilities and warranties etc will be unclear without some attempt at a global accord. These issues are, it should be clear, not unique to geospatial data.

2.4 Privacy

- 2.4.1 The rapid growth of mobile technology and social media has transformed attitudes to privacy in many societies. Many people have a desire *not* to be private, particularly in the online space, and are comfortable with broadcasting information about themselves and



their activities. The rise of the *'Internet of Things'*, where all devices that we use can be constantly online, will make most individuals visible most of the time – in fact it is likely to become increasingly difficult to opt out and hide oneself from other individuals or agencies.

2.4.2 This will challenge the individual's right to privacy. Given the amount of devices emitting and recording information that will exist, even if individuals choose not to use many aspects of modern technology, they will be visible as they move through the landscape. Aside from the moral aspects of a 'surveillance society', individuals will be the focus of targeted messaging, much of which will be driven by combining personal and locational data. Consequently consumer protection and marketing laws and policies will need to evolve to enable the citizen to enjoy appropriate protections.

2.4.3 The ability of the State to track and monitor individuals is already a subject of controversy – this is witnessed by the debates on the use of Closed Circuit Television (CCTV) and the monitoring of voices and texts. As all devices become location-enabled 24/7 broadcasters, the State will have the capability to hugely enhance its ability to observe. While bringing huge potential benefits in terms of national security and disaster management, national laws and oversight bodies will have to evolve to ensure the data is maintained and used appropriately and that personal privacy is not sacrificed.

2.4.4 The issues described above are exacerbated when the citizen moves across the globe. In most cases the information they broadcast, and is acquired about them does not change, but the rights over the use of that data and the legal protections may change radically. There is likely to be a clear and growing demand over the next ten years that the lack of a global framework be addressed by multi-national bodies, such as the UN.



Source: jannoon028/Shutterstock.com

2.5 Data standards and policies

2.5.1 The geospatial community is, relatively speaking, an exemplar industry in the creation and maintenance of common, open standards. The beacon of this is currently the Open Geospatial Consortium (OGC). Open and common technology standards and languages are now well established and adoption is increasing among professional users. Further



development of this will occur over the next ten years, enabled by an enthusiastic and highly competent volunteer community. However these evangelists are not spread evenly across the globe and there is a clear need to sponsor the adoption of common standards in perhaps a more formal way, or else tremendous opportunities to share and explore data will not be enabled.

- 2.5.2 A number of supranational organisations, including units of the UN, have supported the development and uptake of such principles. The need to share data will drive further adoption of these standards, although there is a clear risk that the more formal government-sponsored approach may stifle the creativity and rapid development approach of the more volunteered based models. A clear goal over the next five years should be to further bring together the best of both models under the sponsorship of a body such as the UN.

2.6 Liability and the issue of data assurance

- 2.6.1 The issue of liability for the quality and accuracy of data is likely to grow in prominence over this period. Historically NMCAs and other providers of geospatial information have largely been able to avoid this issue, publishing disclaimers that strive to absolve them from any litigation risk. The wording of one government's open licence offers a typical example. 'The Information is licensed 'as is' and the Information Provider excludes all representations, warranties, obligations and liabilities in relation to the Information to the maximum extent permitted by law. The Information Provider is not liable for any errors or omissions in the Information and shall not be liable for any loss, injury or damage of any kind caused by its use.'⁶
- 2.6.2 However, there have been situations in the wider government data environment where attempts have been made to seek legal redress, where the data can be proven to have been inaccurate and hence the user has suffered a loss. It is hard to predict the impact if such a trend were to grow, but it is an issue that all data providers will have to consider carefully and may also impact on wider lawmaking within government.
- 2.6.3 The response to this increasing risk over the next few years seems likely to take one of two forms: A continued acceptance of the risk, with government legislation to minimise the litigation risk; or the development of 'warranted' data model, where at least some attributes of data specification will contain a form of guarantee. This will inevitably command a higher price to cover the risk, but may genuinely be seen as a value-add by professional users making high impact decisions in years to come.

⁶ This is an extract of the UK Government's Open Government Licence, which can be viewed at <http://www.nationalarchives.gov.uk/doc/open-government-licence/>



- 2.6.4 The adoption of 'Big Data' solutions may in part be dependent on the provision of warranties and liabilities, as it will not be feasible for users to check each piece of data.

2.7 Disparities between legal and policy frameworks

- 2.7.1 Legal and policy regimes differ significantly from country to country and will continue to do so in the coming years; indeed, this fact may in itself create one of the most significant trends over the coming five to ten years.
- 2.7.2 There is a major possibility that significant disparities will emerge in the next 10 years between countries where legal and policy frameworks have developed in line with technological changes and whose governments have developed frameworks which enable the growth of location or spatially-enabled societies, and those countries where such frameworks have not developed.
- 2.7.3 Technological developments, as opposed to legal and policy frameworks, are, relatively speaking, without boundary. Whilst technological developments may be leading us towards a spatially-enabled society, the legal and policy frameworks required to facilitate the development of such a society, and a society which feels confident in using and creating, both actively and passively, geospatial information and location-enabled services, are not developing in a consistent way.
- 2.7.4 It is likely that in the next five years governments will have a greater understanding and recognition of the value of geospatial information as a reference framework for policy development and analysis, as an essential information base and as a growth area for the private sector. However, in many areas of the world a consistent and transparent legal and policy framework in areas such as privacy, national security, liability and intellectual property, may not have developed.
- 2.7.5 There is a counter argument to suggest that in areas where no such frameworks are in place, it may provide the space for appropriate framework development free of possible constraints from any over-zealous legislation in this area. However, the greater risk is that technological and business applications that would be of great value to society will not be available in certain countries due to a lack of clarity or a lack altogether of the necessary legal and policy frameworks.
- 2.7.6 Ensuring that this divide does not occur, or at least ensuring that the divide is not too pronounced, may represent one of the major challenges within the legal and policy environment in the coming years.



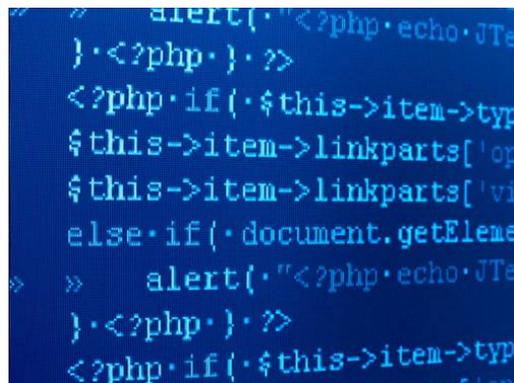
3 Skills requirements and training mechanisms

3.1 Maximising the value of geospatial information

3.1.1 Understanding what the skills requirements and necessary training will be in the next five to ten years will be an important component of ensuring the value of geospatial information is maximised. Early determination of and action on these issues is vital, as the development period for both appropriate training capability and then the individuals who adopt the training will take at least five years. The demand is highly likely to exceed the pace of people development. This is being taken seriously and, in some quarters, is evidenced by recent pronouncements from the governments of some of the largest and fastest growing economies of the world who have made substantial investment commitments in geospatial information in the last 18 months.

3.2 Extracting value from a world of data

3.2.1 Although the use and availability of geospatial information will be increasingly democratic, for reasons identified elsewhere in the paper, the proliferation of data, especially unstructured data, will place a premium on highly skilled data modellers. Even among the leading database companies and most advanced NMCA's, the number of experts who truly understand the inter-relationships between data models and data flow is generally relatively small for each organisation.



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3.2.2 Data models will need to continuously evolve to answer the range of questions and manage the rising volume of data. Hence the training of a cadre of data experts, who understand the additional complexities of geospatial and time-based data, must be a priority if the potential benefits are to be realised. In the future this expertise is likely to reside in the public, non-governmental and private sectors and hence it will be in the interest of all to sponsor appropriate education. As today, much of this will be in collaboration with the academic sector, but increasingly focused in the areas of mathematics and computer science, rather than in the more traditional geographical information systems (GIS) field.



- 3.2.3 There will of course continue to be a role for traditional GIS skills, as data outputs will still need interpretation to create information for decision makers. However, these experts will need to become more comfortable with interpreting fuzzy and unstructured data and will also need to find more effective channels for communicating their results.
- 3.2.4 There is still a tendency in many organisations to see GIS as a backroom function with little connection to policy or action; hence, as well as continuous development of technical skills, there is a need to focus on equipping geospatial experts with softer skills in areas such as communication, presentation and influencing.
- 3.2.5 As mentioned previously, the development of robust Open Source technologies will also gain further momentum over this period, and will increasingly sit alongside proprietary solutions, as has happened elsewhere in the software industry. Developers will need to be comfortable in both environments – the option to specialise in one ‘language’ will no longer be sufficient. This type of learning would be particularly enabled through building global networked communities to share experience and ideas, reducing the reliance on formal structures.

3.3 The importance of visualisation skills

- 3.3.1 The role of cartography and data presentation has been understated over the past decade as the industry has focused on data. However, cartography will remain the language through which the data explosion will be spatially interpreted and new methodologies need researching and developing. The fact that increasing amounts of geospatial information will be consumed and interpreted through mobile devices also necessitates an improvement in the quality of cartography for mobile devices.
- 3.3.2 The growth in 3D and especially 4D data capture will set major new challenges for those required to express the resultant information in any meaningful manner. Today tools exist to visualise 3D and time-based data, but the tendency has been to focus on look and feel rather than informing decision makers. There will be a need for data interpreters from a more design-orientated background, rather than solely from the traditional cartographic skills, and a need for those involved in visualising geospatial information which will be displayed on multiple devices to harness skills from other related disciplines.

3.4 Formal mechanisms for the development of skills

- 3.4.1 The development of these skill bases will be delivered through a wide range of professional, academic and in-business approaches. These requirements will have a major impact on NMCAs. The adoption of data-driven rather than cartographically-driven geospatial content will see a fundamental shift in the skills base and costs. Leading NMCAs are already finding that their data management staff base is more costly than that of their cartographic and data collection units, hence, much of the re-skilling will need to happen with capable in-house staff.



- 3.4.2 The content of academic studies of geographic information (GI) will also need to evolve to attract and develop students with the necessary skills. Courses will need to be increasingly interdisciplinary, drawing on methods and best practice from traditional GI, computer science, design and the related social sciences.
- 3.4.3 Many of the most critical issues where geospatial data can assist are found in less developed nations. There will be a potential major role for NGOs and development agencies in ensuring that the skill base is developed globally. Without this, there is a risk of a 'brain-drain' as the limited pool of talented individuals will be drawn to the private sector opportunities in higher-wealth economies.

3.5 Education and advocacy

- 3.5.1 As well as the development of core skills, there will be a need to educate policy and decision-makers, planners and delivery agents in geospatial data, potentially to the very highest levels of governments and NGOs, to enable them to fully understand the potential of geospatial data in solving key issues. This will assist them in formulating questions and also in interpreting the data. This familiarity has been enhanced by the use of simple geospatial in consumer applications, but needs to move beyond 'points and colours on a map'. These users will need training in and access to simple and intuitive tools that allow them to manipulate the data, rather than working through back office specialists.

3.6 Investing in Research and Development (R&D)

- 3.6.1 Investment in Research and Development (R&D), in all sectors, will continue to be vital to both developing the skills required in the coming years, but also in order to ensure the potential benefits of emerging trends are realised.
- 3.6.2 Current trends in research reflect many of the identified continuing and future trends for industry, including the more effective and automatic processing of sensor data, the development of location-based applications and the integration of high volumes of unstructured data. Investing in early-stage prototyping, testing and evaluating in emerging areas of interest, will mean both that the benefits of such developments will be realised at the earliest opportunity and that such developments will be understood within a wide range of organisations.



4 The role of the private and non-governmental sectors

4.1 Making mapping accessible to the masses

- 4.1.1 The reduction in barriers to entry, the growth of Web and mobile mapping and the enthusiasm for crowd-sourced geospatial data have massively increased the role of the private sector and the volunteer community over the last decade. The fact that 'Google maps' is a global brand, highlights that it is the private sector which has made mapping accessible for the masses.
- 4.1.2 Alongside the massive explosion in the use of geospatial information, VGI groups such as OpenStreetMap have gone some way towards popularising, albeit within a relatively niche community, the collection of geospatial data.
- 4.1.3 User generated content has already gained widespread acceptance in many aspects of our lives as a source of data, Wikipedia perhaps offering the most well-known example, though issues around trust and reliability remain. This use of user-generated content is likely to continue, as mentioned elsewhere, with both active and passive data creators providing a wealth of location data which would not be economically viable or in some cases even possible for traditional data collectors to have recorded.
- 4.1.4 The increasing need for trans-border information has highlighted the limitations of an approach based on national borders. Initiatives bringing together the NMCAs of regions have sought to address these issues, but in most cases private sector suppliers, whether of satellite imagery or mapping, have transcended borders, perhaps inevitably, far better than government sources of information and have therefore been called upon to provide data where issues cross national boundaries. Private sector and VGI groups are likely to continue to lead the way in this area, whilst governments, naturally constrained by their national borders in a way in which capital is not, attempt to catch up through supra-national and intergovernmental mechanisms.

4.2 The future role of the private sector

- 4.2.1 The private sector is likely to continue to play a vital role in providing the technologies, identified earlier in this paper, that will enable governments, and indeed other private sector bodies, to produce and collect the vast quantities of data we are likely to see in the coming years; to provide the technologies to manage and make sense of this data; and to find value in providing access to the skills necessary to maximise this data.
- 4.2.2 In the consumer sphere, and for uses where ease of access and use and a generalised location reference are the dominant requirements, the private sector, alongside the VGI



community, are likely to dominate people's everyday interactions with geospatial information. In general, however, this information is unlikely to come with the quality assurances, level of detail and maintenance regimes that are required to inform major business or public service questions - for example, the management of energy supplies to a population, the recording of land extents or the deployment and provision of a detailed common operating picture for emergency services.

4.2.3 Nevertheless, alongside the spread of VGI, the private sector is increasingly likely to wish to compete with government sources of information, analogous to the competition found in the telecoms and postal industries, in all areas of high economic activity. This will potentially move beyond areas where there is existing competition, such as aerial imagery and generalised data, towards large-scale detailed data.

4.2.4 However, in many cases, particularly outside of the consumer sphere, distinguishing between private and public sector geospatial provision can be artificial. While much of the provision of the data may be by private sector contractors, governments and supra-national bodies often remain the largest customers and commissioning agents.

4.2.5 Cost and efficiency requirements will see NMCAs outsourcing many processes to the private sector in the coming years. Thus, much of the income generated by, for example, satellite and aerial imagery providers will continue to come from governments and NGOs – indeed the proportion from these sources is likely to increase over this period.



Source: Mechanik/Shutterstock.com

4.2.6 Sector-wise, highly technical defence-related geospatial will grow as a market for the private sector specialists, as defence structures refocus on new challenges and reconfigure into ever more technology driven solutions. Recent conflicts have shown how detailed geospatial data can greatly increase the effectiveness of forces – the trend over the next five to ten years will be applying these techniques across more governments and further into counter-terrorism and asymmetric conflicts.

4.2.7 Whilst the maturity of markets for location-based services is likely to vary from country to country, the proliferation of mobile devices in all regions of the world is likely to offer an increasing number of opportunities for entrepreneurs to develop valuable location-based services and companies. The private sector may be fastest to recognise some of the valuable uses to which geospatial information can be applied, or at least fastest at bringing these uses to the mass public, and in doing so can help to create many jobs as well as provide valuable services.



- 4.2.8 In other regions however, a major challenge for private sector data collectors in the coming years, will be finding ready markets outside of those already established. Consumers and small and medium enterprises (SMEs) have an increasing expectation that data will be free at the point of use and also are often satisfied with 'good enough' data. Where profitable consumer niches are identified, there is a possibility that they will be rapidly occupied by mass global players who will be constantly seeking competitive advantage, using geospatial to attract consumers to their wider offerings. Hence funding models will increasingly need to be driven by either valued add-ons – which has proven difficult to make effective – or else releasing through or selling out to a third party, advertising-funded provider.
- 4.2.9 An added risk for the private sector data creator will be the move towards Open Data, since high-quality maintained data created by NMCAs could be released at the mandate of a government, threatening previous streams of income or at least necessitating a shift in where in the value chain to focus.
- 4.2.10 The predicted increase in passive crowd-sourcing, where devices carried by individuals relay information, has been noted elsewhere in the paper, and is likely to offer new opportunities to the private sector in the coming years. Already data aggregators are using mobile phone movements to identify new road openings and the location of traffic incidents. With more accurate triangulation and faster data processing of higher volumes, similar techniques are being applied to the movements of individuals and this data is being collated by mobile phone operators, packaged and sold on to users, such as retailers.
- 4.2.11 The wealth of data that will be created in this way offers huge potential for the private sector to add value to existing geospatial information bases. The private sector is likely to have a key role in interpreting and analysing the vast amounts of information that will be created in the coming five to ten years, and in using this information to offer value-added services that can enhance the provision of services to users of geospatial information, both at the consumer level and at business and governmental levels. This new role, combined with squeezes on funding for many government entities involved in the collection and provision of geospatial information, will likely lead to a greater number of public-private partnerships.
- 4.2.12 Increasingly, therefore, the private sector will need to exploit their understanding of and capability in geospatial to focus further up the value-chain. As well as continuing to play a key role in developing the technologies which will facilitate the development of spatially-enabled societies, they will play a key role as data aggregators and intelligence providers, interpreting the data they collect and integrating with other data sources to provide more complete information and eliminating the need for users to acquire skills and technology themselves. This will open up markets to industries who have hitherto adopted geospatial information on only a very limited basis.



4.3 The future role of Volunteered Geographic Information (VGI)

- 4.3.1 The advent of global mass communication through mobile technology is already unlocking the potential of both the passive and the active crowd in enriching geospatial data. Examples, such as the Haiti earthquake, where volunteers helped to enrich other sources of information and fill the urgent need for data, are well known. However, the potential is enormous and will increasingly be realised over the next decade.
- 4.3.2 Whilst in some countries the availability of crowd-sourced data may be an addition to a wide range of other sources of geospatial information, in others it will be an essential building block for social and economic development, particularly in areas where no or only limited other data is currently available.
- 4.3.3 VGI brings with it a number of benefits. VGI can act as a valuable mechanism to encourage public participation and engage and empower citizens. Again, in countries where other sources of data are less readily available, this public participation may be a necessity as opposed to a choice.
- 4.3.4 In areas that, for example, lack formal addressing frameworks, a user-led, crowd-sourced address geography may, in the early stages, offer a more relevant structure than an attempt to impose an arbitrary government-lead model, enabling from an earlier point in time some of the benefits to the development of the economy and public services which such an information base can provide.
- 4.3.5 At the very least, such a crowd-sourced information base could create a source layer that could then be used to fill in a more formal structure. It is worth noting that countries which develop geospatial information bases in this way may be in a position to lead the way in exploring how VGI can best be integrated with NMCA data.
- 4.3.6 A further benefit of VGI will be as an educational tool, teaching citizens the value of geospatial information in daily life. As Community Knowledge Systems are built on this information, citizens will experience the value of geospatial information in a more direct and first-hand way.
- 4.3.7 In those countries where alternative well-established geospatial sources are already available, VGI is likely to include valuable additional information, which would fall outside the scope of most government specifications. This data has the potential to enable a user's view of their geography, which if utilised by policy and decision-makers, will allow for potentially more effectively targeted interventions and more tailored public services.



Source: [image courtesy of kiwanja.net](http://image.courtesyofkiwanja.net)



4.3.8 Nevertheless, whilst VGI brings with it many benefits and its use is likely to continue in the coming years, certain aspects of it mean that we are unlikely to see it significantly erode the need for quality-assured and trusted geospatial information. Its reliance on the voluntary contributions of a group of dedicated individuals; the lack of a quality assurance regime, which is widely recognised by the broader user-base of geospatial information; and the absence of a regular maintenance regime means that, whilst in some areas it may provide an essential information source, it will not remove the need for a wide range of core, quality-assured, geospatial information. It is possible that the NMCAs may take a role of developing quality assurance mechanisms and standards for VGI data so that a level of authority can be included with VGI data.



5 The future role of governments in geospatial data provision and management

5.1 The impact of change

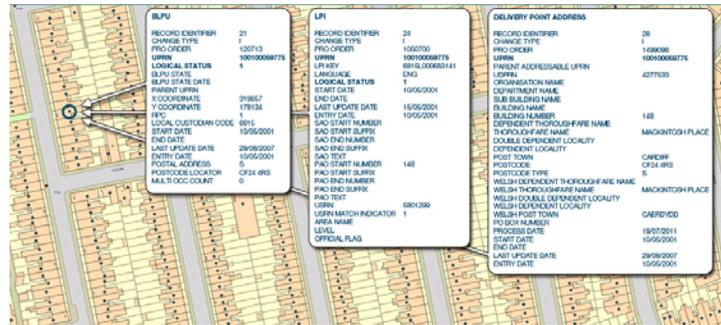
- 5.1.1 Many of the aforementioned changes will have a considerable impact on the role of governments in geospatial data provision and management. However, despite the increasing number of organisations and entities collecting geospatial information, NMCAs and indeed government and business users of geospatial information, are most unlikely to be able to wholly rely on data from the private sector or VGI.
- 5.1.2 Private sector providers, meanwhile, will need to justify all collection and maintenance based on a return on investment – for remote geographies the main customer will be government agencies, so in this case the private sector will only collect data on behalf of the government – rendering the distinction between private sector and government irrelevant to collecting information of a certain kind or in certain places. VGI tends to be limited in its coverage and without a scheduled maintenance regime, particularly one which is widely recognised by major users of geospatial information.
- 5.1.3 As such, governments will remain in a unique position to consider the requirements for geospatial information for society as a whole and will continue to play a key role in providing a reliable, trusted and maintained geospatial information base. Nevertheless, as in the previous ten years, government providers of geospatial data are likely to witness significant change in the coming years.

5.2 Bridging the gap: coordination and collaboration

- 5.2.1 Additional data sources, particularly crowd-sourced information, offer a huge opportunity to enrich existing and future geospatial information bases. As such, and combined with pressures to reduce costs, it will be increasingly important in the years to come for governments to facilitate collaboration between all sources of information. This may include actively encouraging the collection of additional information by non-government sponsored bodies and providing frameworks to incorporate the data in a structured way.
- 5.2.2 Hence, it is possible that one of the key trends and key challenges over the coming five to ten years will be for NMCAs to work with the private and VGI community in order to maximise the value available from these various datasets. VGI should not be seen as a competitor to government-sourced data; instead, it will be similar to a collaboration between all actors, with VGI incorporating Government-sourced data and, potentially, vice-versa. At the moment there is a significant gap between authoritative and crowd-sourced data; this gap is likely to decrease in the coming years.



5.3.2 However, despite the increase in producers and providers of geospatial information, government agencies will retain a key role in other areas where trust in the data produced is seen as vital and where natural government monopolies exist.



5.3.3 Whilst arguments over what constitutes what have been termed ‘core reference datasets’ are likely to continue, there is likely to remain a set of reference datasets for which it makes sense for the government to produce and maintain, in order to ensure they are collected only once yet used many times.

5.3.4 A number of uses of geospatial information, essential for sustainable economic and social development and in some cases life-critical, rely on the provision of geospatial information that is detailed, is provided to a high level of specified accuracy, is trusted and is regularly maintained. This information is used to provide registers of land to enable a managed system of property ownership and dispute resolution; assists in identifying health inequalities and effectively targets interventions down to household level; and is used to route emergency response vehicles to a major incident, ensuring that all those responding have a common operating picture, to name but a few.

5.3.5 Recognising the increase in data sources, one of the key roles of the NMCA in the coming five to ten years therefore, will likely be to define and maintain quality standards and the data currency regimes for data that government requires for its operations. Governments are in a unique position to carry out this role and to assess the level of detail of information required to deliver such information.

5.3.6 Given the proliferation of additional sources of data and potential competition from other sectors, however, we may see government providers of geospatial information taking on a role that shifts more towards a policy, advisory and procurement role. In a trend that has already started to emerge, governments may increasingly no longer see it necessary to collect all geospatial information required themselves, but will instead commission the data from the most appropriate and suitable source, be that a private or VGI source, or, where appropriate, collecting the data itself.

5.3.7 Governments and those government agencies who have previously played the role primarily of data collector, will instead move towards a role of commissioning and managing the delivery of a complete geospatial framework, ensuring data is captured and integrated from areas of lower economic activity, as well as those for which there is likely



to exist a greater economic market, and providing a trusted geospatial framework that can be relied on by users in their decision-making processes.

- 5.3.8 The procurement of data from a wider number of sources will likely free up resources to increase focus on overseeing the management and maintenance of the data collected. Focus can then be targeted on ensuring that rich sources of information are available, are maintained and are available as widely as possible, whilst ensuring the necessary funding is secured to ensure the sustainable provision of a maintained data supply.
- 5.3.9 The role of government as an authoritative supplier of quality, detailed and accurate geospatial information, drawing on the wide range of valuable sources of information, will become increasingly crucial as awareness of the value of geospatial information increases amongst decision-makers and reliance on this information in the decision-making process increases. End-users should be able to consume government-assured spatial data with the level of trust in its quality and provenance as they do when they consume water from a tap or electricity from the socket – knowing that as soon as they access data from that source they are going to get what they expect every time.
- 5.3.10 The increasing use of authoritative, trusted geospatial information will drive adoption of geospatial information and ensure that it reaches ubiquity in the government and business decision-making process, as well as in the consumer sphere. Governments will have a vital role in ensuring that frameworks are in place that will enable the effective cooperation and collaboration between the plurality of actors that will increasingly be involved in the provision and management of geospatial information, and in ensuring that the benefits which a spatially-enabled society has the potential to offer are realised.
- 5.3.11 Geospatial information has a key role to play in delivering sustainable social and economic development across the globe. Awareness and understanding of this is likely to increase in the coming years as more people interact with geospatial information and an ever greater number of people experience the value of using geospatial information to inform decision-making. Governments have a key role to play, bringing all actors together, to ensure that our future society is a sustainable, location-enabled one, underpinned by the sustainable provision and effective management of reliable and trusted geospatial information.



A Full list of contributors

We are grateful to all of the below who have contributed to this work through either providing a written contribution or partaking in the discussion forum in April 2012. We recognise that, despite our best efforts, some contributors may not be listed below. We apologise if this is the case and ask that anyone who contributed and who wishes to be recognised in this list in any future publications, please email either Mr Jevon Snell at jevon.snell@ordnancesurvey.co.uk or Mr Greg Scott @ scott12@un.org.

Ms. Aida Opoku-Mensah, United Nations Economic Commission for Africa

Professor Allan J. Brimicombe, University of East London, UK

Arnulf Christl, OSGeo

Sr Azlim Khan, Malaysia

Bengt Kjellson, Lantmäteriet, Sweden

Chris Holmes, Open Geo

Danny Dorling, University of Sheffield and Society of Cartographers, UK

Datuk Prof. Sr Dr. Abdul Kadir bin Taib, Department of Survey & Mapping, Malaysia

David Stevens, United Nations Office for Outer Space Affairs

Dr D.G. Clarke, National Geospatial Information, South Africa

Dr. Walter Scott, DigitalGlobe Inc.

Drew Clarke, Department of Resources, Energy & Tourism, Australia

Erik van der Zee, Geodan

Foster K. Mensah, University of Ghana

Geoff Zeiss, Autodesk Inc.

Professor Gottfried Konecny, Leibniz University Hannover, Germany

GSDI Association

Gunter Schaefer, Eurostat

Helen Owens, Office of Spatial Policy, Department of Resources, Energy & Tourism



Professor Dr. Henk Scholten, Vrije Universiteit Amsterdam, Netherlands and Geodan

Mr. Hiroshi Murakami, Geospatial Information Authority, Japan

Ingrid Vanden Berghe, Eurogeographics and National Geographic Institute, Belgium

Jack Dangermond, Esri

Jeff Jones, IBM

Colonel John Kedar, UK Ministry of Defence

Jun Sung Kim, National Geographic Information Institute, Republic of Korea

Keith Hofgartner, Trimble Navigation Limited

Kevin D. Pomfret, Centre for Spatial Law and Policy, USA

Kumar Navulur, DigitalGlobe

Dr Li Pengde, National Administration of Surveying, Mapping and Geoinformation of China

Luiz Paulo Souto Fortes, IBGE, Brazil

Mark Reichardt, Open Geospatial Consortium

Professor Marek Ziebart, University College London

Matthew O'Connell, GeoEye

Dr Niels van Manen, Vrije Universiteit Amsterdam, Netherlands

Mr. Ola Rolle'n, Hexagon

Olaf Magnus Østensen, Norwegian Mapping Authority, Norway

Peter Batty, Ubisense

Peter Large, Trimble Navigation Limited

Peter Miller, ITO World Ltd

Peter ter Haar, Ordnance Survey, Great Britain

Prof. D.C. Lee, Sejong University, Republic of Korea



Prof. Dr. Woosug Cho, National Geographic Information Institute, Republic of Korea

Dr. Saad Al-Hamlan, GCS, The Kingdom of Saudi Arabia

Steven Fruijtier, Geodan

Steven Hagan, Oracle

Dr. Swarna Subba Rao, India

TH Schee, Serial Entrepreneur

Office of the VP of Civil Survey, The General Commission for Survey, Kingdom of Saudi Arabia

Timothy Trainor, US Census of Bureau, USA

Professor Dr Tom Veldkamp, Dean ITC faculty of Geo-Information and Earth Observation,
University of Twente, Netherlands

Tony Frazier, Geoeye

Ulf Sandgren, Cadastral and Land Registration Authority, Sweden

Uzochukwu Okafor, Ministry of Lands and Resettlement, Namibia

Dr Vanessa Lawrence CB, Ordnance Survey, Great Britain

Yola Georgiadou, University of Twente, Netherlands







UN-GGIM

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Global Geospatial Information Management