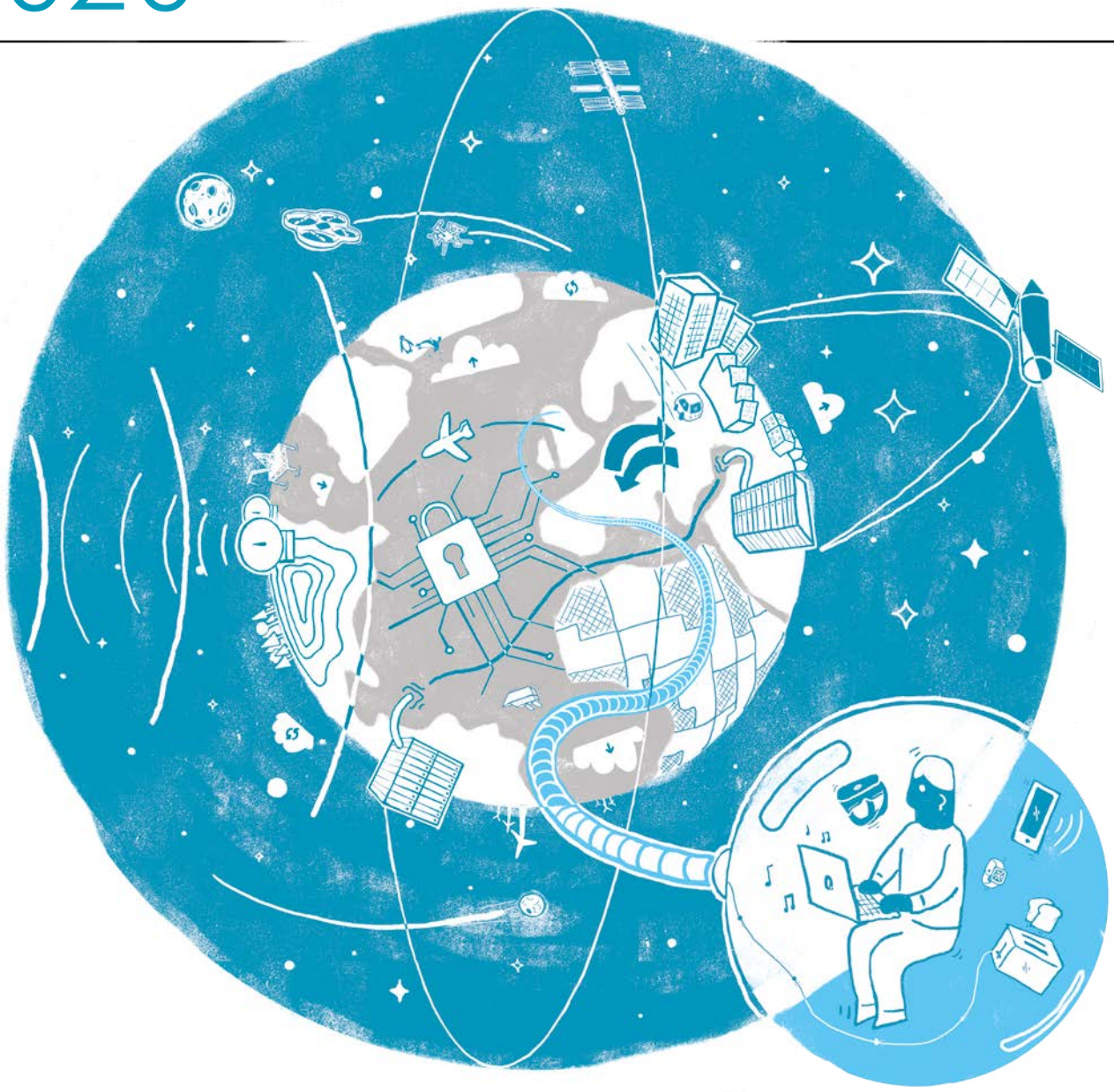
THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

AGI Foresight Report 2020



THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

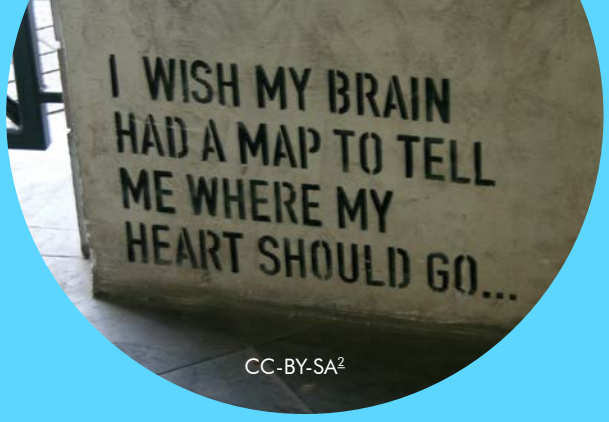
Executive Summary

The AGI[1] Foresight Report 2020 gives insight into the issues we believe will have a significant impact on our economy, environment and society over the next five years. The purpose of the Report is to both observe and challenge the current role of Geographic Information (GI) in relation to these issues.

The Report highlights five key themes that are of relevance not only to the GI industry, but to anyone with a vested interest in how technology and information will change our world and businesses in the next five years.

These five themes – Open, Big Data, BIM and Future Cities, Innovative Technologies and Policy – form the backbone of our Report, bringing together papers from experts across industries and disciplines. They show that the GI community can, and must, play a big part in helping us to understand and maximise benefits from these areas, and meet head on the challenges and opportunities the next five years will bring.

[1] The Association of Geographic Information



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A heartfelt thanks to the editing team: Simon Wheeler, Graham Wallace, and Emma Bee - and to Gesche Schmid for her timely and insightful review.

Finally, many thanks to the contributors – particularly to those who have contributed the 60 papers which form the backbone of the report, and are listed in Annex 1. There are also many people who have participated in our discussions and been generous with their thoughts and guidance – thank you.

[2] https://www.flickr.com/photos/infidelic/3145212317/in/faves-14575809@N00/

Foreword

There has never been a more urgent need for a paradigm shift in how we inhabit our planet. Whether we look at the current crisis through the lens of climate change, population growth and migration, socio-political unrest, or mind change – it should be clear that our current trajectory is unsustainable and unpalatable.

In the past, technological shifts have allowed humanity to advance its resilience, adaptability and influence – with the benefit of hindsight, we are able to see that this has not always been for the better.

We have the opportunity to take careful consideration of how we take our next steps – but the problem is complex, constantly shifting, and differs depending on the outlook of those addressing it – influenced by their culture, experience or expertise.

Against this background, the geospatial industry is in a state of considerable flux – but with that comes significant opportunities.

The AGI's mission is to serve the needs of society, environment and the economy, by bringing geography and information together. This Foresight Report endeavours to address how the Geographic Information (GI) industry can make a difference during an era of massive change, and incredible need.

As you read this report, it may be useful to question your assumptions, and re-think your position. Here are a few challenges to help you:

- If we don't transform we will be subsumed…
- In an era when geography couldn't be more relevant, are we actually asking the right questions …… smart cities??? Really?
- Are we still entrenched in our heritage of maps and pretty pictures? When will we sell the powerful intelligence of analytical modelling?
- Having spent years trying to make Spatial Special, how do we get everyone to realise it isn't special anymore? As for - Spatial is 'just' data….isn't it?
- So you think you can do this on your own ….. In these challenging times, who do we need to partner with?? Could your old enemy now be your closest friend?

We intend to use this Foresight Report as a catalyst for further debate – we welcome further paper submissions – but would like to follow up with a number of roundtable discussions which can inform the way ahead. Not for the GI community on its own, but in collaboration and understanding of the much wider community which can contribute to the fascinating digital world that is evolving so rapidly around us.

Dr Anne Kemp
Editor, AGI Foresight Report 2020
Atkins Director and Fellow

Past chair of the Association of Geographic Information 2012-2014

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One.
Introduction

This Foresight Report 2020 provides insight into the key issues which the AGI considers will have a significant impact on the economy, environment and society – which will pose both challenges and opportunities for the geospatial industry – over the next 5 years to 2020. These have been collated around:

- Open
- Big Data
- BIM[3], Asset Management, Future Cities
- Innovative technologies leading to consumer services
- Policy and cultural

We fully recognise that these themes are common to other industries as well. The purpose of the study is to act as a reference document – observing, and as necessary, challenging the current role of Geographic Information (GI) in relation to these key issues, and promoting the future role the interplay of geography and information could and, we feel, should play, not only within the geospatial industry, but across sectors. Indeed, we feel that this is not only an imperative, but a given in the next 5 years.

The last Foresight Study: The UK Geospatial Industry in 2015 was completed in 2010[4]. In 2014 and 2015, the AGI has been running an event series on the Big 5 industry issues of intrigue and interest for its members. These events have brought the GI community together with the wider industry and stakeholders, to discuss current and emerging practices, challenges and opportunities. These events have been progressively serving as a co-creation opportunity – helping us to capture the insights, challenges and best practice which are emerging. They have provided the catalyst for requesting white papers from a wide range of people, and we are pleased to have brought them together and published them collectively with this Foresight 2020 study in 2015, the subject year of our last study.

This time, working from the springboard of the UK, the focus of the Report has not been limited to the UK but has looked globally for trends, threats and opportunities. By involving partners and other professional bodies we have extended the reach and impact of these studies, fostering new collaborations and partnerships and in general, showing how geography can help in solving real-world problems.

Overarching the 60 white papers (provided as Annex 2) is this summary report, which highlights the key findings, draws out cross-cutting themes and makes key recommendations to the GI industry and beyond. Note that, throughout the report, we draw on the contributions of the white papers by referencing the author (xxx), which is a hyperlink which takes you directly to the relevant paper.

We very much hope that these white papers, together with the over-arching synthesis, will be used as a reference guide and source of valued insight within the GI industry and beyond.

> This time... the focus of the Report has not been limited to the UK but has looked globally for trends, threats and opportunities.

Towards a common understanding of geographic information (GI)

We are all aware that 'everything exists somewhere' and that location and place are important in most areas of our lives. GI or GIS is the means by which we can bring location into the equation when we are looking to analyse information and data. A good explanation of GIS can be found here.

[3] BIM – Building Information Modelling

[4] www.agi.org.uk/foresight

Two.
The previous AGI Foresight Report

– Did we get it right?

Commentary by Andy Coote, Steven Feldman and Robin McLaren

It is a slightly strange feeling to look back at something written just over 5 years ago, predicting what the geospatial industry would be like around in 2015.

In some ways nothing has changed, the pace of technology change, which seemed "electric" in 2010, has if anything accelerated. The graphics look dated – with the advent of Prezi and YouTube, today would we have bothered publishing a written summary paper.

The Chinese economy has unexpectedly slowed (perhaps only temporarily) during the latter part of the intervening 5 years and the US recovered more quickly than the Eurozone. We certainly expected greater pace of "inroads" into the UK market of Chinese products than has been the case. Their internal market has so far absorbed their expansion, but with thousands of Geomatics and Earth Observation professionals graduating every year, it is just a question of time until China competes more strongly internationally.

The growing dominance of cloud-based solutions has happened as predicted, but with many of the same players as in 2010 still dominant. Google, despite their somewhat unexpected withdrawal from the enterprise GIS market, and Esri are still the "400 pound gorillas" in the market. However, the rise of open source which was predicted has been perhaps more pronounced than we thought. The lack of money for investment in the public sector during the continuing period of austerity we correctly saw, has been a huge factor in this respect. Mapbox and CartoDB are perhaps the few startups that have really emerged into multi-million pound businesses, what a shame they aren't British. The cost of starting a GI company, especially the technology tools, has considerably reduced over the past five years. It is therefore surprising and disappointing how few successful new GI start-ups there have been across the sector.

The move of B2C[5] applications into the B2B[6] space has happened, largely without us noticing, again the GIS market leaders appear to have successful absorbed the mobile "platform" into their product suites. In 2010 the term platform was more readily understood in the context of rail travel than computing, but this is not the only instance of terminological rather than real change over the period.

In the technology space, whilst we predicted the huge increase in the number of satellites, we failed to spot the dramatic reduction in the costs of designing, building and launching to a level that having a constellation of nano / micro-satellites is within reach of many small size corporations should they think there is a viable market for their services. Planet Labs is a great example. The open data movement, particularly in respect to the European Union Copernicus (then GMES[7]) programme, are starting to provide "infrastructural" location data of un-believably high quality for free. The availability of such imagery does call into question the sustainability of national mapping organisations in their current form.

Crowd sourcing has followed the ascendant path we predicted. The growing support of OpenStreetMap (OSM) and its widespread use in innovative and humanitarian applications has been phenomenal – see OSM HOT[8]. However, the contribution of "professional" as well as "citizen" sources wasn't anticipated. Furthermore, the impact of crowd sourcing in the marine environment was completely missed.

As expected, augmented reality, which was possibly at the top of the hype cycle in 2010, is still hamstrung by the bandwidth and battery constraints we identified.

To borrow from Oscar Wilde, "reports of death of the (2D) map have been wildly exaggerated" and the cartographic profession seems to be re-inventing itself in visualisation, perhaps underscoring the belief in the paper that the "spatial mindset" would still have value long beyond 2015.

The Internet of Things referred to as the "sensor web" in the study has become reality in the design of buildings, for instance, and creating smart cities much more quickly than expected. The consequent renaissance for the land surveyor, if they get their act together and don't get swamped by the engineers in BIM, is a welcome consequence.

Laser scanning from vehicles got a mention in the 2010 report, but its rapid rise as an aerial tool for both terrestrial and marine applications we didn't see. The emergence of UAVs[9] and the current debate about safety was also unexpected as was the speed of emergence of autonomous cars and the centrality of location technology to their viability.

The significant role of GNSS[10] and location based services was highlighted in the study, but we failed to see the importance of indoor navigation solutions.

[5] B2C – Business to Consumer

[6] B2B – Business to Business

[7] GMES – Global Monitoring for Environment & Security

[8] Humanitarian Open Street Map - https://hotosm.org/

[9] UAV - Unmanned Aerial Vehicle

[10] GNSS – Global Navigation Satellite System

Probably most significant of all is that the term Big Data doesn't appear at all. Whilst we recognised the issues of data management that the "fire hose" of abundant data would cause, the new insights delivered by data mining these sources was not recognised. It may be way past my demise when the truth about the use of this technology to keep the UK safe from terrorism over the last 5 years becomes public knowledge but the role of the industry in that field has been hugely significant.

In 2010 the adoption and implementation of the INSPIRE[11] directive was embryonic. We were cautiously optimistic about the economic and environmental benefits of INSPIRE. However, the financial crisis has reduced the investment in its implementation across Europe and seriously reduced its benefits. Despite this, the Open Government and associated Open Data initiative has built considerable momentum and provides much more open access to environmental datasets to support environmental assessments. The extent of the Open Data movement and its impact on society was not predicted in the study.

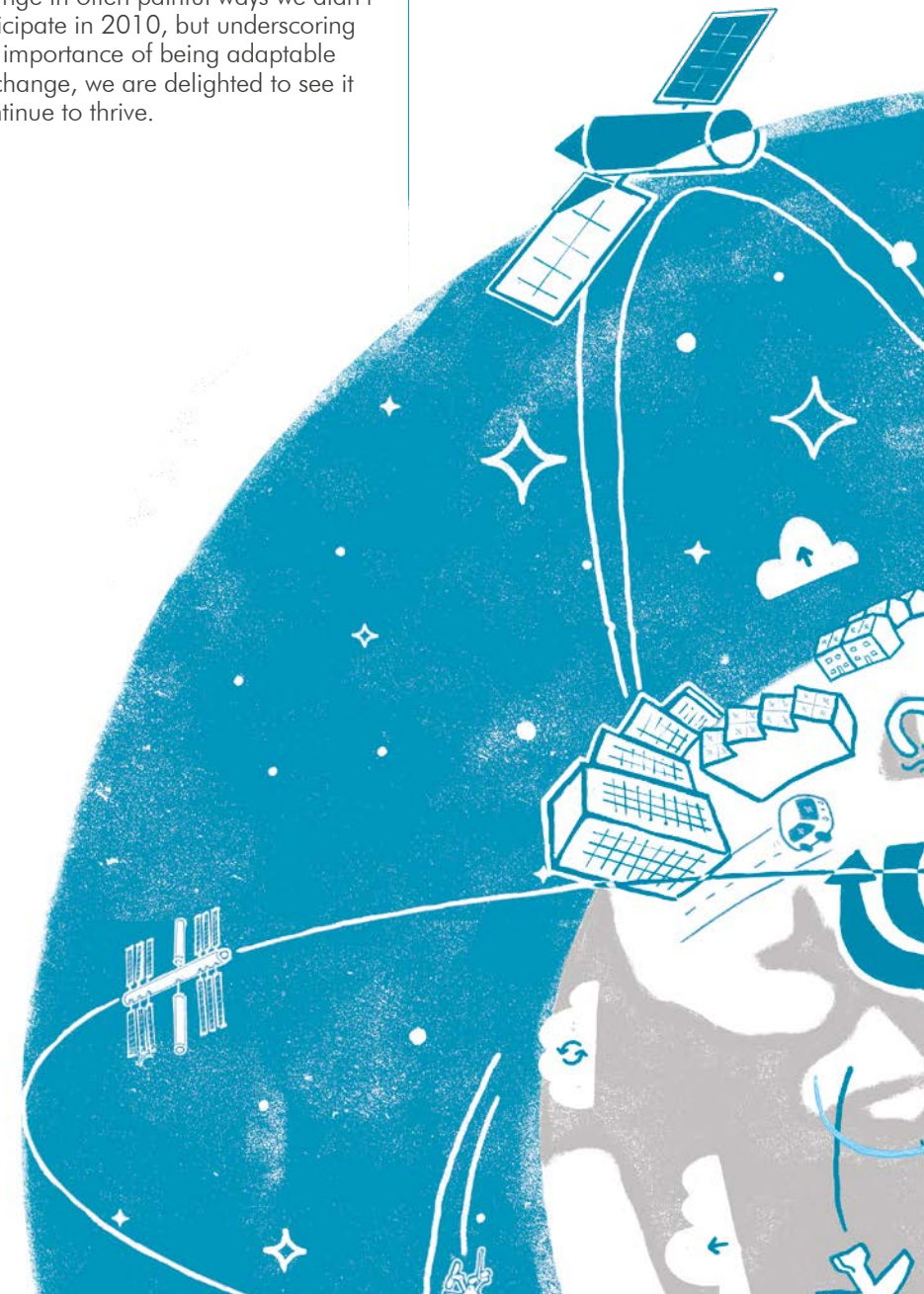
It seemed inevitable five years ago that the Ordnance Survey GB would be privatised – and one could argue that it is in all but ownership. Whether this is positive for the industry we leave for others to judge.

We implicitly thought there were sufficient governance arrangements for the global geospatial information sector, so the success of UN-GGIM[12] is an unexpected but positive surprise. This has helped to significantly raise the sector's profile at a political level.

Reviewing the key challenges for the industry identified at the end of the report, we can see that most are still relevant. Organisations are still struggling to attract enough of the right calibre of staff, environmental concerns still dominate the global agenda. However, we appear to have absorbed many of the quite fundamental changes that have occurred in the past five years with less pain than might have been expected. Perhaps, we can arrogantly imagine that the report helped readers navigate a path through the change, but the more likely reason is that we are capable of adapting as professionals more quickly than we thought.

And finally, the AGI itself has had to change in often painful ways we didn't anticipate in 2010, but underscoring the importance of being adaptable to change, we are delighted to see it continue to thrive.

> We predicted the huge increase in the number of satellites, we failed to spot the dramatic reduction in the costs of designing, building and launching to a level that having a constellation of nano / micro-satellites is within reach of many small size corporations.



[11] INSPIRE – Infrastructure for Spatial Information in the European Community - http://inspire.ec.europa.eu/

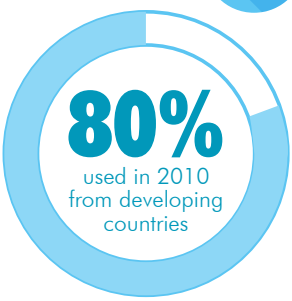
[12] UN-GGIM – United Nations Committee of Experts on Global Geospatial Information Management http://ggim.un.org/

Three.
Setting the Scene

The context for the Report is based on the premise that there has never been a more urgent need for a paradigm shift in how we inhabit our planet. Whether we look at the current crisis through the lens of climate change, population growth and migration, socio-political unrest, use of natural resources, or mind change – it should be clear that our current trajectory is unsustainable and unpalatable.

More than half of the world's population lives in cities, and this is expected to reach 75 per cent by 2050. 95% of this expansion is projected to occur in the developing world, in areas that will experience significant climate change and resource pressures. At the same time, technological developments mean that we are seeing a rapid increase in data, from mobile devices, sensors and social media. For example, over 80% of the world's five billion mobile phones in use in 2010 were in developing countries[13].

5 billion mobile phones worldwide



There is no escaping that technology dominates our lives, with a large part of the world's economy and society now relying on phones, IT and internet. And at the heart of today's world is the data that this generates. Yet, in these days of big data, open data, Internet of Things, sensors, augmented reality and almost instantaneous sharing of details around events, such as disasters, on social media, there's a mismatch between the rate of change of technology and the ability for the world's leaders and policy makers to keep up and understand the implications of the technology. The on-going challenge is that, whilst the INSPIRE[14] Directive is a great example of such collaboration, the time taken to deliver such policy and standards is extraordinarily long and technology is moving in cycles several times faster. Increasingly, diffused innovation is the key digital transformation method.

Worlds population living in cities

95% of this expansion is projected to occur in the developing world

In the past, technological shifts have allowed humanity to advance its resilience, adaptability and influence – with the benefit of hindsight, we are able to see that this has not always been for the better.

It is very clear from the papers that, with the proliferation of mobile devices, the idea of "location" is more widely used than ever, but the term "geospatial" remains fairly niche. The increase in data volumes, the increased availability of real time data feeds from a variety of sources, including mobile apps and remote sensors as well as increasing levels of accuracy and data resolution from high volume data sources such as LiDAR[15] and Point Cloud applications are all factors impacting the realm of the geospatial industry. With both mobile and mapping functionality, everyone with a mobile phone or tablet is a surveyor now, or probably is being surveyed now. Yet autonomous vehicles require digital mapping that is an order of magnitude more detailed than anything in Google. Digital Engineering is requiring precision accuracy and real-time monitoring of infrastructure assets both during construction and in operation. And indoor navigation is becoming an expected requirement.

The geospatial industry has reached an existential moment, with the past belief in our central role and importance eroded by the realisation that geo-technology and its use is now so ubiquitous as to be almost invisible, or so integrated as to be taken for granted. Many of the key skillsets we had previously taken for granted as exclusively ours, are now shared by other professionals, users and even hobbyists such as gamers, geo-cachers, travellers/ramblers and many more….

[13] http://www.unglobalpulse.org/sites/default/files/BigDataforDevelopment-UNGlobalPulseJune2012.pdf

[14] INSPIRE – Infrastructure for Spatial Information in the European Community - http://inspire.ec.europa.eu/

[15] LiDAR – Light Detection & Ranging

However, the Geospatial Industry has the opportunity to morph into a new role in this information rich world, but it must take charge of technology and not be its slave, raising its head to view the wider geospatial picture in context. There is far more to location intelligence than maps. It's all about the data, what you do with it and what outcomes you can provide that counts. Businesses are now trading information to drive an improved customer experience – data is no longer an asset but a 'modus operandi'.

Spatial information has a critical part to play here. Providing a sense of place is extremely powerful: as humans, we gain comfort from knowing our place and position in the world. Our environment is dynamic and fluid, not static, so integrating information on movement and whereabouts should become second nature to our businesses. The next 5 years will likely see the emergence of hybrid solutions which combine proprietary systems with open source data and open software. And the geospatial industry has the skills to shape and tame this information, such as scenario modelling to produce probabilistic outcomes, such as forecasting of extreme events. Managing this level of complexity requires a clear approach to data management. But there are other lessons to be learned. As with the Film and Computer Games industries (with SIM City and Minecraft as examples), the combination of massive amounts of computing power with leading edge visualisation techniques (with sight of all human senses, having by far the greatest bandwidth) improves the ability of human analysts to interpret and derive insight from large quantities of data, as well as using creative visualisation involving the use of images to process large amounts of data to tell a story.

One of the main applications of GI is Predictive Analytics, and with the evolution of big data, there has been a natural shift to embrace this phenomenon within the scope of the GI field. Whilst the range and variety of solutions that have been developed is immense, end users typically aim to address the following types of issues:

Risk management

Identifying where specific types of risks may occur and making sure that suitable steps have been taken to mitigate these risks. Examples include assessing flood risk or evaluating the potential impact of chemical spills. Invariably these types of solutions aim to prioritise how and where limited investment funds can be applied to minimise the overall impact of any losses. Similar techniques are used to assess the risk of disease spreading.

Improving workflow

Applications such as predictive maintenance solutions aim to build up a clear profile of historic events and to allocate resource to ensure that potential issues are addressed before larger and more costly machine or plant failures disrupt production, output or performance. These types of applications are often linked to routing and scheduling algorithms.

Output planning

The volume and values of outputs from activities such as agriculture, forestry and manufacturing depend on decisions made in the past. Many GI practitioners use Predictive Analytics to draw on past experience to quantify the expected outputs from these activities. This work doesn't always deal with tangible outputs – as in the case of weather forecasting, traffic management or investment in health care provision – but there are many similarities between the techniques used to capture data, analyse and interpret information and to plan resource allocation.

Emergency response

Predictive analytics is also used to assess the potential impact of an event such as a train derailment or an oil spillage and to plan how specific locations might be accessed, how emergency response crews will be deployed and to assess the potential impact on medical facilities. These techniques are applied across a multiplicity of industries but are also applied to more mundane problems such as gritting roads in cold weather.

> **The Geospatial Industry has the opportunity to morph into a new role in this information rich world, but it must take charge of technology and not be its slave.**

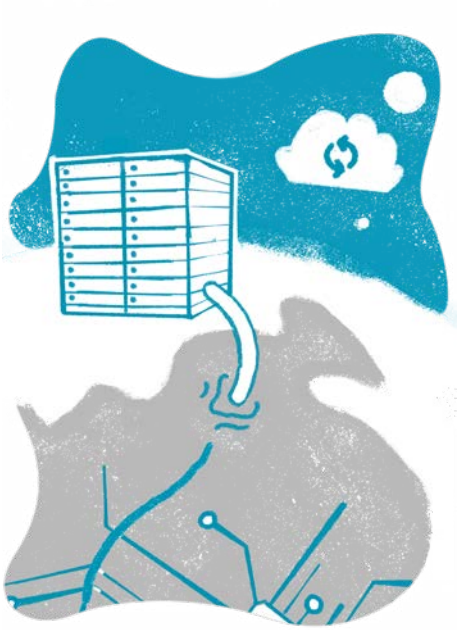
This, in turn, highlights a point made by many contributors, namely that, in the future, 4D rather than 3D information will be considered the norm by analysts. The art and science of communicating information is central to the world of geographers, so visualisation analytics will be likely to form a source of competitive advantage for astute practitioners of GI and GIS over the next 5 years. There is a much greater need to focus on the customer experience to improve the usability of tools to ensure that much of the promise offered by increased data processing capabilities and analytical insights can be used effectively by a wider audience.

The geospatial industry has to understand how to switch from being a data provider, to being a data service. And our market proposition needs to focus on value creation, quality and trust. We will come under increased pressure to protect people's data in a world where increasingly it will be ever easier to identify individuals through ever better data granularity. If we are to make cities smarter then we have to recognise patterns as they emerge, not after the event. This means that location (just as time) will need to be a component in the solutions that develop to 2020. This means becoming a part of a parallel processing data driven architecture, and overcoming the *technology translation gap* where technologists (including geospatial practitioners) are unable to succinctly explain the usefulness or value of their data, tools or services. We have to adopt language which easily conveys that to potential collaborators and users of the services we can provide. And that, for the moment, seems to be holding us back, with an on-going perception of an "inner sanctum of GIS". The sooner we can ditch this image the better.

One example is the potential to converge with BIM. Just as there is a conception that GIS is just about mapping, so there is a misconception that BIM is just about 3D modelling. Wrong on both counts. So we can help here – massively. If you think of BIM as "Better Information Management" – entailing the whole life cycle of the whole built environment integrated with the people and the services it delivers – you can understand that this complements and converges fundamentally with geospatial. Ultimately this will take us to the "Digital Earth" which embraces gaming technologies, semantic ontologies, on a scale which we can only just start to comprehend – but will require issues of data quality, security, and clarity of use, interpretation and enhanced decision making to consider not only technology, process and data – but more importantly the human dimension – at a behavioural and psychological level. To do this requires a fundamental and deep understanding of our relationship with digital data, and how we can draw out intelligence from that data, to inform better dialogue, and derive better decisions – setting the context for whole lifecycle information management and improved asset performance management.

This has to be one of the biggest latent and untapped opportunities for the geospatial industry. Not maps, not 3D – but recognising the latent possibilities of the data and the value-add services that can and should be delivered. What a phenomenal opportunity.

The AGI's mission is to serve the needs of society, environment and the economy, by bringing geography and information together. This Foresight Report seeks to challenge how the GI industry can make a difference during an era of massive change, and incredible need.



Now is the time to take careful consideration of how we take our next steps, and realise the importance of collaborating across industries. Our recommendations include identifying and exploiting the linking of multiple technologies and policies - based strictly on an outcome based approach. This will include BIM, indoor navigation, asset management, internet of things, smart cities, artificial intelligence and big data, integration of data science and analytics, creative visualisation and analytics. Location Intelligence can and should become critical ("the geography of everything") and provide the foundation on which business decisions are made. But if this is to happen, we need to open up the industry and make it more accessible, better understood and less exclusive. Part of that may lie in drawing on our generic roots as geographers, which will allow us to understand, enable and embrace a multi-disciplinary mind-set.

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Four.
Synthesis of the Geo:Big 5 Themes

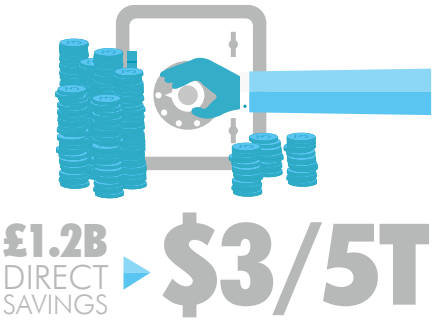
The role of the Foresight Report should be as much about stimulating the agenda for the industry looking forwards as it does reflecting on the learnings from the past year, acting as a summary of how the industry might evolve, and needs to evolve to cope with future challenges / opportunities. The series of Geo:Big 5 events that AGI has run over the past two years has provided a useful backdrop to evaluate the broader position of the industry, provided by the huge response to the call for white papers. In this synthesis, we will provide a summary of the issues covered, whilst challenging the industry to think wider and become aware of any unconscious bias and limiting assumptions.

4.1 Open

With 'Open' now a widely accepted concept amongst the geospatial community, the challenges facing us include;

- How do we maximise the use of Open Geospatial?
- What are the barriers to this?
- What mechanisms do we use to create value around Open Geospatial?
- Where have we progressed and what lessons do we need to learn going forward over the next 5+ years?

Open Data has been one of the outstanding success stories of the last 5 years. In 2010 the Ordnance Survey had just released some of their mapping for free, and OpenStreetMap was becoming popular, but was hardly mainstream (Cook). One of the big drivers for opening up data has been the huge returns to the economy in both straight economic returns through new business and wider societal benefits through other efficiencies. These have been documented in many reports and vary from £1.2[16] billion of direct savings[17] to $3-$5 trillion[18]. In 2015 it is almost expected that public bodies will make some of their data openly available, although many still have to be convinced of the benefits.



There have been some notable recent releases including the release by DEFRA[19] of its LiDAR catalogue, and similar stories have occurred in the marine sector (Edmonds). The concept of 'Exhaust Data' has also been raised, where the releasable data is simply a by-product of the business process (Wheeler). As more data becomes available and pressure increases on government spending, there may also be a need to revisit the funding models by which data is created and released.

It is easy to see this data release continuing throughout the next 5 years as the cost benefits of this "channel shift" become obvious. However, there are some problems which need to be resolved, such as the perception of risk in opening up data, making it useable by anyone, and potential issues over privacy (Cook).

The release of open data, and the volumes made available, will continue to increase over the next 5 years.

This will become increasingly apparent as the full EU Sentinel satellite programme becomes operational, and as data sets such as DEFRA LiDAR increase. This not only crosses over into the realms of Big Data, but also into the world of API's[20] (Cook). These will play an increasingly important role in the Open Data revolution allowing anyone to access data as a service, with multiple outputs for multiple audiences. From necessity, API's have always had a strong reliance on open standards and technologies, and there have been recent efforts to further standardise these, with increasing collaboration of organisations such as the OGC[21]. Cost considerations and a need to avoid costly software licensing issues will become increasingly important. Whilst some users will still want to access the raw data, many users simply want to access the data without the need to spend time and money manipulating and refreshing the data.

[16] Shakespeare Review of Public Sector Information (2013) - https://www.gov.uk/government/publications/shakespeare-review-of-public-sector-information

[17] The Open Data Economy: Unlocking Economic Value by Opening Government & Public Data (2013) - https://www.capgemini-consulting.com/resource-file-access/resource/pdf/opendata_pov_6feb.pdf

[18] http://www.mckinsey.com/insights/public_sector/how_government_can_promote_open_data

[19] DEFRA – Department for Environment Food & Rural Affairs

[20] API – Application Programme Interface

[21] OGC – Open Geospatial Consortium http://www.opengeospatial.org/

There is a suggestion to build a common analytics web API standard which will enable more flexible analysis methods[22].

Open source software is finding headway. Within government, increasing financial pressures mean that open source is seen as a cost effective way forward, and formally, the government IT strategy says that open source should be procured where appropriate[23]. Greater bandwidth and an increased demand in level of functionality will see more solutions moving to the web.

The transition to openness and relatively unfettered access to data will see the death of stovepipe IT and closed proprietary systems currently used (Alderson). Traditional vendors are seriously looking at different business models, and not least hybrid where proprietary systems will integrate with open source.

However, the open arena, particularly around Open Source, has raised the issue of how the community puts something back. Whilst it may be perceived as free, there is a cost somewhere, even time. Are you a good Open Citizen and are you contributing back to the Open community[24]? (Miles, Wheeler)

Open Standards are an area which will need to be considered far more in the future as we see new technology and far more data sharing. The INSPIRE directive gave the Geospatial community a leg up to the use of both Open Standards and good metadata. For the integration and delivery of largely environmental data sets, thought had to be given to good metadata descriptions and also exposure to open standards of delivery. This is now being transferred to other data holdings. Interoperability will be eased by the adoption of open specifications and standards which will still be emerging over the coming years. Five years ago it was reasonable to set standards within the Geospatial community – in future we will increasingly need to work with other domains.

The ecosystem of open standards development is complex – the challenge for the future will be to work in trust rather than competition (Parslow).

Three key domains where collaboration will be needed are:

BIM – the UK is as a recognised leader in this space. The British Standards Institute (BSI) have formal liaison with other standards committees (including the AGI Standards Committee), and internationally with others. By 2020 we should see rich asset management information available in open specifications about significant structures.

Smart Cities – there have been problems due to the context, however the geo standards organisations including OGC are currently planning pilots to identify existing standards which will support Smart Cities with cities such as Dubai[25] and Glasgow[26].

Internet of Things – as a 'bottom up' technology, networks of sensors from the same manufacturer work together. Making the data available on the net in open formats will enable interoperability, but also raise concerns. BSI are setting up a technical committee. Whilst some development has occurred, there is as yet no standard way to find the physical location of the sensor.

The world of Open has exciting prospects. Open data has many potential rewards particularly from the range and availability of data which are, and will become available in the future. They present challenges as to how the data will be stored, served and analysed, along with the question of Trust over the reliability of the data. Will funding for data collection reduce over time creating gaps and quality issues, and will this create a need for new funding models? This will become more apparent over the next 5 years. The area of Open standards will however enable the many new areas of BIM, Big Data, Smart Cities and the Internet of Things to integrate with the Geo world.

To thrive and achieve its full future potential, the GI Community must embrace openness in the broadest sense; open standards; open data, open systems; open architectures and open and collaborative business models.

Many organisations are nervous of releasing data with fears over quality, potential misuse and potential lost revenues. Take a leap of faith and release your data.

Encourage and educate on the benefits of data sharing, better utilisation and encourage openness

Look at collaboration opportunities with other areas outside our space which may have mutual benefits to both.

Continue to work on standards, and ensure that we work with the existing bodies outside our usual space.

[22] https://www.capgemini.com/blog/insights-data-blog/2015/11/a-call-for-an-analytics-web-api-standard

[23] https://www.gov.uk/service-manual/making-software/open-source.html

[24] http://knowwhereconsulting.co.uk/there-is-no-such-thing-as-a-free-lunch/

[25] http://www.atkinsglobal.com/en-GB/angles/opinion/open-data-steps-dubai-towards-smart-city-goal

[26] https://data.glasgow.gov.uk/

4.2 Big Data

The dramatic growth in the volume and intelligence of data available from devices within the 'Internet of Things' is set to become the next big game changer facing both society and industry alike[29]. Every day we create 2.5 quintillion bytes of data — 90% of the data in the world today has been created in the last two years alone (Hudson-Smith). New applications, software and hardware, sensor equipment and measuring tools are being developed to make collection and analysis faster and more accurate and easier to share. These issues affect all companies and partners who rely on it, whether in construction, transport, utilities, engineering planning or development teams. If you accept that location is the DNA that runs through all data, if only on the basis that virtually every piece of data relates to something that is located somewhere, and with an increasing amount of this data is geographically tagged, this relentless proliferation presents both huge challenges and significant opportunities to the GI Community in equal measure.

Big Data is generally viewed as requiring new forms of processing to enable enhanced decision making, insight discovery and process optimization (Penney), with the key challenges and opportunities of data growth are generally known as:

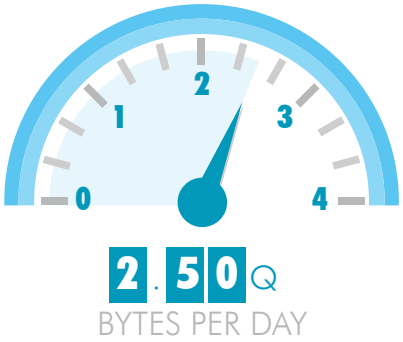
- Volume
- Velocity
- Variety[30]

Other features which are sometimes referenced now include

- Veracity
- Validity
- Value
- Visibility

> Big Data and Analytics will increase in importance as IoT[27] evolves to become more commonplace. Data generated through sensors embedded in various things/objects will generate massive amounts of unstructured (big) data on real-time basis that holds the promise for intelligence and insights for dramatically improved decision processes…[28]

Every day we create
2.5 Quintillion bytes of data



[27] Internet of Things

[28] "Key Areas of Focus for the Internet of Things". Telecom Engine, September 2015.

[29] IBM. (2013), Big Data at the Speed of Business, http://www-01.ibm.com/software/data/bigdata/

[30] Laney, Douglas. "The Importance of 'Big Data': A Definition". Gartner. Retrieved 21 June 2012

Examples of digital data falling in this camp (Darch) include:

Data exhaust: passively collected transactional data e.g. from phones

Other information such as social media, from which inferences can be made

Physical sensors: remote-sensed from ground based sensors or satellites

Citizen reporting or crowd-sourced data, which is explicitly sought

The increase in availability and use of crowd-sourced data, resulting from improvements in the array of apps linked to mobile phones, the impact of social media feeds and the ability of software such as Hadoop and R to process large volumes of data have all helped in the uptake of Big Data. The Centre for Ecology and Hydrology (August and Roy) wouldn't be able to fund a data collection on the scale that existing crowdsourced feeds provide for monitoring flora and fauna distribution and trends over time, and argues that data collectors or "Citizen scientists" create robust and high quality data and that sample sizes all but eliminate any perceived deficiencies in data quality. However, whilst endorsing the benefits offered by "Citizen scientists", **COST ActionTD1202 Consortium** has been established to identify good practice and protocols for the acquisition, description, storage, dissemination and use of citizen derived data in relation to common mapping applications.

Clearly crowd sourced data introduces real time information to existing workflows, processes and insights, but it's worth considering what response is appropriate to this information. On the one hand early sight of an issue may encourage immediate action - on the other hand an isolated incident may have to be ignored due to cost or resource constraints. These types of operational concerns are faced by the armed forces, security services, the police force and insurance industry on a daily basis. Risk assessment, risk modelling, impact modelling and cost-benefit assessments may well become an integral part of Big Data analysis within the GI community.

MapAction[31] is already taking advantage of the intelligence that Big Data can bring - if handled the right way – to help victims of natural and man-made disasters to enable humanitarian aid (Hughes). What better way to provide insights to the way forward for the industry?

The opportunity exists to use Big Data to improve cities and make infrastructure more resilient and responsive to our changing environment and needs of society. Big Data can help us identify gaps in service provision and target infrastructure investments to those people and areas that need it most and where the benefits are greatest. It can avoid some of the issues associated with data collection notably statistical sampling, cost and security. Big Data can also provide new insights to behaviour that would not be possible using traditional techniques, for example through its timeliness and sample sizes (Darch, Future Proofing Cities[32]). Most of these are spatial issues and geographical information will therefore have an important role. This will include both spatially continuous (e.g. satellite data) and point (e.g. mobile data) data.

There is a need to accommodate Big Data and crowdsourced data into operational processes. There is a lot of work being done around machine based decision making (computers, robots and other devices), including machine processing of geo-data, e.g. for autonomous vehicles, and photographic analysis in the security industry (Elliot). But there is a significant cautionary note here, which has taken time, surprisingly, to register. And that is ensuring the security of our digital infrastructure[33]. Over the next 5 years this will be a crucial activity which will likely differentiate the successful from the failures within the sector. Considering how these techniques could be applied to workflows, data management and data analysis gives us a glimpse of the future, but for the moment we are still to truly harness the power of computing to address many of the complex challenges which we currently face. What is certain, is that the reliance on algorithms, data models and scenario planning will introduce a new dimension into risk assessment for the GI industry.

> **Big Data can help us identify gaps in service provision and target infrastructure investments to those people and areas that need it most and where the benefits are greatest.**

[31] http://www.mapaction.org/

[32] http://www.unglobalpulse.org/sites/default/files/BigDataforDevelopment-UNGlobalPulseJune2012.pdf

[33] http://www.atkinsglobal.com/en-GB/angles/opinion/protecting-digital-infrastructure

Clearly, Big Data is not a panacea (Darch), and there are two key factors for making Big Data work:

- Contextualisation, both in terms of the data itself and the cultural setting
- The critical role of analysts to ensure we become "sophisticated users of information[34].

Today, organisations are moving away from viewing data integration as a standalone discipline, to a mind-set where data interoperability, data quality, speed of transfer, metadata management and data governance are designed and used together. With this change however, the challenges the industry must also face are (Penney):

- Increasing client expectations,
- The need to develop and meet new industry standards
- Provision of training and development of employees to address changing roles and skill sets

Moving forward, there is a need for more rigour in the assembly and classification of data using a structured and scientific approach. Perhaps the relevance of the AGI is, in part, informing and developing standards and ensuring data inter-operability, and to emphasize the importance of the Data Scientist role when assembling and classifying data. We need to bring people and communities together, which can be done in many ways through creation of new centres of excellence, trade associations, standards committees, workshops and conferences, providing a movement and level of coordination that is now needed to deliver the value of the IoT (Elliot).

Areas of growth are anticipated in the Retail sector, particularly where predictive analytics are applied to Omni-channel Retailing or the convergence of High Street shopping and web based experiences. This domain is expected to grow rapidly over the next five years – and should become a showcase for the power of GI with measureable outcomes and clear commercial benefits – particularly with the focus on Big Data. However, this is uncharted territory and it will inevitably involve significant investment. Similar observations can be applied to the use of Telematics in the insurance industry – a field which has been on the verge of a breakthrough for the last 15 -20 years – and Autonomous vehicles.

There are obvious challenges to the "data deluge" with many off the shelf software programs unable to handle or store the size of data, in terms of extent and volume, without processing. Teething problems still exist when it comes to taming Big Data tools such as Hadoop and for a GI environment, to allow the power of Predictive Analytics to be harnessed if the underlying tools can't be shown to work consistently. In the end, harnessing the power of Predictive Analytics and Big Data is likely to revolve around how we, as GI practitioners, promote the benefits and adapt our skill sets to move beyond worrying about data quality, standards and the performance of the technology and focus on how we can improve our ability to drive transformational change.

Data revolution or data deluge – every day we create 2.5 quintillion bytes of data. 90% of all data has been created in the last 2 years. There is an urgent need across industry to widen the capacity and increase the capability for new skills to analyse data.

Many organisations are nervous now of cybersecurity – and rightly so. Far more investment needs to be made to protect our critical infrastructure, AND our individual citizens[35].

Insight must be actionable. Need to focus on solutions not data. LiDAR/UAV/M2M/remote sensing/SCADA are only useful where applied to solve problems.

Urgent need to work on standards, and ensure that we work with the existing bodies outside our usual space.

Call for a cross-sector collaborative centre of excellence.

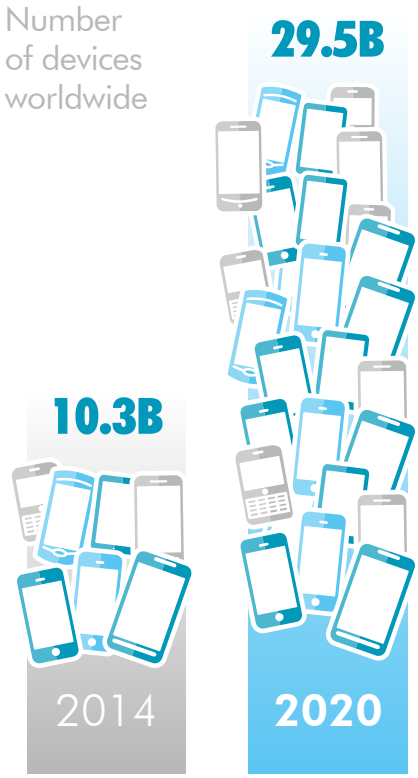
"Areas of growth are anticipated in the Retail sector, particularly where predictive analytics are applied to Omni-channel Retailing or the convergence of High Street shopping and web based experiences."

[34] UN Global Pulse initiative, White Paper: Big Data for Development: Opportunities & Challenges, 2012

[35] http://www.atkinsglobal.com/en-GB/angles/opinion/cyber-security-challenges-and-the-skills-balance and http://www.atkinsglobal.com/en-GB/angles/opinion/protecting-digital-infrastructure

4.3 Innovative Technologies

Over the next five years, one of the biggest changes in technology will be the sheer volume and variety of data collecting methods available to us. The Internet of Things[36] (IoT) or Internet of Everything is taking the internet into the real world and embracing a plethora of real world objects. Now everything is potentially a data source or data gatherer, from the traditional science based weather stations (now on-line) to the house hold toaster. Not only will this bring a huge increase in data sources (10.3Billion devices in 2014 to 29.5 Billion in 2020)[37], but will also increase the amount of possible noise which will need to be sifted through to find real nuggets. An increasing number of these will be spatially located which opens up more opportunities for the Geospatial world. Are we heading towards the Geography of Everything (Hudson-Smith)?



Many of the sensor systems will become smaller, lighter, cheaper and more powerful, opening up even more possibilities of how they can be deployed. Enter the Internet of Me - mobile phones and wearable devices increase the possibilities, not only for data gathering, but also the applications for geography never envisaged a few years ago. On the horizon we will see more personal data being collected, collated and shared – we can track our own and others well-being, track vital statistics and get an overview of our health. Track our fitness levels with apps such as Strava, then compete against strangers when exercising in a 'real come virtual' world. Whilst this health & wellbeing data, and social network style data will provide new insights into geospatial patterns, it also throws up questions around privacy, data sharing and cyber-security which also need to be considered in the policy arena.

So what will the impact of the IoT be on the Geospatial world? IDtechX[38] calculates that 45% of the multi trillion dollar IoT market will be covered by the sensor market, however there is some way to go before the IoT achieves this and makes its way into the mainstream market (Elliot).

However, with the potential of this type of technology, it could represent one of the largest business growth opportunities to have wandered into the Geospatial space, and has the potential to transform virtually every industry vertical. But with every growth opportunity comes a warning. With the ubiquitous nature of the IoT, the embedded devices themselves are often low-cost, low power devices that are restricted in both memory and computing power. As such the security controls will be basic and it is possible for example, to hack your bank account via a connected lightbulb. Developing suitable security barriers will be one of the real challenges to ensuring the IoT really does become a safe and viable reality[39,40].

[36] IoT – Internet of Things

[37] Forbes 2015: http://www.forbes.com/sites/gilpress/2015/07/30/9-new-predictions-and-market-assessments-for-the-internet-of-things-iot/

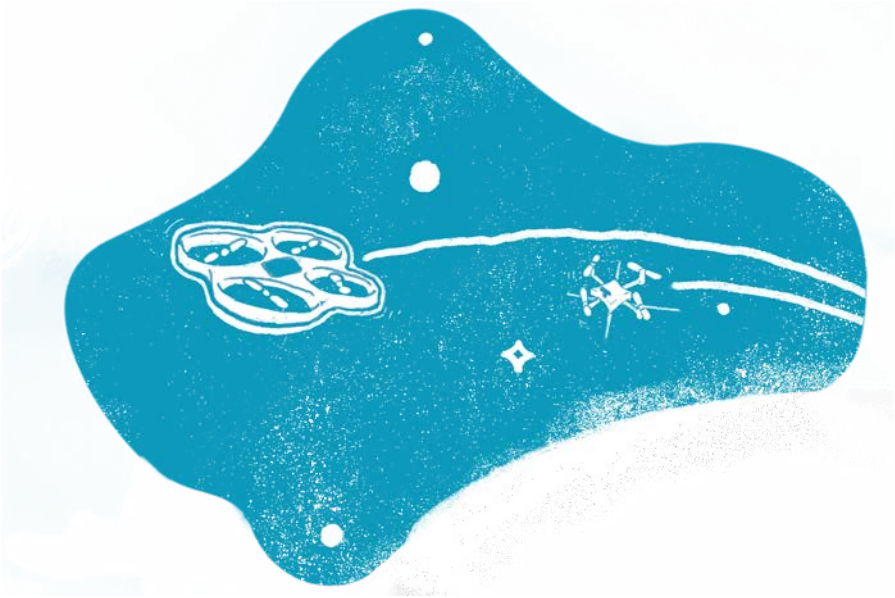
[38] http://www.idtechex.com/research/reports/internet-of-things-iot-business-opportunities-2015-2025-000386.asp

[39] http://www.tripwire.com/state-of-security/risk-based-security-for-executives/connecting-security-to-the-business/hacking-the-internet-of-things-beware-of-the-toasters/

[40] http://www.tripwire.com/state-of-security/security-awareness/3-internet-of-things-security-nuances-you-may-not-have-considered/

UAVs[41] are now available as cheap toys, allowing anyone to capture aerial photography. The range of sensors are already allowing, not only normal photography, but Infra red, thermal and 3D to pick a selection. More sensors will develop over time allowing, for example, in-situ chemical measurements and pollution meters (Kovac). Micro-robotics will enhance this technology over time. Sensors will develop in tandem with the carrier and look to the natural world for inspiration. For true automation to be possibility, 'Sense and Avoid' capabilities plus making them more crash robust are the big challenges.

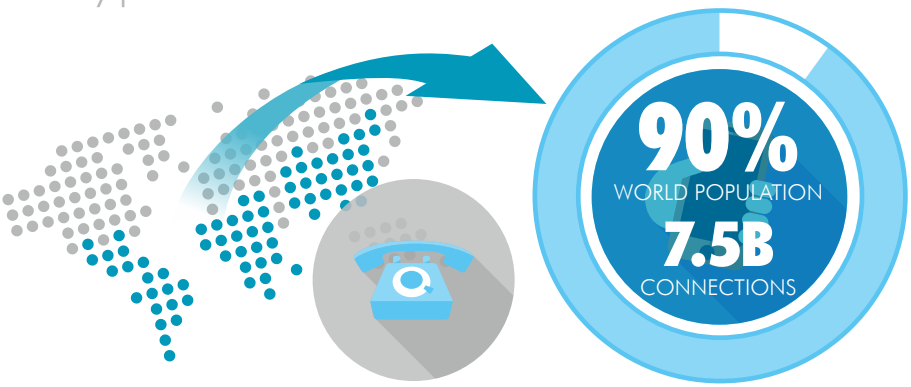
At the other end of the spectrum, Facebook and Google are currently looking at large unmanned vehicles (or High Altitude Platforms - HAP's) which will fly at very high altitude to bring internet access to areas[42] such as rural Sub-Saharan Africa and Asia which account for 3.4 billion of the 4.8 billion not yet connected to the Internet[43]. They are likely to develop other uses for these, including remote sensing, but likely will allow IoT data collection from even more remote locations, making both social and scientific data available on a truly global scale.



More than half the world's population live in cities, and this is expected to reach 75% by 2050, with 95% of the expansion occurring in the developing world (Darch). Much of the developing world has by-passed landline communications and is going straight to cellular technology, with 90% of the world's population having access to cell coverage[44] with 7.5billion connections (3.7 billion unique connections)[45]. There is also an ever increasing array of sensors collecting data, and a desire to access in real time wirelessly, putting a new strain on communications systems and available frequencies which can be utilised.

The Satellite Catapult study, included in this report with kind permission, looks at changes to 2020, and then to 2035, in areas of communications, positioning & timing, and Earth Observation. By 2020, they observe that the 5G generation of cellular technology should be available bringing major leaps forward in power, functionality and data access required for the Internet of Things. Positioning and timing will see availability of GNSS[46] of not just U.S. GPS[47] and Russian GLONASS positioning systems, but the European Galileo and the Chinese BeiDo systems. The increased number of available satellites will enhance accuracy, availability and integrity to any system using GNSS for positioning or timing.

Much of the developing world has by-passed landline communications



[41] Unmanned Aerial Vehicles

[42] http://www.theguardian.com/technology/2015/jul/31/facebook-finishes-aquila-solar-powered-internet-drone-with-span-of-a-boeing-737

[43] http://www.cta.tech/Blog/Articles/2015/July/How-Mobile-Phones-Are-Changing-the-Developing-Worl

[44] http://www.gsma.com/mobilefordevelopment/overview

[45] http://www.cta.tech/Blog/Articles/2015/July/How-Mobile-Phones-Are-Changing-the-Developing-Worl

[46] GNSS – Global Navigation Satellite System

[47] Global Positioning Systems

GNSS is insufficient however, for indoor navigation, which will see a marked increase in demand from retail, emergency services, healthcare and logistics in this timeframe. This trend has been picked up by the UN-GGIM[48] and OGC looking at data standards[49]. Key technologies include WiFi, Bluetooth and RFID[50], inertial measurements and magnetometers. A requirement is likely to be openly available indoor plans for public buildings allowing the various sensors to interact with plans – overlapping with the themes of Open and BIM already discussed in previous sections.

In the space arena, Earth Observation has seen major investment with high quality commercial imagery available and this is readily available through various suppliers. However, the earth observation sector is seeing a growth in small satellites using commercial off the shelf (COTS) technology. Companies such as Surrey Satellite Technologies changed the economics of space (Satellite Catapult) and this trend has been continued by others such as Skybox. This will continue with the development of constellations of high resolution sensors with unrivalled temporal resolution by 2020.

Other sources of remote sensor data include the EU Copernicus Sentinel constellation of Earth Observation satellite, which should be fully operational just after 2020, and will supply open data. The availability of this data, crossing into the big data, open and standards arenas, will likely whet the appetite of consumers for more and varied earth observation data.

> **In 348 months of working with earth observation, I have never experienced the sense of opportunity associated with the industry as I have in the last 3 (Wells)**

Autonomous technology has seen huge investment in the order of billions. Whilst the technology will have matured by 2020, it is likely that fully autonomous systems will still be in their infancy. The geospatial industry has a significant role to play in making autonomous cars a reality (Knight). Those in the geospatial industry who have a role to play in planning the transport systems of the future will need to plan for autonomous vehicles now[51]. Several of the investors are relying on on-board sensors as well as highly detailed maps to work out where they are. Autonomous vehicles in general will also use the IoT to access and pass on data about where they are, and update their own mapping systems as they drive. Investment in sensors such as LiDAR for vehicles will have an impact on the cost and size of the sensors, potentially making LiDAR available to other markets such as UAV's. Autonomous technology will not just be seen in cars, but in sectors such as agriculture, marine and retail where a customer might well find their shopping delivered by autonomous delivery drone (either land or air) as currently being developed by Amazon.

With new data sources, and more efficient communication, there is also expected to be new ways to access data and visualise it. Google glasses are low key at the moment, but are likely to re-appear once issues, such as human interface, have been worked out. The increase in data volumes, the increased availability of real time data feeds from a variety of sources, including mobile apps and remote sensors as well as increasing levels of accuracy and data resolution from high volume data sources such as LiDAR and Point Cloud applications which will all impact on what has traditionally been the realm of the cartographer.

> **By 2020, they observe that the 5G generation of cellular technology should be available bringing major leaps forward in power, functionality and data access required for the Internet of Things.**

Not least, the evolution of augmented and virtual reality technologies through the Microsoft Hololens and Oculus Rift will increasingly streamline the viewing of 3D and 4D data (Hudson-Smith), with the leadership of organisations such as the Augmented Reality for Enterprise Alliance[52] helping to ensure that activity focuses on the value-add rather than the technology for its own sake.

So how do we move forward, particularly on these newer technologies notably the Internet of Things? In the U.S., the National Institute of Standards & Technology is taking a leading role in the government supported programme US Ignite[53] to develop a common operational framework and repository for many US IoT projects (Elliot). In Europe we are still at the stage of investing in research and innovation to deliver essentially separate, silo-ed IoT and Big Data pilots and demonstrators.

[48] http://ggim.un.org/docs/meetings/GGIM5/Future%20Trends%20in%20Geospatial%20Information%20Management%20%20the%20five%20to%20ten%20year%20vision.pdf

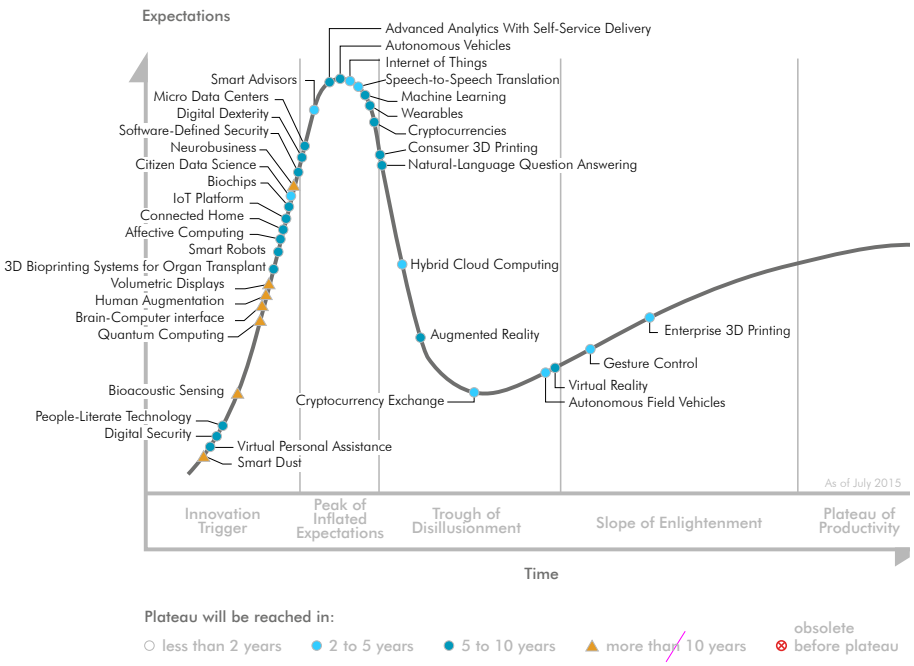
[49] http://www.opengeospatial.org/blog/2263

[50] RFID-Radio Frequency Identification

[51] http://www.atkinsglobal.com/en-GB/angles/opinion/the-future-is-now; http://www.atkinsglobal.com/en-GB/angles/opinion/autonomous-vs-connected-vehicles-whats-the-difference; and http://www.atkinsglobal.com/en-GB/angles/opinion/going-driverless-out-east

[52] http://thearea.org/

[53] https://www.us-ignite.org/



Gartner (2015)[55]

There is great synergy coming in public and commercial IoT initiatives, but they could take up to 20 years to develop. Major IoT initiatives will begin to gain impact starting in 2020 as critical adoption points are reached, and major issues such as interoperability and security are solved. With the advances in communications and ability to access data from anywhere globally, the need for global standards and a coordinated response is ever increasingly needed to ensure the data can be interpreted from anywhere and by anyone. A central repository, coordinated activity and a common framework to verify quality of service across Europe, or better globally is therefore urgently needed.

During the Big5 we also embarked on a touch of crystal ball gazing, using the Gartner hype curve[54] as a guide to see where these technologies sat, and also encouraging the industry to collectively look for opportunities for Geospatial.

Two of the technologies mentioned (IoT and Autonomous Vehicles) here are currently at the 'peak of inflated expectations' curve for emerging technologies with a predicted 5 to 10 year period to get to realising true productivity gains. Whilst much of the investment in autonomous vehicles will come from big business and government investment, Gartner predict that 50% of the IoT market will be created by start-ups less than 3 years old, representing a very high level of growth in invention, innovation and private investment. So we once again leave you with a challenge – what do you see as the emerging technologies where Geo can play its part?

Focus on the Value of Big Data and the IoT to help design common frameworks, rather than the technology itself

Develop a national or European Centre of excellence for IoT to bring a diverse set of skills together for the right ecosystem

Source leaders in developing industry standards and best practice to bring together disparate Big Data/IoT pilots and demo's, to ensure quality and trust is delivered before mainstream scale up.

There is a tendency and a danger to become too specialised. Education needs to foster an inter-disciplinary approach encouraging collaborative working across the disciplines.

Encourage geospatial to look outside our traditional areas and look for the opportunities elsewhere – if we don't then someone else will exploit them.

[54] http://www.gartner.com/newsroom/id/3114217

[55] http://www.gartner.com/newsroom/id/3114217

4.4 BIM, Asset Management and the transition to Future Cities

BIM may be defined as 'the purposeful management of information through the whole life cycle of an infrastructure asset'. Simply using the latest '3D' technology does not provide BIM. It is this managed approach, as a concept, which makes BIM so important in the GI arena. However, while there is generally a good understanding of the benefits of 3D modelling, this has not converted yet into a deeper technical understanding of how to exploit all digital data as the lowest and re-usable common denominator of information, beyond just the graphical output[56].

BIM is a game-changer – think of it as 'Better information Management'. BIM is a method for collaborative working, aiming to deliver accurate, validated and controlled information about individual assets, with the concept of state with respect to time, multiplied over portfolios.

The UK Digital Built Britain (DBB) strategy[57] was launched in February 2015, bringing together the Industrial Strategy – Construction 2025[58], the Business and Professional Services Strategy[59], the Smart Cities Strategy[60] and the Information Economy Strategy[61] to provide a consistent vision as to how we can create a high performing, transparent economy that efficiently delivers services to all of its citizens. The DBB strategy identifies asset availability as one of the main challenges for sustainable economic growth, pressure on resources and the emergence of the Digital Economy. We have to find ways of maximising the time that facilities and networks are available to be used by the public. This means using modern technologies to continuously monitor the condition and operation of infrastructure and to intervene before problems arise and to develop better solutions for the future.

BIM and geospatial data are opening new opportunities for civil engineers and specialists to address global demands for infrastructure investment, delivering projects at lower total costs, quicker and with fewer available resources. Whilst BIM is a process focused on improving the ways we design, construct and manage our physical assets, through digital models and improved collaboration, to improve the efficiency of the construction industry, GIS brings together information into a digital Geospatial database to make more informed decisions, with many tools available to help analyse the data using location as the key (May).

BIM requires a framing of the questions in a design and survey context, imagined and as-built, an alignment of virtual and actual reality. An alignment of decisions and outcomes in both. This not only demands collaboration, expertise and knowledge sharing through all professions, it goes further. It requires trust in what each individual is providing. Hence the Holy Grail associated with BIM – a single source of the truth. If ever a profession had spent its life trying to do just that it has to be the geospatial industry. We start with reality and virtualise it so it can be used, accessed, understood, improved, conquered, changed ..

It seems a shame that, with BIM being the relative 'new kid on the block', BIM and GIS have been developed in isolation. There is now significant interest and activity to rectify this, with increasing collaboration of organisations such as the Open Geospatial Consortium (OGC) and BuildingSMART.

[56] Kemp, A. (2015) Building Information Modelling – are we there yet? [Online], Available from: http://issuu.com/potion/docs/1chc_mag_p1-76_online [Accessed 11th May 2015]

[57] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/410096/bis-15-155-digital-built-britain-level-3-strategy.pdf (Accessed: May 15)

[58] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/210099/bis-13-955-construction-2025-industrial-strategy.pdf [Accessed: 24th April 2015]

[59] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/211842/bis-13-922-growth-is-our-business-professional-and-business-services-strategy.pdf [Accessed: 24th April 2015]

[60] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/246019/bis-13-1209-smart-cities-background-paper-digital.pdf [Accessed: 24th April 2015]

[61] https://www.gov.uk/government/publications/information-economy-strategy [Accessed: 24th April 2015]

Asset Management

Kervell observes that the need for accurate asset information for large infrastructure managers (e.g. utility companies, Highways England, Network Rail, Environment Agency) is an essential enabler for the safe and efficient operation and maintenance of those assets and for decision support[62]. However, owing to the nature and scale of the asset base in large infrastructure sectors, the asset object geometry held in these registers (often in GIS) is fairly simple. With the UK Government BIM mandate taking a whole life cycle portfolio approach across the sector, a significant opportunity exists for asset managers of large physical infrastructure to improve information management.

The difficulty that needs to be overcome is that a significant amount of legacy infrastructure assets already exists. Where not captured, changes to the existing infrastructure slowly degrades the quality of any data kept, and its reliability for use in operations and maintenance planning. The approach of delivering and updating data directly from the construction process into asset systems through BIM should increase the trust in the data. But other initiatives, such as defining a consistent approach to effectively record and share information on buried assets, are important to ensure that this can occur [63]. The continuing challenge is to get industry to get behind these initiatives, helping to fund and resource the activity required.

The seven critical infrastructure components of a city

Future Cities

The interface of the mega-trends of urbanisation, climate change and Big Data provides an opportunity to better understand the risks and opportunities for delivering developing world cities that are smart and sustainable for everyone. City leaders around the world are turning to integrated and intelligent smart systems and sub-systems and associated big-data concepts to realise integration of city administration, education, healthcare, public safety, real estate, transportation and utilities - the seven critical infrastructure components of a city[64]. In a smart city, these are all linked under a common framework, where it is clear what we need from data, how to unlock its real value and how to avoid untrusted and unmanageable information overload.

There is a connection between Smart City data and BIM data, both providing data about our built environment for further use in operations, maintenance and performance management[65]. The ability to measure 'in service' performance and compare it to 'as briefed' and 'as delivered' assets is the single biggest opportunity to improve both asset cost and carbon performance, e.g. through condition-based maintenance (see May, Kervell)[66].

[62] Asset Management – The Woodhouse Partnership Limited, July 2012

[63] https://www.ice.org.uk/news/knowledge/october/improving-visibility-and-resilience-of-buried-serv

[64] Washburn & Sindhu, 2010: pp.5-8; Department for Business, Innovation & Skills, 2015

[65] Department for Business, Innovation & Skills, 2015: p.14

[66] http://www.atkinsglobal.com/en-GB/angles/opinion/resilient-cities

Collecting data for design and build using BIM is of an order of magnitude more detailed than the traditional scope of the geospatial professional, requiring far more data and greater accuracy than previously. According to Sanderson, we are undoubtedly getting better at defining standards (BIM4, CityGML, ISO19157), and quite rightly, for the construction industry, the digital asset is becoming as important as the physical asset. This paradigm shift is in the process of transforming the sector. The data cannot be regarded as proprietary but needs to be passed on as accessible and trusted - cities won't become smart if the data are not treated as such. This represents a massive challenge, but a huge opportunity for the geospatial professional.

Data handover should be considered as a lifecycle component like any asset – "Would you handover an asset without an operating manual?" (Sanderson) In the data sense this means handing over the semantics and metadata, ideally mapped to an ontology. This is no different to any data time series. A city cannot be smart if it can't let the maintenance contracts which will keep it smart.

The momentum around BIM, and the increased activity around data standards is in no small part driven by the urgent need to introduce data into the information ecosystem which is reliable and trustworthy. The ISO[67] standard on the quality of geographic information has been updated.

By 2020, it will not be unusual to have geo-located sensors feeding live information for live decision making in a variety of urban situations. We should also have a better evidence base for decision making, whether at the planning or operational level. All this will be built on a core of open specifications.

Progressing to the Integrated Digital Built Environment

Inspired in part by Digital Built Britain[68], BuildingSMART International and the Open Geospatial Consortium have recently started working together on the concepts behind the 'Integrated Digital Built Environment' (Plume).

Computer games like SIM City give a foretaste of what is to come, giving players the tools to construct cities based on both physical and analytical data. In the future, advancements in technology will allow us to 'build' in much the same way, using collaborative or converged BIM and GIS processes, seamlessly connected to help improve the quality, reliability and usage of data. In a future with Smarttechnology, Smartbuildings and Smartcities the way we design, construct and manage the built environment also needs to be 'Smart'. The lines between site and design office will become blurred and automated construction will drive the demand for on-site 3D data to define tasks, locations and areas From existing capabilities merging GIS and BIM technologies[69].

Through Geointelligence and the use of reliable and real-time information, FM[70] teams like our gamer playing SIM City, will be able to make decisions and react to situations far more effectively. With the inclusion of sensors in the field, improved accessibility, and improved quality of data, facilities managers will be able to manage their assets even more effectively, from simple devices to manage temperature and humidity within a building, to high accuracy total stations used to monitor the integrity of a large bridge. In the future these systems will be able to learn and react automatically to changes in the environment. Train stations themselves will be able to manage the flow of trains into and out of the station, the flow of cars and the flow of people into, through and out of the station, through retail outlets, car parks and

By 2020, it will not be unusual to have geo-located sensors feeding live information for live decision making in a variety of urban situations. We should also have a better evidence base for decision making, whether at the planning or operational level.

[67] Geographic Information - Data Quality (ISO 19157:2013)

[68] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/410096/bis-15-155-digital-built-britain-level-3-strategy.pdf (Accessed: May 15)

[69] http://www.atkinsglobal.com/en-GB/angles/opinion/the-fourth-dimension-visualizing-rail-and-transit-in-real-time (Suchocki)

[70] FM – Facilities Management

> Train stations themselves will be able to manage the flow of trains into and out of the station, the flow of cars and the flow of people into, through and out of the station, through retail outlets, car parks and pick-up points.

As with many other technologies, the Internet of Things and Internet of Everything will play a major part in the way autonomous technologies will gather and use data to allow their operation. To be truly effective, these sensors will need to have a sense of place. Plume refers to this combination of proprietary tools and open standards as the Integrated Digitally-Enabled Environment (IDEE), which affords us a comprehensive way of holding information about the natural and built environments in which these autonomous technologies will operate.

For the IDEE to be of value to us, we need a way of accessing that information as and when we need it. That leads to a set of facilitating technologies to enable the IDEE to operate (Plume):

- The internet to transport the information
- The semantic web to enable smart ways to find and retrieve information
- Geolocation technologies to enable searching based on geographic context
- RFID[71]'s with sensors to facilitate the internet of Things to realise a sensate environment

This may be the way in which the world of BIM could interact with the autonomous world of smart cities, to create for example, the future transport networks that can support autonomous vehicles, and indoor navigation that facilitates a better and safer experience for people moving through the urban environment.

Focus on the Value of BIM to help design common frameworks, rather than the technology itself

Ensure geospatial supports the development of Digital Built Britain, and the concept of a future Integrated Digitally Enabled Environment (IDEE), by building on the foundation blocks currently encaptured in "BIM Level 2"and bring a diverse set of skills together for the right ecosystem

Assist maturing of BIM within the infrastructure sector, through geographic perspective, and geospatial approach

Drive support for the further collaboration and convergence of open standards through organisations such as BuildingSMART, OGC and W3C

Faciliate further understanding and convergence of BIM and asset/facilities management communities through linkage to business outcomes and risk management - enabled by geospatial[72]

[71] Radio Frequency Identification

[72] http://www.atkinsglobal.com/en-GB/angles/opinion/time-to-plan-for-easy-tech-upgrades-in-built-to-last-infrastructure

4.5 Policy and Cultural

The geospatial industry is changing largely driven by technological innovations which will have an impact on society, economics and the environment. Organisational and cultural changes are often lagging behind these technological advances. Government can act as a sponsor and advocate to promoting the take-up of technology through policies and supporting incentives. At the organisational level we notice a trend to greater collaboration to keep in line with those changes.

Over the last five years, the coalition government saw the digital economy as a driver for growth and hence promoted a range of initiatives and policies supporting an overarching digital infrastructure through the support of superfast broadband roll out to 95% of households by 2017. The government digital data service is taking the lead on government service as a platform and the national information infrastructure recognising the need for a management framework for the most strategically important data held by government. Open data and transparency policies proactively encourage the release of public data. Over 20,000 datasets are available through data.gov.uk, of which 43 % are related to location. In local government, INSPIRE was the main driver for publishing of over 6000 geospatial datasets financially supported by government (Schmid).

The Government is driving a range of collaborative technology initiatives such as BIM, Smart Cities, Digital Built Britain and at international level, Future Cities (Penney). As presented in section 4.3 (BIM), The UK Digital Built Britain (DBB) strategy was launched in February 2015, bringing together the Industrial Strategy – Construction 2025[73], the Business and Professional Services Strategy[74], the Smart Cities Strategy[75] and the Information Economy Strategy[76] to provide a consistent vision as to how we can create a high performing, transparent economy that efficiently delivers services to all of its citizens (May).

The UK is having a leading international role in knowledge and digital economy and belongs to an exclusive club of world leading nations (known as the D5 - Alderson). But more needs to be done to make the value case of geospatial in the wider economy and to address environmental and societal problems (S.Ramage). The Government has realised the potential of Big Data and the newly established UK Data centres to create insight into evidence based decision and policy making. However, Hadley reminds us of the continued need for decision makers to understand the contribution of geospatial technology and ever developing innovative technologies in policy making in government, while Coady points to the importance of statistics in decision making and linking this to geography.

[73] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/210099/bis-13-955-construction-2025-industrial-strategy.pdf [Accessed: 24th April 2015]

[74] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/211842/bis-13-922-growth-is-our-business-professional-and-business-services-strategy.pdf [Accessed: 24th April 2015]

[75] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/246019/bis-13-1209-smart-cities-background-paper-digital.pdf [Accessed: 24th April 2015]

[76] https://www.gov.uk/government/publications/information-economy-strategy [Accessed: 24th April 2015]

In local government, the role of geospatial information and use forms part of the wider digital transformation driven by severe budget cuts and an increase in service demand from a growing population. Local Government is transforming from a public service provider to a commissioner. Services will be increasingly provided by the private and voluntary sector and as such local government will move from a data creator to a user which will have an impact on how local GI will be provided (Schmid). Miles argues for the need for more collaboration amongst authorities to harness innovation and sharing of open source.

There is an increasing recognition of the need for greater collaboration driven by globalisation, the connectivity through the internet, public sector austerity and addressing sustainability and environmental issues around the world. Several reports (Alderson, Lawrence, S.Ramage) that look at the overall GI industry, examine the role the UK plays in international collaboration.

A series of global activities are underway that are bringing together government and industry leaders to share ideas and concerns around sustainability, such as the Eye on Earth Summit[77] and the United Nations initiative on Global Geospatial Information Management (UN-GGIM)[78]. Both these activities and many other initiatives involving international bodies have been addressing sustainability and the sustainable development goals (SDGs) [79](Lawrence, S.Ramage).

The United Nations Committee of Experts in Global Geospatial Information Management (UN-GGIM) was set-up in 2011, to identify, at a global level, the challenges and opportunities for geospatial information in the short- to mid-term (Norris, Lawrence). The second edition of the UNGGIM[80] report recognises that the most significant changes would come, not from a single technology or organisation, but from the linking of multiple technologies and policies, and focuses on four emerging and developing trends:

Smart cities and Internet of Things;

Artificial Intelligence and Big Data;

Indoor Positioning and mapping;

Integrated statistical and geospatial information

> Local Government is transforming from a public service provider to a commissioner. Services will be increasingly provided by the private and voluntary sector and as such local government will move from a data creator to a user.

[77] http://www.eoesummit.org/

[78] http://ggim.un.org/

[79] https://sustainabledevelopment.un.org/topics

[80] http://ggim.un.org/docs/meetings/GGIM5/Future%20Trends%20in%20Geospatial%20Information%20Management%20%20the%20five%20to%20ten%20year%20vision.pdf

The UNGGIM has instigated a simple but comprehensive list of change taking place at policy level, predicated by the principle that "everything happens somewhere" (Lawrence). They include:

- The change by many governments to the use of mandated international Standards
- The changes taking place with institutional arrangements
- The recognition of the economic value of using 'place-based data' to enhance decisions being made at the highest levels of countries
- The change by many governments as to their thinking about how to add a level of 'authority' into citizen collected data
- The understanding that spatial data infrastructures underpin the information systems of countries and assist the decision-making of the governments and the private sector
- An understanding that 'place-based data' is a vital component of the SDG agenda

The UNGGIM together with the European Commission INSPIRE Directive and Eurostat Task Force on the Integration of Statistics and Geospatial Information all seek to harmonise the approach to the integration of statistical data and geospatial information at the European or global levels (Coady).

Organisational changes are also marked by greater collaboration and partnership working. Public-private partnerships, cross organisational working will become more the norm. This is partly fostered by the transparency and openness agenda. Hitchcock and Smith provided examples of collaboration as a model for doing business in various industries e.g. retail, oil and gas.

Changes in geospatial technology have an impact on the need for skills. General skills of using GI in data analysis have broadened as GI has become more mainstream and forms part of many online tools (Kavanagh, Brayshaw, Penney). However, several contributions reflected on the shortage for data analysts to meet the increasing demand for BIG Data, predictive analysis and modelling while data scientists are needed for developing structures and architecture for creating and linking data. (Hitchcock, Brayshaw, Booth). At the same time there is a need for broadening the general understanding of data analytics within an accredited workplace GI skills set.

Geography continues to attract more people and the outlook for geography graduates due to their broad skill set is looking positive (Jones).

Government can act as a sponsor and advocate to promoting the take-up of technology through policies and supporting incentives. At the organisational level we notice a trend to greater collaboration to keep in line with those changes, e.g. the collation government supporting an overarching digital infrastructure through the support of superfast broadband roll out to 95% of households by 2017.

There is a shortage for data analysts to meet the increasing demand for BIG Data, predictive analysis and modelling while data scientists are needed for developing structures and architecture for creating and linking data. There is a need to improve workplace GI skills accreditation covering standards, data management, data sources and most specifically creating business cases to support investment decisions and risk assessment work.

Harmonise the approach to the integration of statistical data and geospatial information at the European or global levels.

Continued need for decision makers to understand the contribution of geospatial technology and ever developing innovative technologies in policy making in government, and the importance of statistics in decision making and linking this to geography.

More needs to be done to make the value case of geospatial in the wider economy and to address environmental and societal problems.

Five.
Challenges and Opportunities

Much of our work to 2010 was centred on analysing static data and a GI focus on building Spatial Data Infrastructures. But if we are to make cities smarter then we have to recognise patterns as they emerge, not after the event. Time, as much as location, will need to be a component in the solutions that develop to 2020. This means becoming part of a parallel processing data driven architecture. The glory days of geospatial in the 2000's, with its monolithic approach from capture to visualisation going mainstream has, over the past 5 years been challenged and by 2020, geospatial will be part of the solution if not then part of the problem. Woe betide others who may try that approach going forward.

The growth of digitally enabled services is substantial across the world, with notable activity in China, India, Russia and Eastern Europe. It is anticipated that competition in this space will increase considerably over the next 5 years. One of the key differentiators, not much referred to by the contributors, will be around security – both at a personal and at a societal level. Critical infrastructure is increasingly vulnerable as digital connectedness becomes de facto. How this is dealt with is anticipated to become one of the most hotly debated issues in the next few months and years.

A truly smarter generation will only really emerge when its citizens can share trusted knowledge for their gain. Inspiration may be drawn from other related technology-intensive industries who have succeeded with a focus on; value creation, quality and trust (Elliot). There is a real risk, even as the technology giants move into this space, that the mainstream use of Big Data and the IoT will not be maximised unless these elements are considered carefully.

There is a significant debate about the appropriateness of the concept of "smart" in cities. Whilst connectedness both of things and people gains more and more focus, one shouldn't forget the importance of increasing the resilience and well-being of the global society and economy which this enables. Attention needs to be given to the management of our natural and agricultural resources, and the environment if our cities are going to be truly sustainable. Moving to 2020, Big Data will increasingly help to identify gaps in service provision and target infrastructure investments to those people and areas that need it most and where the benefits are greatest. However:

> **…. Big Data is not a panacea and the UN Global Pulse White Paper highlights two factors for making Big Data work for development: firstly, contextualisation, both in terms of the data itself and the cultural setting, and secondly the critical role of analysts to ensure we become "sophisticated users of information"**
> **(Darch)**

> **There is a significant debate about the appropriateness of the concept of "smart" in cities. Whilst connectedness both of things and people gains more and more focus, one shouldn't forget the importance of increasing the resilience and well-being of the global society and economy which this enables.**

There is a very human dimension to the rapid transformation of our lives into a more digital world. Evidence suggests that we are adapting more quickly than might be expected[81,82], and there will be undoubtedly both good and bad ramifications to this. For those involved in how the real world is represented in a virtual sense, this represents a serious responsibility over the next few years, which must not be overlooked.

[81] 'Mind Change", Susan Greenfield

[82] "The Shallows: How the internet is changing the way we think, read and remember", Nicholas Carr

The GI Community needs to embrace openness in the widest sense; open standards; open data, open systems; open architectures and open and collaborative business models to meet the challenges and unleash the potential opportunities that this new world order brings. Greater freedom and movement of geospatial data, powered by open software will in turn create 'richer pictures', enable better analysis and insights and create greater value for the industry as a whole (Alderson). The Geospatial industry:

> …has the opportunity to morph into a new role in this information rich world, but it must take charge of technology and not be its slave and raise its head to view the wider geospatial picture in context. If successful we will be ideally placed to support society and community initiatives. However, failure will see the industry wither within the confines of historic tradition and methods.
> (Penney)

Globally, Europe and the UK in particular, are often looked at as excellent exemplars as to how the geospatial information underpins so many of the daily decisions made, not only by policy makers, but also by citizens. Lawrence advises that opportunities are there to be developed - but often requires collaboration between UK companies to be able to put together a total offering for a country that is large enough for them to consider. We need to use all the available technologies, as many nations wish to have similar outcomes but will want to use the rapidly evolving technologies to do so. Other nations outside Europe are doing this and so should the UK, if the industry wishes to grow and benefit from the ever-growing use of geospatial around the World.

In a number of sectors – from marine through environment to buried utilities, the need for a clear vision, collaborative working and funding arrangements, agreed standards, inter-operability and a sustained focus on creating productised data are paramount. Over the next few years…

> There needs to be a shift in focus from collecting and managing to contextualising data and adding value.
> (Royse)

For the GI Industry to reap the benefits of the geo data deluge:

> …we must work more intelligently and collaboratively, not simply pooling our collective knowledge but our collective minds, setting aside our individual vested commercial interests for the common good, creating a vision beyond what we are doing at present by unleashing the potential of our collective imaginations. For in the immortal words of Albert Einstein, "The true sign of intelligence is not knowledge but imagination" (Alderson)

> The GI Community needs to embrace openness in the widest sense; open standards; open data, open systems; open architectures and open and collaborative business models to meet the challenges and unleash the potential opportunities that this new world order brings.

Many of the Foresight Report contributors feel that the GI community cannot operate in isolation any longer. With this explosion of spatial information, geospatial is no longer a niche area of activity.

One area where we are seeing increasing levels of collaboration – evidenced by the joint activities of Building Smart and Open Geospatial Consortium - is around BIM and the progression through Smart Cities to the Integrated Digitally Enabled Environment described by Jim Plume. Having "geo-enable-d the internet" (Gleeson), common thread through the papers is the sense that the next big challenge leading to 2020 will be to Geo Enable BIM:

> **...whatever term or interpretation you put on the acronym "BIM", or indeed even if you refuse to use it, the BIM vision has the potential to transform the geospatial industry. The only question is will the geospatial industry be at the heart of that transformation or not. Or more precisely what are you prepared to do? (Gleeson)**

Areas which require specific focus to geo-enable BIM have been proposed by Survey4BIM, and provide a logical roadmap (figure 1) to allow concrete progress.

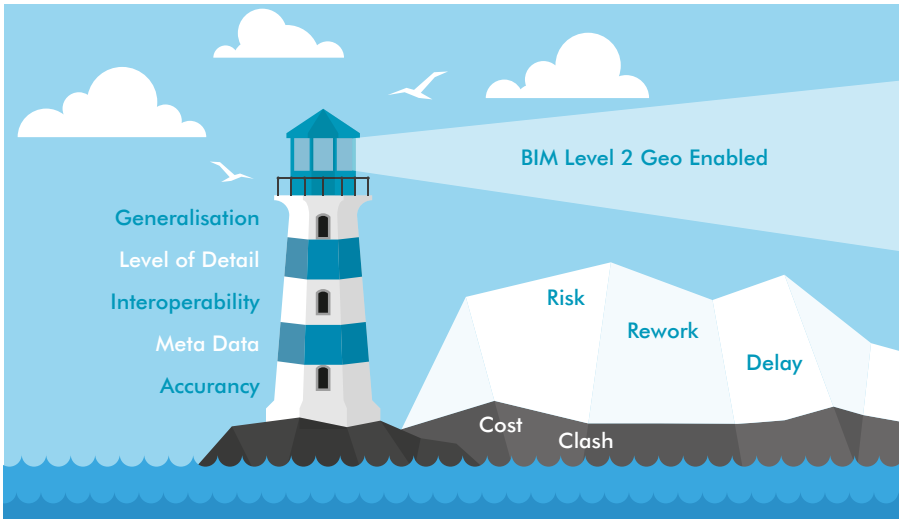


Figure 1 – BIM Lighthouse (Image courtesy of the Needles Lighthouse)

Across many sectors, there is a technology translation gap where technologists (including geospatial practitioners) are unable to succinctly explain the usefulness or value of their data, tools or services (S.Ramage). Some of the reasons for the existence of the gap include the use of jargon or industry specific terminology, the lack of a clearly articulated business case or return on investment (which may not necessarily be limited to a financial return) and a lack of education or knowledge on the part of the governing body.

This is an area where a number of contributors call on the AGI to focus more energy:

> Only a few organisations in the UK are poised to take a leadership role to tackle this communications issue and the AGI is one of them. (S.Ramage)

> Of course, this increasing leadership role is not simply an opportunistic response to the emerging data challenges. It is now over 25 years since the AGI became one of the very first associations to form around GI internationally, a pedigree that makes the UK a natural global leader in the development of world class digital and GIS skills. (Alderson)

However, whilst we may have been first out of the blocks in global digital leadership, maintaining that position will require a coherent approach that brings together Industry, Universities, Schools and Colleges in a seamless and coordinated assault on the growing digital skills gap. The challenge is not unique to the geospatial industry, and it would be a mistake to do this from a limited perspective. The transition to a digital, knowledge based economy will stall unless this is seen as a priority, with STEM subjects forming the core of all curricula content, cradle to grave. This will require a generous and spirited effort towards collaboration across institutions and across industry sectors in possibly an unprecedented way.

In many areas, during the recession, the number of GI specialists has been reduced, leading to a drain of skilled resources. But at the same time, GI specialists have been well equipped to meet the skill set of data scientists and have extended their responsibility to include management and delivery of data services, embracing the open data/open source, the BIM and smart city agendas, and driving a range of innovations, from autonomous vehicles, through to mobile mapping and indoor navigation. As Hudson-Smith concludes:

> We are moving into an era of ubiquitous data, visualized within three-dimensional environments. Geospatial is moving into the analysis of data worlds, we will look back at terms such as data store, smart and Big Data with wry amusement. Yet it is these trends that mark early glimpses of the future of data and geospatial. In the same way that the QRCode is long gone in the fast moving world of the Internet of Things, we are at the start of a new data revolution and it's the most excited I have been about geospatial data in my life.

Annex One. **Roadmap of Papers**

THE GI COMMUNITY: OPEN TO A BRIGHT FUTURE

Dr John Alderson | Informed Solutions

This paper looks at the Future of Geo over the next 5+ years.

CITIZEN SCIENCE & GEOGRAPHIC INFORMATION

Tom August & Helen Roy | Centre for Ecology & Hydrology

Citizen science and crowd sourcing using examples from the environmental sector.

AGI FORESIGHT STUDY TO LOOK AHEAD OVER THE NEXT 5-10 YEARS

Stephen Booth | PV Publications

This paper looks at the Future of Geo over the next 5+ years.

WHY THE GI INDUSTRY NEEDS A TRANSFORMATION IF LOCATION INFORMATION IS TO BECOME TRULY INDISPENSIBLE TO ENTERPRISE

James Brayshaw | Pitney Bowes

This paper looks at the Future of Geo over the next 5+ years.

YOU CAN'T DESIGN FOR EVERYONE: EXPLORING THE IMPLICATIONS OF UNLEASHING UBIQUITOUS GIS TECHNOLOGIES

Michael Brown | The University of Nottingham

The future of Geo and how User Centred Design can play it's part.

BIM FOR THE SUB-SURFACE: CHALLENGES

Jérôme Chamfray, David J Wright, Simon Miles | Atkins **Gary Morin, Carl Gricen** | Keynetix **Holger Kessler** | BGS

Challenges for the BIM envionment in sub-surface includiding standards.

GI IN RETAIL

Audun Clark | Tesco

Future trends in GI and retail - mobile, social media and IoT.

STATISTICS & GEOSPATIAL INFORMATION

Ian Coady | Office of National Statistics

Role of evidence based decision making using statistics and geospatial.

OPEN GEOSPATIAL IN 2020

Jo Cook | Astun Technology

All things Open - Open Source, Open Data, Apis and Openwash.

AGI FORESIGHT STUDY 2010: DID WE GET IT RIGHT?

Andy Coote | ConsultingWhere **Steven Feldman** | KnowWhere Consulting **Robin McLaren** | KnowEdge

A retrospective look on the AGI Foresight report of 2010 and did we predict correctly?

REALISING THE POTENTIAL OF BIM. IS COMPETITION RESTRICTING EFFICIENCY OPPORTUNITIES FROM COLLABORATION?

Andrew Cowell | MWH

Within BIM, are we missing out on the potential efficiences through common standards through a belief in competition?

PUSHING THE BOUNDARIES OF THE SURVEY PROFESSION

Dr Paul Cruddace | Ordnance Survey

What are the Challenges facing the GI community compared to 2010, and how do we move forward.

THE GI COMMUNITY: PROBLEM & PERSPECTIVE

James Cutler | emapsite

A critical look at the GI Community and it's future.

BIG DATA IN FUTURE PROOFING CITIES

Geoff Darch | Atkins

How can Big Data help to support and protect the human communities of tomorrow.

DRAWING THE THREADS TOGETHER: TURNING DATA INTO KNOWLEDGE

Peter Edmonds | The Crown Estate

Data sharing and Open data in the marine environment.

BIG DATA & THE INTERNET OF THINGS

Robert Elliot | National Physical Laboratory

Big Data and the Internet of Things is about the outcome; Changing Behaviors through a focus on value and quality.

ADVANCES IN 3D GIS

Claire Ellul & Kelvin Wong | University College London

3D perspective on Standards, Open Data, Internet of Things and BIM.

CURRENT STATUS & FUTURE TRENDS IN CROWD-SOURCING GEOGRAPHIC INFORMATION

Giles M. Foody | University of Nottingham **Peter Mooney** | Department of Computer Science **Linda See** | Ecosystems Services and Management Program **Norman Kerle** | University of Twente **Ana-Maria Olteanu-Raimond** | IGN France **Cidalia C. Fonte** | University of Coimbra

How citizen sensing or crowd sourcing is affecting all aspects of data gathering looking at issues including quality and future trends.

GEO-ENABLE BIM - THE BIG5 CHALLENGES. WHAT ARE YOU PREPARED TO DO?

Barry Gleeson & Martin Penney | Survey4BIM

How to Geo-Enable BIM. The Big 5 Challenges, Opportunites and Actions.

IS THE 'WHERE' THERE IN OUR POLICY MAKING?

Clare Hadley | Ordnance Survey

Geospatial information can have a critical and valuable role in the creation and delivery of policy by administrations. This has not always been the case - what are the reasons and how can AGI help.

TO CAD OR NOT TO CAD? THAT IS THE QUESTION

Barry Hall | Atkins

Looking at data standards in the CAD and GIS worlds for the BIM process.

THE FUTURE OF DESKTOP GIS IN RETAIL

Sarah Hitchcock | GeoLytix

Looking at changes in how GIS will be used by various sectors in retail.

THE FUTURE VIEW OF GEOSPATIAL: TOWARDS THE GEOGRAPHY OF EVERYTHING

Professor Andrew Hudson-Smith | CASA - University College London

Futures in GIS - Internet of Everything, Data Stores, Augmented Reality, the Internet of Me.

GI FOR HUMANITARIAN RESPONSE

Liz Hughes, Chris Ewing & Matt Pennells | MapAction

Looking at new ways to use GI to help in humanitarian response - crowd sourcing, interfaces, competencies, big data and new technology.

A NEW DIMENSION IN CREATIVE VISUALISATION: IS IT A NEW STANDARD FOR TOMORROW?

Richard Kemp Harper | ITO World

How the creative industries can help us exploit visual analytics, data volumes and realise the full power of computing.

CARTOGRAPHY AND EDUCATION

Peter Jones | The British Cartographic Society

Education and the art of map making.

THE STATE OF THE GEOSPATIAL INDUSTRY - WHAT THE POTENTIAL AND CHALLENGES ARE - AND WHAT WE SHOULD BE DOING ABOUT IT

James Kavanagh | Royal Institute of Chartered Surveyors

Future of Geo over the next 5+ years. What are some of the issues facing the industry and how will we address them?

BIM ADOPTION WITHIN INFRASTRUCTURE USING A RISK BASED APPROACH

Andy Kervell | Arup/Network Rail Infrastructure Projects

A significant opportunity exists for Asset Managers of large physical infrastructure to improve information management as a result of the wider adoption of a BIM approach throughout an asset's lifecycle.

SIM CITIES: WHY BIM AND GIS FIT TOGETHER

Mark King | Leica Geosystems

How computer games can help visualise the future city within BIM.

AUTONOMOUS VEHICLES, A FUTURE OF OPPORTUNITIES

Philip Knight | ConsultingWhere

Autonomous vehicles and the opportunities for the geospatial industry.

THE FUTURE OF DRONES AND THE DEVELOPMENT OF MICRO-ROBOTIC UAV TECHNOLOGY

Dr Mirko Kovac | Imperial College London

Future of micro drones and how how their development may assist the geo world in the future.

GLOBAL TRENDS: HOW WILL THEY IMPACT THE UK GEOSPATIAL MARKET

Dr. Vanessa Lawrence CB

Global trends, developing world and sustainability. UN-GGIM and implications and opportunities for the UK Geospatial industry.

THE TROUBLE WITH GEOGRAPHERS IS THAT THEY THINK THE WORLD IS 2D, FLAT & DOESN'T CHANGE!

Chris Little | UK Meterological Office

How to change perceptions for technology to better realise the real world.

THE VALUE CHAIN OF BIM DATA IN A SMART CITY CONTEXT

Ilka May | Arup

How BIM can assist in the Smart City concept.

OPEN-SOURCE GIS IN LOCAL GOVERNMENT - CURRENT TRENDS & FUTURE PREDICTIONS

Simon Miles | Royal Borough of Windsor & Maidenhead

How Open Source is changing the way local authorities do business.

THE RISE OF OPEN DATA AND HOW IT'S SHAPING MARINE GI ANALYTICS

Fiona Miller | ABP Marine Environmental Research Ltd

Open data in the marine world - opportunities and issues and how to make things easier for the user community.

FUTURE TRENDS IN GEOSPATIAL MANAGEMENT

James Norris | Ordnance Survey on behalf of the UN-GGIM

Emerging trends in the geospatial world over the next 5-10 years for the UN-GGIM.

AGI FORESIGHT REPORT: OPEN STANDARDS

Peter Parslow | AGI Standards

How standards are developing between GI and other complementary areas, in particular the IoT, Smart Cities and BIM.

EMERGENCY AND DISASTER MANAGEMENT

James Penman | UK Meterological Office

This paper considers how best to facilitate information handling and hence planning and decision making for emergencies and disasters.

BIG DATA: OPENING UP A SMART NEW WORLD FOR THE GEOMATICS INDUSTRY

Martin Penney | Technics Geospatial Surveyors

Realising the benefits of technology and big data within the geomatics industry.

CREATING ECONOMIC AND SOCIO-ECONOMIC VALUE FROM MARINE GEOSPATIAL DATA

John Pepper | Oceanwise

Issues around data value in the marine sector.

INTEGRATING DIGITALLY-ENABLED ENVIRONMENT: THE INTERNET OF PLACES

Jim Plume | UNSW Australia & Building SMART

In this paper, we refer to this combination of proprietary tools and open standards as the Integrated Digitally-Enabled Environment (IDEE), affording us a comprehensive way of holding information about the natural and built environments.

GEOSPATIAL INDUSTRY: CHALLENGES

Alex Ramage | Transport Scotland

Challenges to the GeoSpatial world from disruptors outside our usual space - competing standards, BIM and Open.

LINKING LOCATION TO SUSTAINABILITY: THE UK CONTEXT

Steven Ramage | Ramage Consulting Ltd

It's important that there is a collective ability for geospatial technologists and British policymakers to address the ever-increasing social and environmental challenges facing everyone in the UK.

KEY CHALLENGES AND OPPORTUNITIES FACING THE GEOSPATIAL INFORMATION INDUSTRY

Kate Royse | British Geological Survey

Within the Geo-Environmental sector there are significant challenges and opportunities around the development of smarter data, the use of Open data and cloud services and improvements in visualising the sub-surface and time-series data.

DATA QUALITY FOR A CONNECTED WORLD: SHARED LEARNING TO INCREASE OUR ABILITY TO REDUCE THE RISK OF MAKING THE WRONG DECISIONS

Mike Sanderson | 1Spatial

Data quality underlying smart cities, IoT, Big Data and BIM, and how to reduce Risk.

SMARTER LOCAL PLACES

Gesche Schmid | Local Government Association

Over the coming five years local government and the public sector will be challenged to transform their services to increase efficiencies and productivity.

BIM4INFRASTRUCTURE - RATHER THAN ANSWERS, DO WE KNOW THE RIGHT QUESTIONS YET?

Liz Schofield | ThinkBIM, Leeds Beckett University

ThinkBIM workshop report.

GIS: THE NEXT 5 YEARS IN THE OIL & GAS INDUSTRY

Gareth Smith | Exprodat

How GIS as a platform is changing geospatial in the oil and gas sectors.

THE FUTURE OF GI IN THE 3RD SECTOR

Doug Specht | University of Westminster & VOZ

Advancements in technology and GI analytics are creating exciting and powerful opportunities for NGOs to better engage with communities and local knowledge.

A MAJOR CHALLENGE FOR THE SURVEYING INDUSTRY

Rory Stanbridge | The Survey Association

Addressing skills shortages in the surveying profession.

GIS AND BIG

DATA ANALYTICS: TWO SIDES OF THE SAME COIN?

Trevor Steenson | Digital Transformation Service; DFPNI

GIS and Big Data analytics should not be seen as rivals, but face similar challenges and are in fact complimentary and will benefit from each others advances.

BIM AND SPATIAL DATA; WORKING TOGETHER FOR EFFECTIVE INFRASTRUCTURE DEVELOPMENT

Marek Suchocki | Autodesk

BIM and geospatial data are opening new opportunities for civil engineers and specialists to address global demands for infrastructure investment delivering projects at lower total costs, quicker and with fewer available resources.

GIS AND AGRICULTURE: THE NEXT FIVE YEARS

Julian Swindell | Royal Agricultural University, Cirencester

How technological advances including LiDAR, UAVs and other tech will aid advances in agriculture.

CHALLENGES FOR GEOGRAPHY - THE ENVIRONMENT DOMAIN

Liz Tucker | Head of Geographic Evidence, Defra **Gary Kass** | Deputy Chief Scientist, Natural England **Neil Kaye, Adrian Hines and Alberto Arribas** | Met Office Hadley Centre

Skills and capability development; policy skills to embed 'place' in the decision making process. Examples from the scientific community.

FUTURE OF GI IN FOOD AND FARMING

Dr Toby Waine & Tim Brewer | Cranfield University

Looking at how the agriculture industry is embracing technology and data analysis for Agri and Big Data analytics.

GI IN THE HEALTH & SOCIAL CARE SECTOR

Dr Edward Wallington | EsriUK **Matt Bull** | Public Health England (PHE) **Iain Goodwin** | Ordnance Survey **Matthew MacDonald** | NEL Commissioning Support Unit

How GI and other data analytics has the potential to revolutionise the health care sector in an environment of budget cuts and pressures.

THE ONLY CONSTANT IN LIFE IS CHANGE: A VIEW ON THE FUTURE OF REMOTE SENSING OF SATELLITE IMAGERY

Dr. Andy Wells | SterlingGeo

How exponential changes in the earth observation sector will revolutionise the geospatial arena.

THE FUTURE OF CARTOGRAPHY

Christopher Wesson | Ordnance Survey

The communication of geospatial information is always evolving and remains forever relevant. New technologies demand new methods and perfection will never be attained.

OPEN FOR GEOSPATIAL

Simon Wheeler | AGI Northern Ireland

Open technologies and a report on the Big5 conference Open for GeoSpatial in Belfast 2014.

SATELLITE SERVICES FUTURE LANDSCAPE

Satellite Applications Catapult

Foresight report kindly supplied by the Satellite Catapult looking at the future of communications, navigation, timing & earth observation.

Annex Two.
The Paper Collection

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

The GI [Geographic Information] Community: Open to a Bright Future

Dr. J S Alderson | Informed Solutions

The GI Community consists of a broad and diverse ecosystem of individuals and organisations adding to the geospatial value chain, from collection through to intelligent visualisation and analysis, in many instances delivering great insight, value and new opportunities.

Yet historically geospatial data has all too often been proprietary, locked down by contractual and/or legacy constraints, accessible only via proprietary software and hardware, all with their own sets of restrictions on use. However, a new world order is upon us where a huge volume of geo data is widely and often freely available from a plethora of new and often unregulated alternative sources.

This paper calls for the GI Community to embrace openness in the widest sense; open standards; open data, open systems; open architectures and open and collaborative business models to meet the challenges and unleash the potential opportunities that this new world order brings.

Few people would disagree that we live in an increasingly 'joined up' world, a joining up accelerated by the open principles of the internet. The dramatic growth in the volume and intelligence of data available from devices within the 'Internet of Things' is set to become the next big game changer facing both society and industry alike. CCTV, Automatic Number Plate Recognition, biometric security devices, most forms of retail transaction, drones, satellites, mobile aps; indeed an endless list of technologies, all capture some form of geospatial information.

If you accept that location is the DNA that runs through all data, if only on the basis that virtually every piece of data relates to something that is located somewhere, this relentless proliferation presents both huge challenges and significant opportunities to the GI Community in equal measure.

In terms of challenge, security and privacy loom large. Life changing decisions can be based upon an individual's geographic location; credit ratings, insurance eligibility and costs, access to health and social care resources, education. The often questionable security of geospatial information therefore brings its own particular set of risks.

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Setting aside the potential criminal misuse of such data, the increase in geo-tagging creates huge moral and ethical challenges. Who owns data gathered without or even with fully informed consent that tracks an individual's every movement, interaction and transaction? What should be the limits to its use? How can the individual's privacy be protected? All are vitally important questions to which answers need to be found, but they will not reverse the current inexorable tide.

So how will the GI industry look in five years' time? Well, transformation of the industry is about much more than simply rearranging the deck chairs. The transition to 'openness' and the relatively unfettered access to GI data will see the death of stovepipe IT and closed proprietary GIS systems that most people currently use. Open geo-standards based around the Open Geospatial Consortium (OGC) and the EU's INSPIRE Directive will become de rigueur and spatial services, not spatial systems, will prevail. Managing, conflating, authenticating and making sense of available data will become more important than its actual collection.

The proliferation of data will go on regardless of any intervention by the GI Industry, with crowd sourcing playing an increasingly important role. There are already sterling exemplars of crowd sourcing. Registers of Scotland populate its Crofting Register, a record of all the land in Scotland held in crofting tenure, based on maps created by individual crofters rather than any surveying or mapping professionals. In the marine environment, thousands of leisure craft are linking their GPS and Depth Sounding instruments to web based mapping systems, updating chart data that in many cases was last surveyed over 150 years ago.

The scope of such an approach is unlimited, with the greater network capacity provided by 4G and superfast broadband making real time data collection a reality, and Location Based Services increasingly becoming the norm. Indeed, the pace at which new technologies are developing is already in danger outstripping our ability to dream up new uses for it.

So for the GI Industry to reap the benefits of the geo data deluge we must work more intelligently and collaboratively, not simply pooling our collective knowledge but our collective minds, setting aside our individual vested commercial interests for the common good, creating a vision beyond what we are doing at present by unleashing the potential of our collective imaginations. For in the immortal words of Albert Einstein, *"The true sign of intelligence is not knowledge but imagination."*

On the broader world stage, the UK is already recognised as a world leader in recognising and exploiting the knowledge economy. As a founder member of the D5 group of nations, the UK is actively engaged in addressing on a global scale issues as diverse as the impact of technology on economic growth, improving internet connectivity and teaching young people to code. The GI Industry needs to be an active and valued contributor to this.

Of course, this increasing leadership role is not simply an opportunistic response to the emerging data challenges. It is now over 25 years since the AGI became one of the very first associations to form around GI internationally, a pedigree that makes the UK a natural global leader in the development of world class digital and GIS skills.

However, whilst we may have been first out of the blocks in global digital leadership, maintaining that position requires a coherent approach that brings together Industry, Universities, Schools and Colleges in a seamless and coordinated assault on the growing digital skills gap. The transition to a digital, knowledge based economy will stall unless this is seen as a priority, with STEM subjects forming the very core of all curricula content, cradle to grave.

So how can the GI Community possibly deal with all of this? Well the short answer is that operating in isolation it can't; the reality is that this explosion of spatial information means that GIS is no longer a niche area of activity.

To thrive and achieve its full future potential, the GI Community must embrace openness in the broadest sense; open standards; open data, open systems; open architectures and open and collaborative business models. Greater freedom and movement of geospatial data, powered by open software will in turn create 'richer pictures', enable better analysis and insights and create greater value for the industry as a whole.

As a member of the 'glass half full' camp I remain hugely optimistic about the future of our industry. As Chairman of an SME already espousing the open movement and collaborative working as standard features of our business model, I feel reassured every day that our industry is indeed Open to an extremely bright future.

About Informed Solutions

Informed Solutions is a leading global independent provider of GIS, Geospatial, Digital Transformation and Systems Integration Services. We are highly trusted suppliers to Public and Private sectors, taking pride in our reputation for the timely delivery of high performing solutions to complex business and safety critical problems, particularly where place, location or geography are important. Europe's leading independent GIS consultancy, we have been providing services in some 40 countries for over 20 years. With our UK headquarters in Manchester, Informed also has offices in London, Sydney and Melbourne.

The author is also a past Chairman of the Association of Geographic Information.

DR J S ALDERSON

Chairman
Informed Solutions

Key Points

- The unprecedented proliferation of geospatial data means that the GI Community must do things differently to thrive
- GI is no longer a niche area of activity
- The GI Community must embrace 'Openness' in its broadest sense
- Collaboration is key to maximising the potential of the GI Community in this new world order

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Citizen Science and Geographic Information

Tom August & Helen Roy | Centre for Ecology and Hydrology

Citizen science is a relatively new term for the involvement of volunteers in science but volunteers have made contributions to science through sharing their observations of the natural world for centuries. There is a particularly rich legacy of the involvement in volunteers in astronomy and wildlife recording. Indeed the UK has datasets on the distribution of many species, so called "biological records", that span centuries. These inspiring datasets have been instrumental in documenting the effects of environmental change on the spatial patterns of many species over time. Volunteer observations have not only advanced scientific understanding but have informed policy, conservation action and much more. New technologies are providing opportunities to extend citizen science in new directions through the development of different approaches. This is not just the case for data gathering but also for sharing information through innovative analysis and visualisation of results.

The diversity of approaches to citizen science have been consolidated into three main types:

1. Contributory projects – designed by professional scientists; members of the public primarily contribute data
2. Collaborative projects - designed by professional scientists; members of the public contribute data and inform the way in which the questions are addressed, analyze data and disseminate findings
3. Co-created projects - designed by professional scientists and members of the public working together and for which some of the volunteer participants are involved in most or all steps of the scientific process

An additional fourth approach should also be considered in which members of the public work together on all stages of the project without involvement of professional scientists. As an example, this has been the case for the production of wildlife atlases in Britain.

The majority of biological records or wildlife occurrence datasets have been produced in the past 50 years with an escalation in availability of data in recent years in part a consequence of the availability of tools to aid recording. The best example of the latter are smartphones. Having camera, GPS and connection to the internet these are perfect tools for enabling members of the public to record observations of the natural world (**figure 1**).

These volunteers are often called 'citizen scientists' for which numerous definitions have been given. Perhaps the exact definition is not as important as the understanding that citizen scientists are diverse, ranging from unskilled to expert and nature lovers to technophiles.

This data generation has for the most part been a bottom-up process driven by people's natural curiosity for the world around them. However there are now top-down pressures that are influencing data collection. For example the data needed to report on the state of the environment in the UK would be very difficult and costly to gather using professionals alone. This has resulted in a greater appreciation and demand for citizen science collected data.

There are a number of challenges when using geographical information collected by volunteers. There are typically a number of biases in the data which can impede analyses. The most frequent biases in biological records datasets are biases in space (records are much more abundant in the south of the UK for example) and time (there are many more records for most species groups in the late 1900s than the early 1900s). However there may also be differences in skill between volunteers, some may record a complete checklist of species and others only a few charismatic species from within a broad taxonomic group. Additionally the amount of effort in respect of looking for wildlife can vary between volunteers or even visits by the same volunteer on different days.

Thanks to digital photography there is an easy way to ensure quality of identifications for many groups. Images are sometimes submitted alongside records of wildlife observations and these can then be reviewed by expert naturalists (http://www.brc.ac.uk/irecord/) or other members of the community (http://www.ispotnature.org/) to ensure a consensus is reached on the species identification. For many species it is impossible to resolve the exact identification from a photograph but voucher specimens can then be checked. In these examples we rely on humans 'verification' of an observation made by a citizen scientist but in some instances this can be automated. For example, smartphone apps are available that will provide identification for bird song or bat echolocation calls or grasshopper and cricket stridulation. Some citizen science projects involve the volunteer as a sensor, for example using a smartphone to measure ozone. These approaches reduce individual bias but are clearly limited to phenomena that can be quantified by a sensor.

In the world of biological recording a large proportion of data collected by citizen scientists is shared through the National Biodiversity Network Gateway, a data repository. This provides access to millions of records of wildlife and has a web based GIS platform that allows records to be visualised on a map and overlaid with other data such as habitat layers (**figure 2**). The current cutting edge technology in this area has been developed by the Atlas of Living Australia (www.ala.org.au, **figure 3**), which allows users to combine species occurrence data from numerous sources with a wide range of data layers and undertake analyses.

Citizen science has provided valuable data for over a hundred years and has proven key for understanding the state of the environment in the UK. Citizen science is also an important public engagement tool, sharing knowledge and understanding amongst members of the public.

Concerns over the quality of data that is produced by citizen science projects have been addressed using both automated and supervised quality assurance as well as sophisticated analyses that model the biases in the data collected.

The increasing use of technologies in biological recording and in our everyday lives is going to increase the volume and diversity of data and data types that are available for analysis. This is going to further boost the potential of citizen science and we should be prepared to seize the opportunities and tackle the challenges that this presents.

Key Points

1. Citizen science is an approach that combines excellent engagement and real science.
2. Citizen science provides exciting opportunities for gathering large-scale (and long-term) datasets but it should not be considered as cost free.
3. Citizen science datasets can be considered high quality. There are many ways that can ensure the data gathered is of known quality from the provision of effective resources and training through to data checking by experts or automated systems.
4. Feedback is critical to the success of a citizen science initiative but can be time-consuming particularly for mass participation projects.
5. Collaborative approaches to citizen science enable everyone to be involved at every stage of the scientific process.

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Roy, H.E., Pocock, M.J.O., Preston, C.D., Roy, D.B., Savage, J., Tweddle, J.C., Robinson, L.D (2012) Understanding citizen science and environmental monitoring: final report on behalf of UK Environmental Observation Framework. Wallingford, NERC/Centre for Ecology & Hydrology, 173pp.

Figure 1 – There are many apps available for free that allow users to submit geolocated records about the natural world around them (www.brc.ac.uk/apps). Thanks to Karolis Kazlauskis for use of this image.

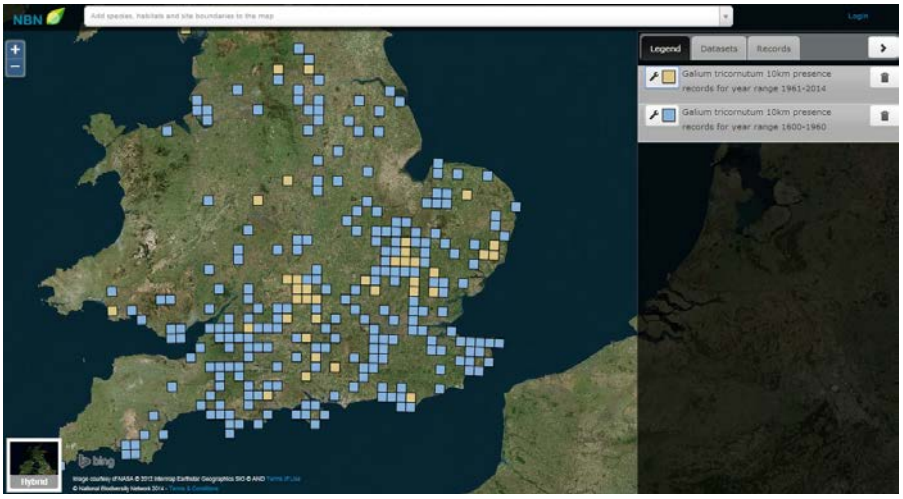

Figure 2 - The NBN gateway offers an online GIS system for exploring and downloading over 110 million wildlife records from the UK.

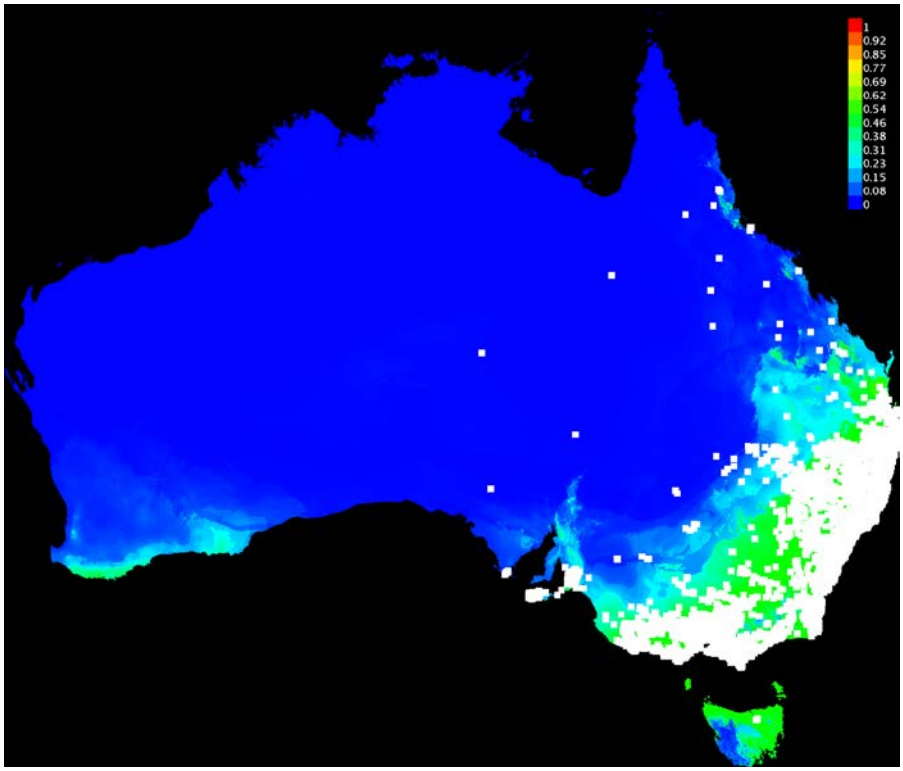

Figure 3 - The Atlas of Living Austrlia (www.ala.org.au) can be used to model species distributions from publically available data. Here is a simple model of Koala distribution (blue to red) created from occurrence data (white squares) and environmental data layers.

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

AGI Foresight Study to look ahead over the next 5 – 10 years

Stephen Booth | Editor and Publisher, PV Publications

"The state of the geospatial industry – what the potential, and the challenges are – and what we should be doing about it. I'd envisage in particular you would be challenging around open standards, BIM, survey and future cities – but the choice is yours! The more controversial the better!"

From editor Anne Kemp

"It's crystal ball time again folks. Let's start by asking a fundamental question: does Britain get "geospatial"? Three statements ring out. Last November when GIS Professional interviewed **Vanessa Lawrence** at GeoCommunity 2014 we asked her how many world leaders really get what geospatial is about. She thought 70 – 100. Speaking at the same event, the UK government's chief scientific adviser Sir **Mark Walport**, assured the conference that "geospatial data underpins just about everything government does".

Both are encouraging statements. But meanwhile, five years ago GiSPro interviewed **Mike Segal**, director of the Department for the Environment, Food & Rural Affairs strategy and evidence group and chair of the Location Council. Interestingly, he said: "My role in Defra is to promote data-sharing across this whole network. Not all of the relevant datasets are location-based but location is fundamental to many of them. I don't believe, in this context, that 'spatial is special'". The latter statement, that "geospatial is not special" should sound a warning for us all in AGI and the wider geospatial community of professional institutions and trade bodies.

Segal's statement is a reminder that we should not assume that those we serve understand the subtleties of position and location, or the difference between accuracy and relative accuracy. We have constantly to ensure that those in government and industry understand the limitations of geospatial technologies; that mapping from Ordnance Survey or Google is neither infallible or always very accurate. Positioning and location technologies are about fitness for purpose; yes, they will continue to improve and offer better accuracies (the European Galileo satellite constellation should finally come on stream by 2020) but we will be dealing with legacy data for a long time to come as well as having to explain the difference between postcodes, OS grid references based on OSGB36 and satellite positioning based on WGS84.

Challenges

The 21st century is proving every bit as trying for human beings as the 20th century was. Those of us in geospatial, whilst we can't solve many of these big problems we can provide the hard geographical information for evidence-based policy and decisions (alas there are too many in government who do not follow this approach but that's another story). Providing robust data with provenance is what geospatial is about. Alas, not all vendors or end users of data capture equipment understand this.

Younger generations are very savvy with IT, used to using social media and appear to have no problems in adopting quickly a new device, media, software etc. Will that change as they get older? The author for instance cites that the only new technology he had to get to grips with in the first ten years of his career was the pocket calculator, a device which in a very few years eliminated thousand of routine calculating jobs and left millions of pounds worth of mechanical calculators on the scrapheap. Since the pace of new technology and its adoption has quickened, like Moore's Law for processing power, I wonder if we humans are really equipped for this rapid evolution; our backs often tell us we should have stayed in the trees while our brains enjoy the simple daily routines that have evolved since the agricultural revolution that replaced hunter gathering. A truly fascinating read on this is provided by **Yuval Harari**'s *Sapiens: A Brief History of Humankind*. He argues that we have gone through three revolutions: the cognitive, agricultural, the scientific & industrial; and we are about to embark on the fourth: the biotechnological revolution. I could hardly put it down.

Impact Of BIM

Described by some as "a GIS for building", interest and adoption of Building Information Management (sometimes modelling) has been growing for at least ten years, driven by 3D design software and governments eager to deliver cost savings on large construction projects, which too often are not delivered on time or to budget.

But is the potential of BIM really understood? For it to work and the maximum benefits gained, participants in the process must use software that can freely exchange data and work interoperably with other players. Ambiguity over language and how things are described can cause problems. A recent lecture heard that even something as deceptively simple as a polygon is described differently in CAD software.*

There are many hindrances to the wide adoption of BIM. Writing in *Geomatics World* (September/October 2015), **Stephen Ward** of the Faculty of Science, Technology & Mathematics, Coleg y Cymoedd, South Wales, reported that there is "a severe lack of pre-defined components that could be downloaded into the model." In the same article Ward sees opportunities for surveyors by becoming BIM consultants. The focus should be on BIM as-builts says chartered surveyor **Richard Groom**.

If the implementation is successful in construction and really does bring about a cultural change amongst the traditional squabbling participants in a construction project – architects, engineers, surveyors, contractors, subcontractors, suppliers, etc – to work in a more collaborative way, there will certainly be lessons there for other large projects such as defence or IT. It may lead government to demand a similar approach but perhaps only where several major suppliers and contractors are involved.

Like the early days of GIS it is too easy to underestimate the cost of getting adequate, accurate and reliable data into BIM. Can the cost benefit be demonstrated? It may take a substantial number of projects and many years to answer this question. As several people have argued, including the author, the benefits of BIM can only come after the facility is finished and in future years as new owners or operators decide to change features.

*The language problem bedevils our business sector. Writing in the August issue of GiSPro former AGI director general Chris Holcroft says it's all about effective communication and we should forget the "GIS Dictionary". It's a similar situation for geomatics, a term embraced by RICS more than a decade ago, following the use of the term in academia in Canada since the early nineties as a way of attracting students into what had hitherto been called land surveying. Visiting Canada recently Richard Groom reports that he met an electronics engineer who does 'geomatics'! This person considered land surveying to be an obsolete term and definitely not related to what he does. Interestingly, the latest edition of Geographical Information Science & Systems (to be reviewed in the October 2015 issue of GiSPro) does not mention the word geomatics.

INSPIRE & extra national networks

National politics plays an inevitable role here. If Britain for instance was to leave the EU, would we would pay much attention to INSPIRE? Not if the Daily Mail has anything to do with it! Nevertheless, Britain would be likely to remain in membership of many pan European organisations and would be unlikely to isolate itself from all European contacts for mapping and geodesy (notwithstanding an annual average 2cm geodetical drift away from Europe!). Interestingly, General Roy maintained our scientific contacts with the French during the Napoleonic wars, as both sides surveyors remained focused on measuring the earth.

Despite whatever changes may occur in political relationships, demand from business for commercially-produced pan-European and global datasets will grow. Business remember, if it has invested money and time in setting up systems, ultimately prefers the status quo.

Technology

Surveyors today have a continually evolving range of high accuracy remote sensing tools, whether terrestrial (laser scanners) or airborne/spaceborne (LiDAR, imaging, multi-spectral, etc). These devices are increasingly internet aware through their own IP address – they are becoming part of what has been described as "the Internet of things".

The danger with many of these devices is that the vendors often promote them as simple to use, encouraging organisations to give them to barely trained (and often underpaid) personnel. Trial and error is not a good strategy for using surveying equipment, especially GNSS and laser scanners.

Remotely sensed data – from space or terrestrial platforms, dynamic or static, is bound to continue to grow in significance. Accuracies will improve and costs will continue to fall as more platforms are launched and new players enter the market.

Whether data is captured from space, the air or terrestrial devices, digital photogrammetry is now an underpinning geospatial technology. It is likely to be used increasingly with LiDAR, which can see through tree cover to give bald earth terrain models. This is likely to continue the downward push on costs.

During the next 5-10 years UAVs / UAS is a technology that's bound to mature as a platform for a range of ever smaller (and more accurate) sensors, including LiDAR. Guided by updated GNSS, data capture will become very cheap, but again end users will need to understand the limitations, accuracy and provenance.

Here is a personal question: is there a problem with the larger IT suppliers who are swimming (some drowning) in billions of dollars of surplus cash, which they are using to pursue all sorts of research projects as well as acquiring start-ups that they foresee as potentially profitable? Some of this technology has profound implications for humanity, eg Google glasses, robotic vehicles, data mining, etc. Human institutions (i.e. governments) are losing control of this agenda and can only respond (usually weakly) when things go awry. With the turnover of several of these companies equivalent to that a small country's GDP, these are worrying times for those who care about democracy. Interviewed in *The Observer* [http://www.theguardian.com/technology/2015/aug/30/kentaro-toyama-geek-heresy-interview-technology] Kentaro Toyama, author of *Geek Heresy* and a professor at MIT, observes, "The current way corporations work is that, as long as they're not breaking specific laws, they can almost do as they please with the money they accumulate.

But increasingly we're in a world where a few powerful corporations have tremendous influence over the lives of billions of people and not all of that is accountable to the public in any way, shape or form." Do we want government by Google?

For GIS professionals we can expect open source software to offer cheaper possibilities than the traditional OEM suppliers but that may be something of a false dawn as we move into the cloud and pay-as-you-go software grows, already there with ArcGIS online and heralded to begin next year with Autodesk.

For communication and processing technologies, things will continue to get easier as the mobile phone network is strengthened and new technologies like mesh radio and grid computing become available.

Computing

Geospatial is very much part of ICT. Whether Moore's Law will continue to hold sway is probably less important as we move into the age of cloud computing for both processing and storage. Software vendors will be keen to move us all to a pay-as-you-go model. For those who don't maintain their software, this will be expensive. The question arises, will users still want to retain their files locally? Large organisations almost certainly will want to be very careful about where their data is stored and backed up. Smaller organisations will need to think this through carefully.

The evolution of devices will continue. Challenges remain over the ease of use of interfaces (you can do it all on your phone but do you want to?) and the intuitiveness of software, which continues to be blighted by ambiguity of language and interoperability (see the Impact of BIM above), will improve. As yet, there are no devices that can be used to replace print under all circumstances.

Kindles and e-readers have proved very popular, especially for holiday reading but recent studies have shown that our brains retain less when we read on screen compared to the printed page. A good read on this topic is Naomi S Baron's *Words Onscreen: The Fate of Reading in a Digital World*.

Business

For geomatics, the business is likely to continue to move towards practitioners becoming part of much larger engineering and infrastructure design and management organisations. The days of true SMEs in this sector maybe limited. To set up a small company, say aiming for a turnover of £1 million, is costly for self-starting entrepreneurs. Specialist H&S, financial, HR and facilities management personnel are needed to meet legislation. Unless you can find a wealthy backer the choice increasingly is stay an employee or become a self employed consultant. The future therefore may well favour independent consultants as sole practitioners with specialist knowledge in areas like BIM, geodesy, GIS and land management.

Education

One of the encouraging signs in recent years in the geomatics space has been the improved collaboration between the leading industry bodies. The Royal Institution of Chartered Surveyors (RICS), the Chartered Institution of Civil Engineering Surveyors (CICES) and The Survey Association (TSA) are all working better today than in the past, with less competition and turf wars, despite the odd hiccup as narrower interests occasionally prevail.

The supply of good trained personnel is likely to ease for geospatial as the government's initiative and focus on apprenticeships grows. You don't need a degree to capture data or to understand the importance of the underlying geometry and geodetic systems; just good maths and natural curiosity.

The Survey Association has done sterling work in supporting a survey school in Worcester, which has produced over 300 technician graduates since its foundation.

GI is itself an area occupied by many non-geographers as the use of day-to-day GIS is within the capability of just about anyone. But there is the potential to build on this with more focused courses through web-delivered education and training. As fewer students are tempted to go to university and more apprenticeships become available this route could be a fertile one for organisations who rely on GI.

Mapping & Positioning

The arrival of Google Maps a decade ago began a change in how the world views mapping. Ordnance Survey in Britain has a constant battle to remind users that its topographic database of the country is constantly being updated because they employ teams of surveyors working locally, checking for new developments approved by local authority planning departments. Google does not do this and neither does OpenStreetMap, however laudable the latter is. Data captured on an ad hoc, one-time basis will never be adequate for many users. Neither will mapping derived from aerial imagery and digitised by people who have never seen the terrain they're working on.

There are other players in the mapping space too. Mobile phone operators need to offer mapping. It is extraordinary how satnavs have quickly become old technology, replaced by apps on phones. With the sale of their imagery interest by Microsoft to Uber, are we witnessing the start of tighter focusing on their core business by the big IT players?

There is also the prospect of driverless cars. *Writing in The Observer* newspaper (30 August 2015 - http://www.theguardian.com/commentisfree/2015/aug/30/self-driving-car-future-google-kpmg), after identifying the mobile phone and driverless cars as the two most significant technological developments of the last 20 years, John Naughton says, ". . . autonomous vehicles require digital mapping that is an order of magnitude more detailed than anything in Google. . ." He's on the money there and to achieve that will require a lot of effort by the geospatial and software communities, and especially in image recognition. Think temporary traffic lights and the many other transient features of our road network.

Conclusions

As someone observed, the best way to predict the future is to invent it yourself, and no one has done more in the geospatial field than Jack Dangermond, the founder of Esri. But as we move deeper into the technological age it becomes ever more difficult to see who or what the "future inventors" in geospatial might do or be. Perhaps it will be in the field of driverless cars; Google is going to need some competition!

The next 5 – 10 years will continue the technology rollercoaster ride that began around 40 years ago, indeed there is no sign that the pace will not quicken. There will be many unforeseen events and technology developments (Donald Rumsfeld's "unknown unknowns"). Governments and citizens are only now beginning to understand the consequences of free and open social media.

As publishers we find it horrifying that it is possible to provide an open, free, un-moderated, unedited platform where anybody can post whatever they like. We cannot do that in print publishing; the law is far more prescriptive. It is welcome that Facebook can act quickly and remove a post of a murderer's video of his killings. Nevertheless, many people still saw the post before it was removed. The internet and social media remain a digital wild west, which too many citizens have come thoughtlessly to enjoy while governments and security organisations see it as a great opportunity to gather data on us. We may need a new Faustian pact between government and social medium platform operators – we won't spy on you if you properly moderate postings before they're uploaded. As people don't seem able to exercise common sense, this may well depend on better software that automatically detects foul language, pornography and violence before it appears online. However, as someone observed recently, 'sense, alas, is not common'.

For users of geospatial information basic data will continue to fall in cost, become easier to gather and be more timely. Opportunities, driven by big data and smart cities, will expand as more branches of government, both local and national realise what is now possible. We will also come under increased pressure to protect people's data in a world where increasingly it will be ever easier to identify individuals through ever better data granularity. A phrase that's starting to pop up is "democratisation of data". Now I think I know what this means in connection with the consumer market but geospatial? Who knows?

It is reported that the World Bank, which has backed much technology development around the world, there is a view that technology only addresses 10% of problems. The remaining 90% are human issues. I can only concur with Kenitaro Touama's comment, "The only conclusion I could come to is that technology is secondary – ultimately the people and the institutions matter the most."

So, will there be good opportunities in the years ahead for geospatial professionals? You betcha!

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Why the GIS Industry needs a Transformation if Location Information is to become Truly Indispensable to Enterprise

James Brayshaw | Pitney Bowes

We're at a pivotal point in the world of GIS. Whilst not quite poised on the brink of global domination, there is no doubt that the 'where?' of data is becoming increasingly important in the enterprise world. Public and private sector organisations are using Geographic Information Systems to generate intelligence and drive insight, adding depth and credibility to data. Location intelligence tools are reaching a new level of smart as they cleverly detect patterns, trends, risks and opportunities that are unseen to the human eye. But is the reputation of the GIS world restricting the use of location intelligence across organisations? There's more to LI than maps, says James Brayshaw from Pitney Bowes, as he lays down the gauntlet to the GIS industry. It's all about the data, what you do with it and what outcomes you can provide that counts.

The Inner Sanctum of GIS

Businesses are looking to enhance the customer experience by using location intelligence software at an enterprise level to tap into the rich mine of data available across their business, to add context, precision and accuracy to the information they generate and the relationships they foster. Organisations are beginning to use location intelligence to help them identify newer, smarter ways of reducing costs, increasing revenues and getting closer to their customers. This outcomes driven approach is the way foteard. Now may be the time for the industry to take a quick reality check.

Historically, the GIS world has been an exclusive inner circle populated by razor-sharp minds, technical expertise and scientific intellect. Detailed visualisations, complex statistics and a host of acronyms understood only by GIS professionals have added to its exclusivity. All this is fine, but the danger created by this exclusivity is that the industry is at risk of becoming blinkered to opportunity, or of reaching saturation point. Location intelligence has the power to become the most transformative type of information generated by a business. It can – indeed, should - become absolutely critical, the foundation on which business decisions are made. But if this is to happen, we need to open up the industry and make it more accessible, better understood and less exclusive.

To enable location intelligence to reach its full potential, we need to remove the shroud of secrecy that surrounds the inner sanctum of GIS. I'm not talking about dumbing down, or location intelligence 'going mainstream'. One could argue that this is already happening, as we have a huge diversity of location-based information at our fingertips, from mapping our every move using fitbands, to monitoring real-time traffic information on our smartphones. I'm talking about unleashing the potential of spatial insight so that it becomes an asset to an organisation, improving the customer or citizen experience, adding value and driving revenue.

Everyone is a member of the IT department

The digital revolution has led everyone to become, we all feel, technology experts in our own right. This is reflected in the enterprise, too, as IT devolves and becomes decentralised. Whilst there is still an IT leader and core IT function in most businesses, IT management and purchasing is going on across the organisation. Shadow IT is very much a reality, as teams and departments select software, tools and applications themselves which will drive productivity in their own specialist areas. They eliminate IT from the buying process. Indeed, research shows that Shadow IT is expected to grow this year by 20%[1].

Likewise, data, and data-driven insights, are no longer confined to the IT department. Everyone within an organisation is a data guardian: each person generates and manages data, some more so than others. Marketing teams, for example, have had to develop new skills as analytics demonstrate the success of every campaign. Few positions in commerce do not demand some kind of analytical or data management skill.

Data is a modus operandi

With data and its management becoming prolific, it is no longer just an asset but is a 'modus operandi' for businesses, says consultant Arent van't Spijker[2].

Data is becoming a commodity, as businesses trade information to drive an improved customer experience. Tom Goodwin, editor of TechCrunch, illustrates our new data world perfectly. *"Uber, the world's largest taxi company, owns no vehicles,"* he says. *"Facebook, the world's most popular media owner, creates no content. Alibaba, the most valuable retailer, has no inventory. And Airbnb, the world's largest accommodation provider, owns no real estate"*[3].

Asset-heavy organisations are regrouping to consider how they can add value using customer data.

Spatial information has a critical part to play here. Providing a sense of place is extremely powerful: as humans, we gain comfort from knowing our place and position in the world. Our environment is dynamic and fluid, not static, so integrating information on movement and whereabouts should become second nature to our businesses.

Some organisations are already using spatial data to derive insights and improve the customer experience. Telecoms companies and mobile operators are using radio frequency data to identify areas with the strongest and weakest signals, helping them with capacity planning, product development, customer services management and marketing. Retailers are using it to draw insights about populations in a particular geography, driving investments and minimising risk when opening new stores. Banks are using location information to pinpoint particular demographics in specific geographic areas.

But for location intelligence to take pride of place in the data age, the GIS industry needs a reputation overhaul.

How we can drive adoption and understanding

In order for LI to reach its full potential, we, as GIS professionals, must challenge ourselves.

1. We need to educate our audiences that location intelligence is about data, not just maps, and this data can uncover truths which can actually form a key strategic part of a business model
2. Thinking again about the expression 'big data': data, by its very nature, is huge and we're generating more and more of it, in our connected world. 90% of data in the world today has been generated in the past two years[4]; data is big, but it's time for a rethink – it's the ability to derive insight and outcomes from our data that matters here
3. We must break down the exclusivity of the GIS world, and talk about spatial data in a clear, simplified way focusing on its ability to drive customer engagement and generate revenue, rather than baffling with science, acronyms and complex mapping data
4. Rather than getting bogged down in the volume of data, and in Data Lakes, we need to emphasis the importance of the ability to extract precise, accurate and valuable insights from data – from the mass, we can extricate the detail
5. These insights must be actionable: there's no point having access to reams of data, spatial or otherwise, unless businesses are able to use this to drive decision-making, inspire product design, enhance services or generate revenue
6. We need to ensure spatial data is clean, structured and housed on platforms which have built-in flexibility

7. We need to be able to integrate data sets to identify where they sit in context, and in relation to one another; Arent van 't Spijker[5] quotes the example of DHL, which sells data on the environment to organisations seeking information on pollution levels in urban areas
8. We should share industry examples of best practice, emphasising how customers and citizens are actually benefiting from spatial data in everyday life

Technology and the transformation it enables should be inclusive, not divisive, and it's up to us to drive this change.

Location Intelligence in Practice

Torfaen County Borough Council in Wales implemented a location intelligence and data management platform to help drive its transformation. The 'software as a service', cloud-based approach generated significant cost savings. The data also enabled improved citizen services and citizen engagement across the borough through new web mapping services. Local citizens can now visit the council website and use the mapping system to find out information specific to their exact location on topics such as refuse collections, school catchment areas, local nature reserves and nearest leisure activities. It enriches the website, reduces pressure on the council's service support team and improves the citizen experience.

Domino's Pizza uses location intelligence to drive improved business decisions. As the Domino's brand grows, managing franchise territories had become more complex and the risk of inadvertently creating territory conflict had escalated. The business now uses extensive, certified address validation technology. It also uses current street information from a validated source. The ability to keep up to date with any new builds, demolitions and changes to building use on a quarterly basis allows more targeted communications, saving money on wasted direct marketing to addresses that no longer exist, improving the ordering experience and increasing internal productivity.

Peugeot Citroen, Europe's second largest auto manufacturer, wanted to optimise sales forecasting; to provide insights on best performing dealers; and to increase response on fleet orders. Using location intelligence enabled the business to improve the accuracy of drive time estimates; to gain a realistic view of revenue potential; and to learn more about traffic patterns and road conditions.

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[3] TechCrunch, March 3rd 2015, "The battle is for the customer interface"

[4] Source: IBM

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You can't Design for Everyone: Exploring the Implications of Unleashing Ubiquitous GIS Technologies

Michael Brown | Horizon Digital Economy Research and University of Nottingham

This document explores the challenges that will face the GIS community as our technology, techniques, services and products continue their relentless move towards ubiquity. User Centred Design is presented as part of the solution in getting to grips with open, accessible technologies, and complex, precise tools.

Problem / Opportunity Statement

The nature of user interaction with Geographic Information is changing, the boundaries between those who collect, process and consume GI have already become blurred. Movements such as Volunteered Geographic Information (VGI), Citizen Science, Crowd Sourcing and the Internet of Things, supported by the ubiquity of powerful sensor laden smart devices mean that swathes of the general population are now both willing and able to generate, fuse, analyses and share GI. Add to this the upsurge in cloud computing to empower even hobbyists to manage and process large complex data sets and the recent emergence of affordable virtual reality systems for the visualization of data. This all means that GIS is becoming a tool that everyone can and is engaging with.

So, great news all round? Only if we as a discipline are prepared for the myriad of issues that this change will bring with it. We need only look at other technologies that have made the transition from specialist domains to being widely available, to highlight some of the issues that lie ahead, such as:

- **Oh, I can do that.**
  One of the issues that many 'accessible' professions suffer from is a diminished respect and value for expertise. You need only look at web design to find a cautionary tale of a how highly skilled individuals struggle to find careers or support as the black boxes and mystery of designing web sites are torn down by open design platforms such as Word Press

- **Adrift in a Sea of Indifference.**
  A related issue is that as more and more of the process and technologies that GIS professionals hold dear become widely used, finding the best tools, data sources and even talent becomes orders of magnitudes harder

- **Too much data.**
  As the internet of things, smart devices and even low costs earth observation drones come to be common place, GIS has to deal with two massive issues facing all aspects of data science. Data set are growing faster than our ability to handle them using traditional methods and the number of sources of relevant data is growing exponentially often in silos built for nigh impenetrable bespoke information architecture

- **You can't design for everyone.**
  One of the most obvious and inevitable challenges ahead is working out how to design systems, software, services and even data for the ever growing group of stakeholders involved in the GIS discipline. No long can you assume GIS hardware, software, data and services will be consumed by a small group of knowledgeable and experienced individuals. Working in this space is no mean feat as you have to balance the simplicity, openness and accessibility needed by less specialist users with the powerful and often complex utility that will help you stand out from the crowd

As an expert in User Centered Design (UCD) the rest of this paper will focus on this last issue, how can GIS systems, services and technologies marry the often clashing goals of being open and accessible with the focus and precision required to deliver efficient and effective solutions to specific problems that face the world today?

History

Over the last 50 years software designers have slowly and painfully learnt the lesson that as computers have become ubiquitous you simply can't create software that is 'easy to use' for everyone that could come in contact with it. In the early years the only people who were likely to operate computers were those who had built them and had an intimate knowledge of every quirk and flaw. Initially, as more and more expert began using then, software documentation became important for communicating the various eccentricities of each programme. As the group of users expanded further the focus shifted from documentation to 'user friendliness', basically developing programs that anyone could use without any documentation. This mindset definitely improved things but once computers started penetrating every home it became clear that only the most simplistic of programs can be designed with every possible user in mind. It was out of this dilemma that the concept of usability was born, the concept of designing software so that specific groups of users could perform specific actions efficiently, effectively and with satisfaction. The key thing to note is that while 'user friendliness' was seen as an intrinsic quality possessed by a technology, 'usability' is subjective and highly dependent on the context of use.

GIS is following the same path. GNSS integration into smartphones, free at point of use mapping services such as Open Street Map and Google Maps, open source GI software such as QGIS and an explosion in GI based apps have all been significant landmarks on the journey from highly specialized niche domain to ubiquitous systems and services. If events like the dot com bubble have taught us anything it is that in this shifting landscape giants will fall and new market leaders will rise, and the key to surviving will be delivering services and systems that deliver not just functionality but usability and great user experience.

The Solution

The solution sounds easy but is not a trivial feat: placing users at the center the design process. The trick is doing it efficiently, effectively and in an appropriate manner. We, as a discipline, need to develop not only the tools but also accept as best practice ways for letting the needs of users drive the development of services, software, hardware and even data sets. In some cases simply adapting proven methods from Human Factors and Human Computer Interaction will be sufficient, but many of the issues that GIS will face in the communing years have not been addressed satisfactorily in any domain.

While some research and industrial experts are beginning to see the value of User Centered Design[1], it is still see as a specialist subject and far from common practice. In my opinion User Centered Design should for a part of the essential education expected for an expert working in GIS. If you're product/process/analysis/data has users, you should know about UCD. And if no one is using it are you clear what you are hoping to achieve?

For this to happen we need to swallow our pride and realize that we (as GIS specialists) no longer represent the typical user of many the technologies we develop, so we need to accept that we are no longer the authority on how they will be used. Therefore, we need to ask the users!

The Benefits

The financial benefits of adopting a UCD approach have been well documented in other domains[2], with plenty of evidence for the high return on investment gained from User Centered Design activities. However, work still needs to be done to explore what methods are most valuable and useful in the various aspects of GIS working.

Beyond simple profit-loss calculations adopting UCD as a discipline will help GIS reach and benefit the most people for the most good. Projects such as The Taarifa Platform[3] (an open source web API, designed to consolidate citizen inputs alongside more a more formal GIS infrastructure) is a good example of the type of collaboration that enhances data and delivers benefits.

The key is to set out the business case – what do you want your audience to do after consuming your white paper? Is it to find a solution? Change a way of working?

Call to Action

On a personal level it's easy to start this process, just ask some people outside your organization what they think about your current project. It's not a rigorous method that I'd suggest implementing at an organizational level, but some brief informal feedback is often enough to highlight how much user insights can add to a process. Then you can start reading around UCD, the methods, the philosophy and how you can get involved.

The organizational change required to adopt this approach is not trivial, evangelists are needed to sow the seeds of change. We need more case studies showing the value that User Centered Design to show how much business sense it makes to invest these approaches.

Professional bodies such as the AGI need to play a central role in this movement, collating case studies, developing standards and informing best practice. Without visibly and universally accessible resources every institution will have to re-invent the wheel, developing and testing what others have done before.

About your Company

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BIM for the Sub-surface: Challenges

Jérôme Chamfray, David J Wright, Simon Miles | Atkins **Gary Morin, Carl Gricen** | Keynetix **Holger Kessler** | BGS

Most existing BIM 3D models show the ground as a grey amorphous mass, if it is shown at all. The ground is inherently more variable than other construction materials and, in an integrated multi-disciplinary BIM project, it is important that this can be appropriately conveyed in order to avoid poor decision making.

Currently, most software capable of modelling the sub-surface is not designed to facilitate multi-organisation collaboration without separate transfer of significant associated information. Spatial models and information interpreted from factual data cannot readily be transferred in a manner that can easily be reused & modelled. Consequently, information is often utilised in isolation and transfer between different stages in the project lifecycle can be complex. For the same reason, there are also no simple solutions for distributing & updating national geotechnical data for both factual & interpreted info. The BIM for the Sub-surface project focuses on improving data accessibility & subsurface conceptualisation (realised by geologist-driven collaborative geological modelling). The project will allow geologists & engineers to share confidential interpretations securely or contribute their non-confidential interpretations to the national archive & geological model.

This requires significant work to implement complex databases, version control systems, standardised data formats, data validation rules & seamless connection to BGS databases & the cloud.

Some of the technical challenges are to specify standards for transferring interpreted data; storing managing & versioning spatial data; creating a simple to use 3D modelling interface; creating & ensuring a cloud-based solution with the right levels of performance & security; creating sophisticated user interface tools on a lightweight web interface; developing the required rest API services to give enough interoperability; creating robust & flexible validation tools.

In order to achieve this, we will need to make sure that we can clearly and easily convey temporal changes and uncertainty, inherent when modelling the ground, within a BIM environment. For example, we may want to model a surface showing the level at which rock may be encountered differently depending on the purpose of the model. We may choose different levels at the same location when assessing this for excavatability and for foundation design.

Uncertainty is also inherent in the model, and will vary depending a number of factors such as the distance from the nearest exploratory hole available to support the interpretation, and the nature of the data available.

An associated challenge is to transfer this inpterpretation (i.e. the model and associated meta-data) to other parties. IFC format is widely used within the industry for exchanging 3D solid entities and metadata, but is mainly applied to the building environment. Exporting geolocical 3D triangulated or mesh surfaces to this format has yet to be done. One possibility would be to convert the AGS format to an AGS/IFC XML format that would also include surfaces and sections in order to convey this information. The AGS format is a well recognised industry-standard exchange format that provides a means of transferring geotechnical and geoenvironmental data between parties, and the AGS data management commitee is currently looking at this possibility.

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GI in Retail

Audun Clark | Tesco

"Greater granularity in customer information and segmentation, enabled by embedded geodata elements, will allow for wild and exciting interpretations and analyses of the customer profiles, matching movement to will, location to desire and helping to model every expectation of every customer in a dynamically, visually representable way"

Audun Clark AGI Foresight 2015

It is remarkable that the basic direction of my foresight written back in 2010 is still as relevant today as it has been over the last 5 years. What has changed is the profusion of data points, self-inflicted geo-tagging and the uptake of geographically sensitive retail marketing messages.

Mobile and Marketing

Customers are increasingly using mobile apps and mobile native transactional websites to not only enrich their in-store experience, but more importantly to complete their purchases – either for Click and Collect or delivery later that day (**figure 1**). Mintel's report on m-commerce in 2014 reckoned that mobile transactions could double in the next 5 years[1] and as of 2015 40% of online purchases in the UK are now made on mobile devices with about 62% of people in the UK owning a smartphone (*these numbers will doubtless seem absurd in 5 years*)[2].

Most retailers are now clear that smartphones and tablets are the future of customer digital interaction, be that in-store or at home. The really canny ones have realised that, as the customer makes no distinction between online and offline, then they need to provide a seamless experience – the true dream of omni-channel.

The geographical value to be added to this big data, personalisation, marketing mash-up comes in a variety of forms, including (but not limited to):

- Push notifications for offers in your (geographically located) local store
- Dwell time in store – customer self mapping showing hot and cold spots of a store
- Transactional locations
  - what spurred the purchase?
  - when do customers add to basket?
  - when do they check out?
  - when do they drop their basket?
- Enriching the customer experience by alerting sales staff to their individual needs and tastes
- Completing an online purchase in store (and visa-versa)
- Resurrect an abandoned basket (the bane of retailers) through in store promotion

Some of this is already happening. Harris and Hoole has geo-fenced their stores so that you can (after opting in) order your 'usual' before you even enter the store and be greeted by the friendly barrista who not only knows your name and what you look like, but also how you like your soya double-dipped iced double espresso (or what we used to call – coffee)[3].

We will increasingly see the realtime place-sensitive data mining of what have begun to be termed "code halos" (4) to provide emergent, personalised and appropriate marketing and retail messages to engaged consumers. Loyalty will no longer mean voucher through the door and a card to swipe – it will become your gateway to localised offers, limited edition runs and geo-fenced events tailored to you and your segment (**figure 2**).

The Geographical Intelligence will become integrated and entwined into everyday experiences and the increasingly granular understanding of customer activities and acquisitions.

Location and Big Data

One of the large impediments to the useful application Big Data insights is the disparate nature of that information. Even when the individual unique user can be identified the data usually resides in a wide variety of formats and data silos with no universal translator or key. Interoperability of these data is key to providing the holistic view of an individual (or even an aggregated segment of society) (**figure 3**).

"Location can be used as a universal key across disparate data"[5]

Now those in the GIS analysis game may laugh up their sleeves at the easy assumption of interoperable location data but increasingly the methods of location are becoming homogenised through the portal of smart phones and (projection issues aside) it's an awful lot easier to translate coordinate data than it is address or postcode - although there is superb work going on, especially across the social networks (Twitter, Instagram, Facebook) to geo-translate place name mentions against tweets, photography and sentiment. Portions of humanity are already surveilling themselves to an extent most despots dream about.

Customer insights

With the advent and increasing uptake of wearable technology we are able to gain very personal data in geo-located realtime. The potential insights available, given the right analysis and actions will enable retailers to curate a customer's entire shopping existence. The "Frictionless Retail Experience" becomes ever more possible as we understand more about a customer's route to retail.

In conclusion, the last 5 years have seen such changes that it is proud and vainglorious to try and determine an exact vision of 2020, but given the mega-trends already emerging I feel confident we will see Geographically Intelligent Retail as a key component of Customer Intelligence and that from the customer side there will be an effortless, imperceptible broaching of the digital/physical divide.

Key Points

Highlights to look forward to over the next 5 years:

1. Continuous tracking
2. Location recognition with modal opt in activations
3. Tracking of social proximity
4. Code halo coupled with location enabling richer and more complex CRM
5. True personalisation can arise - but will it?

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Figure 1 - Mobile and marketing

Figure 2 - www.cognizant.com

Figure 3 - Location and big data

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Statistics and Geospatial Information

Ian Coady | Office of National Statistics

Statistics play a vital role in the decision-making process and it is becoming increasingly important that policy making, the evaluation of performance and public debate are done on the basis of evidence. Government statisticians are increasingly relied upon to provide the data that is needed to direct the government's economic and commercial activities as well as for analysts, researchers and the public to hold the public sector to account.

Location is an increasingly important component of this statistical process as it is used for the capture of data, the production of statistical outputs and the analysis and interpretation of the data.

As well as within the UK, this is being increasingly recognised at the global level with initiatives such as the United Nations Committee of Experts on Global Geospatial Information Management (UNGGIM), European Commission INSPIRE Directive and Eurostat Task Force on the Integration of Statistics and Geospatial Information all seeking to harmonise the approach to the integration of statistical data and geospatial information at the European or global levels.

The largest component of this international work is the need to use address level information as the foundation for capturing statistics. Capturing statistics at a level such as address allows statistical organisations to produce statistics for any geography by plotting the address directly into a boundary based on its grid reference. There is therefore a need to have access to high quality national address registers that can be used for statistical sampling as well as national census projects. Within the UK this relationship between the census and the national address register has not yet been fully exploited and it is expected that the census process will have an increasing role to play in improving the capture and quality of national address registers.

As government organisations look for the production of more timely datasets, there is also a shift from traditional data capture techniques (surveys and census) to alternative data sources such as big data and administrative data. These new data sources represent a fantastic opportunity for statistical organisations to migrate their work towards data science but the geographic component is increasingly needed as a way of managing the quality of the data and extracting maximum value from it.

The address is needed as the linking mechanism that allows relationships between disparate datasets to be defined and explored. This creates new patterns within the data that have not previously been identified and there will be an increasing use of graph databases to store data and link through the address. New techniques and methodologies will create new disclosure risks for statistics and organisations will need to identify new techniques for protecting people's personal information. As well as the use of these techniques, there will also need to be some revision of the Code of Practice for Official Statistics to recognise the increasing role of geography in the statistical process. This could also potentially take the form of a new ethical code of practice based specifically around geographic information and the Association for Geographic Information, as well as the wider geospatial community, will need to consider the role it takes on in supporting the ethical use of geography.

Although administrative geographies such as local authorities, wards and parishes continue to be needed by users to support the interpretation and analysis of the data available, the previous decade has seen a shift towards 'statistical geographies' – geographies (Output Areas, Workplace Zones) built from the census data and designed to be small, stable and comparable. With an increasing reliance on administrative data for projects such as the census, it becomes increasingly difficult to continue to produce statistics on this basis. Even if the data does continue to allow statistical geographies to be built, the quality of the administrative data may not allow statistics to be produced at this sort of geographic granularity. Alternative dissemination methods will therefore need to be explored, and it seems likely that the use of grids for the production of official statistics will become increasingly prominent.

The regular shape and stability make them a useful building block for statistics though they do represent their own challenges in protecting personal data, but the key benefit to grids is that they are already widely used across Europe and pan-European grids such as 'GEOSTAT' make it easy to join and analyse statistical data at the European level.

Although the decennial census will continue to be the key driver behind the production of most official statistics, new policy initiatives will lead to the production of new datasets. The largest of these is likely to be the UN's Sustainable Development agenda. The 169 metrics used to measure the 17 goals will require the production of an entirely new range of statistical datasets. It is the UN's policy that "nobody gets left behind" however that will require an increasing amount of geospatial data to ensure that statistics can be aggregated or disaggregated to an appropriate level to support the Sustainable Development Goals (SDGs). There will also be an increasing use of satellite imagery to produce official statistics for the SDGs as it will be far easier to extract values such as land use or access to water sources from satellite imagery than traditional statistical techniques.

Methods of dissemination are likely to change over the next decade with statistical organisations moving away from bulk downloads of data towards a more service based approach to dissemination. More APIs and web mapping/feature services will allow the data to be exploited in a more dynamic way. Doing this will require statistical organisations to have a much greater understanding of both statistical and geographic standards and as well as seeing an increased use of technical standards to support the exchange of data, it is likely that the next decade will see work towards the integration of standards so that statistical standards such as SDMX and geographic standards such as GEMINI can be used in a harmonised way.

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Open Geospatial in 2020

Jo Cook | Astun Technology

Since the the earlier Foresight Study (2010), the term "open" has been adopted and used for a wide range of meanings beyond the core triumvirate of open source, open data and open standards. for good and bad. Furthermore, while the idea of "location" is more widely used than ever, due to the proliferation of mobile devices, the term "geospatial" remains fairly niche "industry generally recognizes the value of location, while the value of GIS is not as readily apparent"

CartoDB, Location, GIS, and Investors Bill Dollins Blog

This paper will look at trends in open source software, open standards and open data, but will also try and highlight some of the dangers ahead. Many thanks to my colleague Matt Walker for his insight and helpful comments, and thanks also to contributors from the Open Source Geospatial foundation who responded to my request for predictions.

Developments in Open Source GIS software

A combination of technical requirements and improvements in technology will push many people currently using desk-based GIS packages to using a web browser instead. Bandwidth improvements, mobile and home working, hot desking and increasing use of virtualisation technologies will move many applications to a web-based environment, negating the need for powerful desktop computers. Along with the old adage that 80% of people use only 20% of the functions of any given piece of software, this will push the development of web-based GIS.

All-in-one solutions for presentation, visualisation and analysis, such as CartoDB, will become increasingly compelling for those who wish to build web-based maps with little or no technical knowhow. However for users wishing to "roll their own", javascript-based technologies similar to turf.js and D3.js will provide the basis for spatial analysis and visualisation. Server-based processes such as Web Processing Services will be used where browser and bandwidth limitations become problematic. A need for interoperability will at least guarantee that open standards are adopted, and in many cases open source software too.

"Hybrid" stacks, that are a mix of proprietary and open source software will also become more common, with a proprietary front-end or service sitting on top of an open source server stack.

The desktop GIS ecosystem will continue to thrive, however, in more traditional environments such as local authorities and governmental departments. In those areas QGIS will continue to dominate the open source offerings, particularly as more and more systems providers choose to support QGIS within their applications. The ease of procuring an open source database such as PostgreSQL, incorporating advanced technologies such as auditing and versioning, will drive the continuing move away from file-based spatial formats.

The Vector Tile Format (https://en.wikipedia.org/wiki/Vector_tiles) will be increasingly used for delivering geospatial content over the web. With the convenience and efficiency of tile-based delivery and the functionality of vectors, the Vector Tile Format also requires less server-side processing power, as the rendering is left to the client application. The adoption by ESRI of the Mapbox vector-tile-spec (https://www.mapbox.com/developers/vector-tiles/) suggests that of the current competing formats, this will be the one to see widepsread traction.

The overall trend for open source geospatial software is of maturity. Whereas once open source provided the underlying libraries such as GDAL, GeoTools and GEOS, and then components such as MapServer, it now provides complete end-user applications at both consumer and enterprise-level.

The Rise of the API

Currently Application Programming Interfaces (APIs) are seen as optional additional functionality within a service or application, but not a core feature. However this is a fast growing area of development, with the ProgrammableWeb (http://www.programmableweb.com/) listing more than 13,900 registered APIs, up from 6,000 in 2012. Of these, mapping is the largest category, with over 4,500 registered APIs (What is an API? Carl Reed http://www.opengeospatial.org/blog/4511, accessed 28th September 2015). Geospatial APIs are available for all sorts of functions, such as routing (Mapbox Directions API https://www.mapbox.com/developers/api/directions/), public transport information and timetables (Transport API http://www.transportapi.com/), and surfaces (Mapbox Surfaces API https://www.mapbox.com/developers/api/surface/). In future it will be more common to consume core services such as routing via an API than replicate the time and effort to procure data or develop a solution in-house.

Public Sector organisations are also beginning to appreciate the importance of providing APIs as well as consuming them, for connecting cross-authority systems together and supporting commonly used functions. Good examples of this can be seen at Herefordshire Council, where many council services are provided as a RESTful API: https://restservices.herefordshire.gov.uk/opendata/services, and the Surrey Planning Hub (http://digitalservices.surreyi.gov.uk/), which provides an API for access to planning applications from all the authorities in Surrey County.

APIs will also have an increasingly important part to play in the Open Data revolution. The proliferation of aggregating portals such as data.gov.uk, and a need to provide easy methods of integration are a driving factor. By allowing anyone, be that public sector, private sector or Joe/Josephine Public, on the same set of services, many more user needs can be met.

APIs represent the holy grail of a single data source with multiple outputs, fulfilling multiple uses, for multiple different audiences. Cost considerations and a need to avoid complex software licensing issues will ensure that the many future APIs are also built on an open source stack. The logical endpoint is for an open API connecting to an open source software stack, publishing data under an open license.

By necessity, APIs have always had a strong reliance on open standards and technologies such as SOAP and more recently REST, JavaScript, and JSON. There have been recent efforts to further standardise these, such as the formation of the Internet Engineering Task Force Geographic JSON Working Group (http://geojson.org/). The trend over the next five years will be for further standardisation, and an opening up of the standardisation process, as organisations such as the Open Geospatial Consortium (OGC) begin to open up their development process and encourage participation and collaboration via channels such as GitHub (https://github.com/opengeospatial). The OGC are also collaborating with the W3C to inform the development of standards for spatial data on the web(http://www.opengeospatial.org/blog/2255). These developments are significant, because they represent standardisation and adoption at a level far beyond that of the geospatial industry.

Fighting "openwash"

The widespread adoption of "open" to imbue any technology with a sense of availability and/or sharing must be fought, as it risks diluting the meaning and message and confusing the end user. At a recent technical conference this was taken to an extreme, where a website was defined as "open all hours", as if 24/7 availability for websites wasn't the norm. This message dilution can be already seen in the food labelling industry, where "the mass proliferation of eco-labels in the market-place [over 400 different labels at the last count] removes their value as a differentiator" (Coffee farming which may change the planet, http://www.caffeculture.com/content/Coffee-farming-which-may-change-the-planet accessed 3rd October 2015).

It has been argued that the increasing use of openwash is a sign that open source technologies have won the battle. "The old "open vs. proprietary" debate is over and open won" (How to Spot Openwashing, Klint Finley, February 2011, http://readwrite.com/2011/02/03/how_to_spot_openwashing, accessed 3rd October 2015). Over the next 5 years the end-user or software purchaser must learn to ask their vendor the right questions around licensing, governance and access to source code (Beware of open washing- three questions to ask your software vendor, Peder Ulander, April 2012 https://www.citrix.com/blogs/2012/04/11/beware-of-open-washing-%E2%80%93-three-key-questions-to-ask-your-software-vendor/, accessed 3rd October 2015). The alternative is that we could see a return to the days of software lock-in, vendor-specific solutions, and proprietary data formats, all with a thin veneer of "open" pasted over the top in the form of an API, a free but limited reader application, or some minor tools posted on GitHub.

However, the recent trend for moving everything to cloud-based services could provide another form of vendor lock-in, this time from companies such as Amazon or Salesforce (the owners of Heroku).

Open Source Everything

Over the coming years the term "open source" will be adopted more widely for good reasons as well as bad. We are already seeing the concept of open source companies, political parties, cars, and text books. This trend will continue. As opposed to "open wash", these all adopt the open source ideas of participatory governance, unrestricted access to the source building blocks (for example policies, schematics, or text), and transparent change control and decision making.

As the idea of open source expands away from its original reference to application code, and becomes a more generally understood concept, this will inform the software usage and purchasing decisions that individuals make. While it is unlikely to cause mass adoption of open source geospatial software over proprietary alternatives, it could help people to make more informed and objective comparisons between different applications, for example by making pricing options more transparent and allowing benchmarking tests.

Open Geospatial Companies

The companies that dominate the open geospatial ecosystem in 5 years time will take two forms. The first will be those that offer the types of traditional services around building applications, providing support and training. These companies will not only be judged by their prices and the quality of their applications or support, but also the commitment that they make back to the open source projects that they use. As the idea of open source, and in particular the concept of "free as in speech, not as in beer" becomes more embedded, it will no longer be acceptable for companies to "take" from open source projects without giving something back. Methods for giving back will be financial, such as sponsoring some development, or non-financial, such as bug fixes, documentation, translation and so on.

The successful "development companies" will be those building and innovating in the online GIS space, either building browser-based applications or software as service. Current rising stars CartoDB and Mapbox, for instance, have both received funding via venture capital this summer, and both have their sights set on the full geospatial stack, from data storage, through analysis to visualisation.

Existing initiatives such as the Open Source Geospatial Foundation (OSGeo) will need to evolve considerably to survive the next 5 years. In a way, it has become a victim of its own success, in that many of the projects that matured under the OSGeo banner, such as QGIS and PostGIS now have a much higher profile than the foundation itself. If OSGeo is to survive it must reconsider its aims and objectives.

As discussed above, there is a place for a foundation to advise and educate on open source, to counter claims of "open wash", but there is no longer a requirement for providing infrastructure and source control for projects as this is now available for free or extremely low cost thanks to GitHub, BitBucket and others.

Open Data

Open Data has been one of the outstanding success stories of the last 5 years. In 2010 the Ordnance Survey had just released some of their mapping for free, and OpenStreetMap was becoming popular, but was hardly mainstream. In 2015 it is almost expected that public bodies will make some of their data openly available. It is easy to see this continuing throughout the next 5 years as the cost benefits of this "channel shift" become obvious, but there are some problems that need to be resolved.

Firstly there is still a perception of "risk" involved in opening data. Once made available, that data can be used in ways that it was not originally designed to be used for. While there are cases where this can be genuinely risky, such as mapping flood risk using inappropriately scaled data, this is mainly a fear of losing control. The current situation is that data requests can be refused by one authority when others release it, or can be refused on grounds of commercial interest or national security for often flimsy excuses.

> **"Too many public services are outsourced to commercial providers who have no incentive to open up the data for the good of the country. The pervasive fear that someone, somewhere might behave maliciously acts as a massive brake on the progress of open data. Public authorities have to recognise that these data can provide massive public benefits with little real chance of serious harm."**
>
> (A Tale of Two Open Datasets, Terence Eden https://shkspr.mobi/blog/2015/09/a-tale-of-two-open-data-sets/ accessed 26th September 2015).

In 5 years time it is to be hoped that the advantages will be seen to outweigh the risks, and that openly releasing data will be the norm. However, for this to be successful, the data must also be released in such a way as to be useable by anyone, and not just an expert in that domain, with permissive licensing terms. It should not, for example, be standard to release data under the guise of an open or public license yet forbid it's re-use or combination with other datasets (https://www.zopa.com/public-data-license accessed 28th September 2015).

Making data open should not be seen as a compromise on privacy. Data that allows an individual to be identified, either on its own or in conjunction with another dataset, should be rigorously controlled.

About Astun Technology

Passionate about Geo, passionate about Open

Astun Technology is the UK market leader for enterprise geospatial solutions built on Open Source foundations. Astun helps organisations to realise the power of geography whether managing assets and business processes or determining policy across the organisation and beyond.

Founded by Mike Saunt in 2005, Astun has developed an innovative suite of products and services. Astun's iShare web mapping, data integration and publishing platform is now in use with over 60 organisations including Government Agencies, Local Authorities, National Parks, Blue Light Services and Social Housing.

Astun offers bespoke geospatial application development, training, mentoring and support plus an expanding range of Cloud services.

Astun is peopled by OSGeo experts and enthusiasts with over 100 years cumulative experience in the geospatial industry. We encourage and support our staff in volunteering and contributing within the Open Source, Open Data and humanitarian mapping communities.

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

AGI Foresight Study 2010: Did we get it right?

Andy Coote | ConsultingWhere **Steven Feldman** | KnowWhere Consulting **Robin McLaren** | KnowEdge

It is a slightly strange feeling look back at something written just over 5 years ago, predicting what the geospatial industry would be like around in 2015.

In some ways nothing has changed, the pace of technology change, which seemed "electric" in 2010, has if anything accelerated. The graphics look dated – with the advent of Prezi and YouTube, today would we have bothered publishing a written summary paper.

The Chinese economy has unexpectedly slowed (perhaps only temporarily) during the latter part of the intervening 5 years and the US recovered more quickly than the Eurozone. We certainly expected greater pace of "inroads" into the UK market of Chinese products than has been the case. Their internal market has so far absorbed their expansion, but with thousands of Geomatics and Earth Observation professionals graduating every year, it is just a question of time until China competes more strongly internationally.

The growing dominance of cloud-based solutions has happened as predicted, but with many of the same players as in 2010 still dominant. Google, despite their somewhat unexpected withdrawal from the enterprise GIS market, and Esri are still the "400 pound gorillas" in the market. However, the rise of open source which was predicted has been perhaps more pronounced than we thought. The lack of money for investment in the public sector during the continuing period of austerity we correctly saw, has been a huge factor in this respect. Mapbox and CartoDB are perhaps the few startups that have really emerged into multi-million pound businesses, what a shame they aren't British. The cost of starting a GI company, especially the technology tools, has considerably reduced over the past five years. It therefore surprising and disappointing how few successful new GI start-ups there have been across the sector.

The move of B2C applications into the B2B space has happened, largely without us noticing, again the GIS market leaders appear to have successful absorbed the mobile "platform" into their product suites. In 2010 the term platform was more readily understood in the context of rail travel than computing, but this is not the only instance of terminological rather than real change over the period.

In the technology space, whilst we predicted the huge increase in the number of satellites, we failed to spot the dramatic reduction in the costs of designing, building and launching to a level that having a constellation of nano / micro-satellites is within reach of many small size corporations should they think there is a viable market for their services. Planet Labs is a great example. The open data movement, particularly in respect to the European Union Copernicus (then GMES) programme, are starting to provide "infrastructural" location data of un-believably high quality for free. The availability of such imagery does call into question the sustainability of national mapping organisations in their current form.

Crowd sourcing has followed the ascendant path we predicted. The growing support of OpenStreetMap (OSM) and its widespread use in innovative and humanitarian applications has been phenomenal – see OSM HOT. However, the contribution of "professional" as well as "citizen" sources wasn't anticipated. Furthermore, the impact of crowd sourcing in the marine environment was completely missed.

As expected, augmented reality, which was possibly at the top of the hype cycle in 2010, is still hamstrung by the bandwidth and battery constraints we identified.

To borrow from Oscar Wilde, "reports of death of the (2D) map have been wildly exaggerated" and the cartographic profession seems to re-inventing itself in visualisation, perhaps underscoring the belief in the paper that the "spatial mindset" would still have value long beyond 2015.

The Internet of Things referred to as the "sensor web" in the study has become reality in the design of buildings, for instance, and creating smart cities much more quickly than expected. The consequent renaissance for the land surveyor, if they get their act together and don't get swamped by the engineers in BIM, is a welcome consequence.

Laser scanning from vehicles got a mention in the 2010 report, but its rapid rise as an aerial tool for both terrestrial and marine applications we didn't see. The emergence of UAVs and the current debate about safety was also unexpected as was the speed of emergence of autonomous cars and the centrality of location technology to their viability.

The significant role of GNSS and location based services was highlighted in the study, but we failed to see the importance of indoor navigation solutions.

Probably most significant of all is that the term big data doesn't appear at all. Whilst we recognised the issues of data management that the "fire hose" of abundant data would cause, the new insights delivered by data mining these sources was not recognised. It may be way past my demise when the truth about the use of this technology to keep the UK safe from terrorism over the last 5 years becomes public knowledge but the role of the industry in that field has been hugely significant.

In 2010 the adoption and implementation of the INSPIRE directive was embryonic. We were cautiously optimistic about the economic and environmental benefits of INSPIRE. However, the financial crisis has reduced the investment in its implementation across Europe and seriously reduced its benefits. Despite this, the Open Government and associated Open Data initiative has built considerable momentum and provides much more open access to environmental datasets to support environmental assessments. The extent of the Open Data movement and its impact on society was not predicted in the study.

It seemed inevitable five years ago that the Ordnance Survey GB would be privatised – and one could argue that it is in all but ownership. Whether this is positive for the industry we leave for others to judge.

We implicitly thought there were sufficient governance arrangements for the global geospatial information sector, so the success of UN-GGIM is an unexpected but positive surprise. This has helped to significantly raise the sector's profile at a political level.

Reviewing the key challenges for the industry identified at the end of the report, we can see that most are still relevant. Organisations are still struggling to attract enough of the right calibre of staff, environmental concerns still dominate the global agenda. However, we appear to have absorbed many of the quite fundamental changes that have occurred in the past five years with less pain than might have been expected. Perhaps, we can arrogantly imagine that the report helped readers navigate a path through the change, but the more likely reason is that we are capable of adapting as professionals more quickly than we thought.

And finally, the AGI itself has had to change in often painful ways we didn't anticipate in 2010, but underscoring the importance of being adaptable to change, we are delighted to see it continued to thrive.

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Realising the Potential of BIM: Is competition restricting efficiency opportunities from collaboration?

Andrew Cowell | BIM4Water

Efficiency is a goal in whatever industry we look at and particularly so in construction and infrastructure. Construction and infrastructure has been highlighted as an industry where efficiency can bring significant reductions in construction cost and operating cost. Many of these infrastructure projects are funded by Government or provide a service to the public so either directly or indirectly the cost is one that has an impact on the public. Efficiency helps to keeps utility bills and taxes lower.

Competition is a motivator for individuals and organisations to improve their performance and hence bring about greater efficiency. Competition creates new innovations in materials, products and delivery processes. Competition fits with our belief that the strongest will survive and the weakest will wither away.

There is no doubt that competition drives and delivers efficiency. However as we progress with the digital revolution do we need to review whether our belief in competition means we miss opportunities for efficiency through collaboration?

For the industrial revolution to deliver many of the efficiency benefits we see today it has been necessary to collaborate and agree a framework within which competition can take place. For example for rail networks to develop we agreed a standard gauge, we also agreed a way of standardising time. These become common standards which then allow competition to take place with the design of different rolling stock and different timetables being the variables where we can still see competition.

Agreeing standards encourages innovation because there are some boundaries within which to justify investment. If there are no boundaries setting a longer term framework then decisions are often reactive and short term. Some will argue that putting in place standards restricts innovation. However standards can be revised through collaboration to modify the boundaries to enable incremental improvement through innovation. If there is disruptive innovation that is going to be a step change it is unlikely standards will hold back such a development. Competition will ensure that step change innovations will come through.

Standards do not lead to all things becoming identical, they give us a common language. We are able to communicate because we agree an alphabet and a dictionary of words, which does not mean all books are identical.

In this digital revolution of our BIM world we are in the formative stages where there are many ideas of how to make the best use of the processes and technology we have to draw on. Competitors are seeking to gain an advantage in the BIM market space. There is competition between Contractors, Designers, Clients, Standards and Industry Bodies.

A few examples come to mind from the water sector:

- Standard Libraries of products are being worked on by suppliers, designers, contractors and clients. An amazing amount of resource is being invested yet none will result in a Standard. Can we agree as an industry what is required to define a specific product, level of detail and level of information such as CIBSE Product Data Templates (PDTs)? This gives a common framework within which to innovate different products
- In process plant a basic building block of design is the Piping or Process and Instrumentation Diagram (P&IDs). Each Water and Sewerage Company (WaSC) have their own interpretation of the P&ID symbols. Could we agree an industry standard and remove the inefficiency of the supply community maintaining several variations?
- Each WaSC has an asset hierarchy to describe plant which is basically the same yet the hierarchies are different. Suppliers need to understand all the variations. If the water sector is to connect into the digital world in future should we be collaborating to set some standard asset hierarchy for the sector? For example shaping Uniclass 2015 to ensure it encompasses the water sector
- In the standards we use there are potential overlaps in scope and sometimes competition leading to silos between the groups applying these standards striving to be the lead. Are those looking to apply PAS1192 and ISO 55000 collaborating sufficiently to bring about a coordinated asset management approach?
- In systems there are those who advocate the tool sets associated with BIM and those who are GIS advocates. The key to both is 'information' so let's collaborate to establish solutions that draw on both tool sets, it is not BIM or GIS, we need both
- There are a number of industry bodies that are developing the application of BIM. The energy that goes into these bodies is significant. BIM4Water, Buildoff Site Water Hub, Institute of Asset Management and British Water to name a few. If we could collaborate to harness this effort in a coordinate direction setting the boundaries to improve the efficiency of the water sector that would be powerful

The application of BIM encourages collaboration between project teams to improve project efficiency. There is an industry efficiency to be gained if we can collaborate to set an industry framework within which we all deliver projects. This is a significant change from our current thinking where we believe competition through procurement is the primary route to a more efficient industry. Collaboration can be seen as collusion in some cases so is actively discouraged.

Change needs to be planned so we could draw on the ADKAR model. Firstly to raise 'Awareness' of the efficiency opportunities through industry collaboration. This then needs to generate a 'Desire' to change, we then need the 'Knowledge' to bring about the change and the 'Ability' to deliver the change and then 'Reinforce' to sustain the change.

The application of BIM is part of the digital revolution. The digital revolution is in its early years, in the context of where the industrial revolution was we are probably in the 1920's, its clunky but showing potential. With the awareness and desire to collaborate we can deliver greater efficiency however to do this we will need leadership to set the vision and humility to work together across the many disparate initiatives that are currently underway to create a framework within which we can all then compete.

Let's look for the collaboration opportunities where we can further the efficiency agenda and focus competition in the areas where it is appropriate.

ANDREW COWELL MWH

Chair
BIM4Water

The views expressed here are a personal reflections and not necessarily representative of either organisation.

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Pushing the Boundaries of the Survey Profession

Dr Paul Cruddace | Ordnance Survey

The world is undeniably excited by the value envisaged by the big trends of the future. The journey from big data to big analytics; the rise of BIM and Smart Cities; the development of the Internet of Things; and the realisation of autonomous vehicles are just some of the key hot topics. Some of these are quite well developed and nearing reality. Others are more abstract concepts that are still going through the pain of formation. It is undeniable though that over the next five years, these are big themes with the potential to create significant benefits for those industries that embrace the opportunities and establish leadership - carving out a USP in the value chain will be key to success.

In contrast, the 2010 AGI Foresight Report majored to some degree on the role of GI providing "context", a backdrop. With the benefit of 'hindsight' this thinking now appears to be acting as a constraint and risks keeping the GI industry 'in its' box'. Whilst GI remains an essential underpinning framework, (providing the contextual background and SDI development across the world is as important as ever), the question arises - 'is that the limit of ambition?'

The commoditisation of much of the context data will only increase due to proliferation of open data as well as imagery; mainly through the development of satellite based platforms. From the highly temporal from the likes of Planet Labs, free data from the European Space Agency Sentinel Programme for example, to the high accuracy that has become available from the lifting of restrictions on the commercial satellite imagery providers.

So, how does the GI industry move forward and where does the survey profession engage? There is a unique opportunity, where technology, user demand and an industry's desire to look above the parapet converge, but where should we concentrate? Discipline will be key – as we seek to understand and focus on our customers of tomorrow and anticipate what their needs will be – we need to enable maximum participation and therefore value by the GI sector. In particular it seems certain that the survey profession needs to expand beyond the measurement science business to ensure a strong future (to reduce the risk of being marginalised within the scope of these new opportunities), as well as to bring its expertise in areas such as data management, quality and integration to bear on the challenges. Boutique is interesting, but will not bring longevity. The future will be increasingly one where we ask the question 'what data already exists to which we can add value?' rather than 'what data do we need to collect?'

To move forward, the GI industry needs to work together, joining-up across the spectrum to tackle the barriers to understanding the opportunities, (re)-configuring to meet the challenge and to realise the real benefits. We need to invest capital to take current core GI activity and transpose this to the new opportunities. The work of the Survey4BIM task group is a great example of this – an industry coming together to tackle issues that are fundamentally geospatial in nature, but within a new context. This group has a focus on generalisation, level of detail, interoperability, metadata and accuracy. Once these challenges are worked through, knowledge is built up and expanded into other areas where we can add value – this could be in technical, social, environmental or logistics for example. Moving GI to heart of decision making where the real value lies.

We will need a greater degree of industry cohesion to succeed. We need to be brave by looking outside of our normal domain to become involved in novel opportunities and to quickly understand where we can add value. To do this, the GI industry needs to work together to tackle the barriers and realise the opportunities – in that way the UK will develop highly innovative leadership on a global stage.

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

The GI Community: Problem and Opportunity

James Cutler | emapsite

"Well if you want to get there I wouldn't be starting from here."

Back when SPANS was a quadtree GIS and OS/2 seemed like a good idea, there was no such thing as the GI community and the late Bill Campbell's MAPICS was the digital cartography tool of choice. There was certainly no AGI and it was via the Remote Sensing, Photogrammetry and Cartographic societies that GI surfaced. Geographers in particular but folk from other fields – soil scientists, resource managers, agriculturists, demographers, epidemiologists, engineers, architects, landscape planners – who to a greater or lesser degree in some way had geography in their bones went about their business in their field, with their "apps".

The GI community may have an existential crisis.

In valiantly seeking to provide a common home for these diverse professionals, each already with their own separate disciplinary community, the GI community has sought to distinguish "geographic information" from all other types of information. Hubris? I don't think so; much more an eagerness to praise and evangelise the geo perspective as to market products and capability. It is for me ironic that as a long time Fellow of the RGS the AGI is now at their "home" – geography is on the one hand a "subject" (hence the strong RGS with IBG association with education), on another the basis for "exploration" (hence RGS expeditions and awards) and finally and importantly sits at the heart of the 21st century's globalised world – climate change, geopolitics, migration, energy, water, food, transport, erosion, urbanisation, pollution, piracy, the global commons et al.

Geographers are absolutely the people to shape this century but "geographic information" is but one component of the matrix of data that will feed decision making, regulation, modelling, permitting and policing. Indeed it is "geography", be it of nation state, of parish, of planning authority, of crop production, of organisational reach, of whatever, that will be (one of) the frames, lenses, media through which these challenges will be viewed.

Whatever issue an organisation (public, private, not for profit) looks at, from utility network connectivity for customer communications, to loyalty card membership for focused product offerings, to supply chain certification, to energy distribution, to access to water, to insurance premiums, to improved health and on and on, there is a wealth of thematic data to feed the algorithms, the analytics routines and the available or chosen geographies.

Yet while there are sectoral communities and learned societies there is no "association of botanical information" or "utility information" or any other kind of information. Special pleading for GI makes little sense – we are not a sector and not much of an industry (our products being ever more finely tuned to vertical market needs) though many have striven valiantly to make it so. "We don't get enough customers" at GI community events and few of them join or feel part of the GI community or participate in the SIGs but why would they, what does the community offer, other than as isolated practitioners in their sector, a warm blanket? And unlike learned associations our community rarely sought or demanded academic rigour.

It could be that the emergence of the Open Data Institute (ODI) provides a powerful signal of what is missing and from where we should be starting going forward. Never mind the tools, the technologies or the products, GI practitioners are mostly interested in mashing up data from multiple sources in whatever convenient, appropriate technology meets the representational needs of their audience. The ODI Summit 2015 attracted members and audiences from across a very different spectrum – I would hazard GI community presence within 700 delegates at a handful (ESRI UK, emapsite, transportAPI, OS, Geolytix, Landmark, Land Technologies, LGA for sure) – and not just because of the TBL and "open" sex appeal but because the challenges and opportunities are mostly framed as "issues" and "problem solving".

Disease vectors, media communications, consumer goods provenance, food distribution, disaster response, retail planning, congestion, facilities management. These are all "geographical" challenges too but not framed as such except perhaps in the visualisation. So, yes, spatial analysis, in the database mind, not on the desktop, in near real time and/or with incremental updates to volume data sets is already and will remain a fundamental component of business intelligence and as experts, as (geo)data scientists, understanding and conveying those models, risks, rules, parameters etc will be critical in contributing to the integrity of the outputs and the trust of the wider world in "products" based on data provided, often passively, by that wider world.

Millenials and Generation Open are already suspicious of or cynical about the post-Snowden world and the willingness or ability of "them" to do a great deal about it – for these groups to participate in society, in the decision making and in the solutions, a global, geographic perspective is the default position. Geography has never been more important as a discipline and a perspective but geographic information in and of itself is, however you wrap it up, in BIM, Big Data or Smart Cities, part of the furniture.

As a community we have an opportunity and we need to pivot, rapidly, from maps and tools, to data and solutions, re-framing our little world to better connect to the planet and its problems. Are there things now and coming down the track in our world that can help this ambition?

Sure there are - flocks of micro-satellites, UAVs/drones/UASs, wearable tech, 5G, sensor web/internet of things, ibeacons, VGI/UGC (including personal data), information marketplaces, '000s of open data sets, regulatory changes, emerging standards, inter-operability, BIM, SCADA, LIDAR, unstructured data hoses (social media being but one), new/alternative geographies (of which marine is but one) and, perhaps, most importantly, a change in pace amongst organisations of the recognition of the need to join in and make sense of all of this.

Such sense may take the form of BIM Level 3, of intelligent networks (for energy, transport, lighting, water), of facilities management, of risk profiling or of resource optimisation or be more expedient. "Better" sense comes from embracing the skills that can wrangle the data (from capture to normalise and so on), recognise what is appropriate to interrogate the data (algorithms, mash-ups, profiling etc) and then represent and communicate what they find to inform, excite, for insight. For industries characterised by slow change, legacy systems and cultural inertia the only way to do this is to look to the market, to geographers and the data scientists who speak the 'geo language'.

With all the brouhaha around "open" one could be forgiven for forgetting that the really good stuff is locked up, in business and in government and that the real opportunity comes from bringing those data worlds together. Analytical groups in all sectors do this – actuaries, analysts, experts, people with domain expertise quietly (or not so) delivering value to their organisations by leveraging enormous amounts of often un or under-utilised data to become more insightful and competitive, to provide greater levels of customer satisfaction and to create new revenue streams.

In this context enabling geographic framing (replete with tools, content etc) is to embed geo/location/place. Geography is a cross-domain discipline and geographic information is a multi-domain ingredient. The challenge to all of us individually and collectively is to embed some geographic element of what we do (location, premise, asset, property, route, outcome, distribution, product, service delivery etc) alongside all the buzzwords and tech and tools so that geo is intrinsic.

The Aspiration to make Geo Intrinsic marks a continuity, shaken loose of the ties that bind, of appearing to be the purveyors of one perspective, one motif, a jumping off point for the next stage of our journey.

2020 is not far off and will have seen further proliferation of tools and tech to deal with the continuing explosion in data collection, retention and analysis in which both location and the nature of the issue being addressed will be ever more explicit, from device through processing to audience and outcome. Geo will be subsumed into that wider information environment. This surely has always been our aspiration, whether it heralds our demise or our regeneration is in our hands.

JAMES CUTLER

CEO
emapsite

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Big Data in Future Proofing Cities

Geoff Darch | Atkins

"Big Data constitutes an historic opportunity to advance our common ability to support and protect human communities by understanding the information they increasingly produce in digital forms."

(UN Global Pulse initiative, White Paper: Big Data for Development: Opportunities & Challenges, 2012)

The interface of the mega-trends of urbanisation, climate change and big data, provides an opportunity to better understand the risks and opportunities for delivering developing world cities that are smart and sustainable for everyone.

Problem / Opportunity Statement

More than half of the world's population lives in cities, and this is expected to reach 75 per cent by 2050. 95 percent of this expansion is projected to occur in the developing world, in areas that will experience significant climate change and resource pressures. At the same time, technological developments mean that we are seeing a rapid increase in data, from mobile devices, sensors and social media. For example, over 80% of the world's five billion mobile phones in use in 2010 were in developing countries[1]. But what happens at the interface of these mega trends? What role can big data play in helping us understand changes in demographics, development and climate, and can big data help solve problems associated with poverty, overcrowding and natural disasters? At Atkins we're particularly interested in how big data can help identify infrastructure requirements, at a range of scales, from household sanitation, to city-wide flood defences, early warning systems and transport solutions. We want to use big data to improve cities and make infrastructure more resilient and responsive to our changing environment and needs of society. We think big data can help us plan and develop cities to be more liveable and inclusive.

History

A lot of the thinking on the links between big data and poverty has focused on the potential ability of big data – for example through use of mobile phones – to measure indicators of poverty or socio-economic development. Some commentators are sceptical of the benefits compared to traditional household surveys for example[2], while others are more optimistic[3] suggesting even that in time big data could change the way we measure and even address poverty[4].

The UN's Global Pulse initiative[5], a flagship innovation initiative of the United Nations Secretary-General which aims to analyse digital data to support global development and humanitarian action, published a White Paper on Big Data for Development in 2012[6]. In it four types of digital data relevant to development are identified:

1. Data exhaust: passively collected transactional data e.g. from phones
2. Other information such as social media, from which inferences can be made
3. Physical sensors: remote-sensed from satellites (although this could also include ground-based sensors)
4. Citizen reporting or crowd-sourced data, which is explicitly sought

A World Economic Forum report on new possibilities for big data in international development[7], highlights four potential uses:

1. Faster outbreak tracking and response
2. Improved understanding of crisis behaviour change
3. Accurate mapping of service needs
4. Ability to predict demand and supply changes

The Global Pulse initiative contains a large range of applications, for example recovery from flooding and disease prediction. It also conducts research into the utility of big data, for example through a current project assessing the suitability of aggregated mobile phone data.

The Solution

But what about big data for infrastructure? Our experience in producing Future Proofing Cities[8] – a review of risks and opportunities for inclusive urban growth in developing countries – and wider work in international development highlights the following opportunities for using big data:

- Quantifying vulnerability to risk: where are people located in relation to natural hazards and what adaptive capacity they have
- Identifying infrastructure deficits and damage: where is infrastructure missing or malfunctioning, in relation to demand
- Mapping city catchments: for example, locating the sources of food for a city
- Identifying the movements of people including in relation to the types of transport available
- Developing climate-related thresholds for infrastructure demand and damage
- Understanding how people respond to natural disasters and how they might respond to risk reduction measures

Most of these are spatial issues and geographical information will therefore have an important role. This will include both spatially continuous (e.g. satellite data) and point (e.g. mobile data) data.

We have started to explore the use of big data in this context by establishing partnerships with specialists in this area. For example, we are assessing how citizens utilise transport infrastructure and we are developing approaches that will enhance land use economics and transport models.

The Benefits

Big data can help us identify gaps in service provision and target infrastructure investments to those people and areas that need it most and where the benefits are greatest. It can avoid some of the issues associated with data collection notably statistical sampling, cost and security. Big data can also provide new insights to behaviour that would not be possible using traditional techniques, for example through its timeliness and sample sizes.

However, big data is not a panacea and the UN Global Pulse White Paper highlights two factors for making big data work for development: firstly, contextualisation, both in terms of the data itself and the cultural setting, and secondly the critical role of analysts to ensure we become "sophisticated users of information".

Call to Action

In our work for policy makers, investors and infrastructure operators, we can see enormous benefits in using big data in future proofing cities. Along with traditional sources of data and our usual practice of close working with stakeholders, it will help us answer questions about the where, what and how in terms of infrastructure provision and design. Barriers exist, but we are keen to work with governments, academics, NGOs and others to ensure that big data helps to deliver liveable, inclusive and sustainable cities for everyone.

About your Company

Atkins is one of the world's most respected design, engineering and project management consultancies. We build long-term trusted partnerships to create a world where lives are enriched through the implementation of our ideas. One example is our Future Proofing programme: this started with Future Proofing Cities and onto specific city studies in southern Asia and Africa, as well as assessments of future proofing in water, energy and the environment.

Read about our Company at: www.atkinsglobal.com

Read our thought leadership series at: http://angles.atkinsglobal.com/

Read about our Future Proofing programme at: http://www.atkinsglobal.com/en-gb/group/sectors-and-services/services/future-proofing-cities

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Drawing the Threads Together: Turning Data into Knowledge

Peter Edmonds | The Crown Estate

There is a disconnect between data collectors, data holders and data users. Users say "there isn't enough data." Collectors say "we collected it, so it's ours." And data holders say "there's loads of data here, why is nobody using it?"

What's the problem?

As technology improves and we see the benefits of GI in our day-to-day lives the world is becoming an ever more demanding place. We have the information we need to run our lives at our fingertips. This expectation naturally translates into business. Before making a decision we first want to be given all the information that exists. And what's more we want it to be free and easy to digest. It's what we have in our home lives, so why not at work?

This demand comes not only from our personal expectations, but also in the increased competition for space and scrutiny on all things related to cost and the environment, particularly in the marine sphere where requirements are often enshrined in law.

The availability, but more importantly, the usability of data affects us all. From well-established business sectors such as oil & gas or the cables industry to newer players like offshore renewables and carbon capture and sub-seabed storage. It also affects the public sector as they strive to better plan, regulate, conserve and improve the health of our seas (**figure 1**).

If we have oodles of data, countless demands for spatial information, and the technology to get it together, why haven't we joined the dots already? If we don't understand and manage this over the next 5 years we may miss numerous opportunities for sustainable development and conservation within the blue economy.

Background

We have seen plenty of improvements in technology over the last 5 years in the GI world. Cloud computing, big data, linked data, open data and web services have become the buzz words. Green Papers (and papers of other colours) have been written (e.g. Marine Knowledge 2020), INSPIRE deadlines have started to bite and computer processing continues to follow Moore's law: that the capabilities of processors doubles every 2 years. That means that over the next 5 years we can expect our current processing power to more than quadruple! We can also be pretty sure that over that time we are going to have access to more and more real-time data, remote sensed data, on-the-fly analytics and machine learning. To make use of such data and technology, we have to make sure that we move with the times.

There has been heightened demand for data and GI, particularly in the marine environment. The Marine Planning process enforced through the Marine and Coastal Access Act 2009 and the Marine Strategy Framework Directive are data and GI hungry. They want to know everything about the marine environment, in detail and now.

We've also had the rapid growth of new industry sectors. We have seen offshore wind take-off to the extent it now meets around 5 per cent of UK electricity demand, as well as development in wave and tidal energy testing, offshore carbon capture and storage, and new port development. These industries do not only need data to plan their developments, but they're also data rich. They need to collect high resolution data to inform their consents applications and engineering designs.

Whilst demand has been growing and we have been collecting data, there are also a large number of initiatives aimed at putting data and GI into users' hands including INSPIRE, MEDIN, EMODnet and data.gov.uk.

We at The Crown Estate have been playing our part by collecting together the data gathered, where possible, by the offshore wind, wave and tidal industries into our Marine Data Exchange (MDE) (www.marinedataexchange.co.uk). As an active asset manager of the UK seabed, we do this because we recognise the power of data in helping stimulate research, reduce costs for offshore energy development, and contribute towards the sustainable development of this natural resource to unlock value over the long term.

These initiatives have been developing over the past decade and are beginning to reach a critical mass of content and experience that could instigate change, but the threads need to be drawn together to start providing the data that people really want. It's clear from the criticisms you hear that users understandably now want easy-to-consume data products, not necessarily low level raw data which is what the majority of the aforementioned initiatives have been aimed at collating.

The Solution

To drive the real value out of the data collating initiatives we need to make the data more accessible. Yes it's available, but it's still difficult to get at. It's only once the full quantum of data that is available becomes accessible that it can be efficiently combined to derive the new products and insights that people really want.

The best example I can think of is Twitter. Who would have thought that by making Tweets openly available we would have analytics products that can predict changes in the stock market? Imagine the possibilities when you apply the concept to species distributions, mobile sediments and integrating data on marine or terrestrial activities.

The solution really is as simple as joining the dots. There are 4 simple stages (dots) to join:

1. Gather
2. Collate
3. Normalise
4. Serve

By instigating collaboration between the parties involved in these 4 different stages, we will speed up our move towards a high performing and functional system.

The Benefits

Once we have fully implemented the 4 stage solution above we can start to realise the true value of data and start using it to better understand our environment and plan for future activities in a truly sustainable way. We can stop wasting all our time and money searching for patchy datasets only to realise that they can't be analysed in the way you wanted to, or that the results of your analysis are severely compromised by the quality of the data that went into it.

We will be able to start analysing the data in earnest and with confidence, deriving new insights and making more informed, and therefore better decisions.

Call to Action

The question should really be asked, if it were that simple, why aren't we all doing it already? There are a number of key barriers that we need to overcome to enable proper use of the breadth of data that exists. But what are they?

- **Data hoarding** - some organisations are unwilling to let go of their data, concerned about the consequences. However, the offshore wind industry took this leap of faith when submitting their data to us at The Crown Estate and this data is now managed and shared widely through the Marine Data Exchange with the aim of improving our understanding of the marine environment.

In fact if you ask the industry about their experience of this it is extremely positive.

- **Lack of understanding of requirements** – Users need to engage more to explain their requirements to those that have the power to make the products they need. It was only last year that we at The Crown Estate had a requirement for a better understanding of seabed geology and improved resolution wind resource data to inform analysis of future opportunity. By engaging with industry experts we were able to fully understand their needs. We utilised data from within the MDE and beyond to derive more useful data which is now available for others to extract value
- **Coordination** – there are many stakeholders in this sphere and getting them on the same page and ensuring that initiatives are clear and complementary is not an easy job. MEDIN have been a driving force for this and common denominator for marine data in the UK, but have the challenge of working collaboratively with, INSPIRE, data.gov.uk, EMODnet and others to build on the things they're individually good at, while avoiding duplication of effort

These challenges, although notable, are purely cultural. They are primarily about talking to each other and changing our perceptions of what is truly valuable to us. They impact the speed at which organisations can identify and utilise derived data products, but we shouldn't and can't let these barriers stop us.

What can you do to help?

- Take a leap of faith and let go of your GI data
- Tell us what you need to know to do your job better
- Stop, think and look around you before attempting to coordinate activity or set off a new project
- Collaborate – talk to each other

What can the AGI do?

- Help to educate people on the benefits of data sharing and better utilisation, encouraging openness
- Gather requirements and identify gaps – who needs to know what?
- Join the dots – who's doing what? Provide targeted forums for discussion and knowledge sharing between these groups and opportunities to collaborate
- These issues are not industry or marine specific, the AGI could help to bring cross industry and cross disciplinary forums to work on these largely abstract issues

About The Crown Estate

We are an independent commercial business, created by Act of Parliament, and all of our profit is returned to the Treasury for the benefit of the public finances. Our role is to make sure that the land and property we invest in and manage are sustainably worked, developed and enjoyed to deliver the best value over the long term.

We invest in and manage some of the UK's most important and best loved assets, underpinned by an investment strategy focussing on our core sectors of London's West End, dominant regional retail and leisure, agricultural and strategic land, and offshore wind.

The Energy and Infrastructure team manage almost the entire seabed out to the 12 nautical mile territorial limit around the UK. As The Crown Estate has the rights to explore and utilise the natural resources of the UK Continental Shelf, with the exception of oil, coal and gas, we lease out to 200 nautical miles or the Renewable Energy Zone. Our work covers a variety of interests embracing marine renewable energy, marine aggregates, potash mining, oil and gas pipelines, telecommunications and power cables, carbon capture and storage and gas storage.

About the Marine Data Exchange

The Marine Data Exchange has been developed by The Crown Estate as part of its active asset management of the UK seabed to unlock value and contribute towards its sustainable development over the long term. It has been up and running since 2013, providing free access to survey data and reports collected throughout the lifetime of an offshore project.

The Marine Data Exchange now holds over 100TB of data from over 70 offshore developments, covering the UK continental shelf and beyond. This vast array of data covers themes including marine mammals, archaeology, bathymetry, benthic ecology, wind speeds, birds, geophysics, geotechnics and more (**figure 2**).

You can download the data for free at www.marinedataexchange.co.uk. To help you to discover and keep up to date with data more easily, you can now register which allows you to save searches and receive notifications of any new data that is published which may be of interest to you.

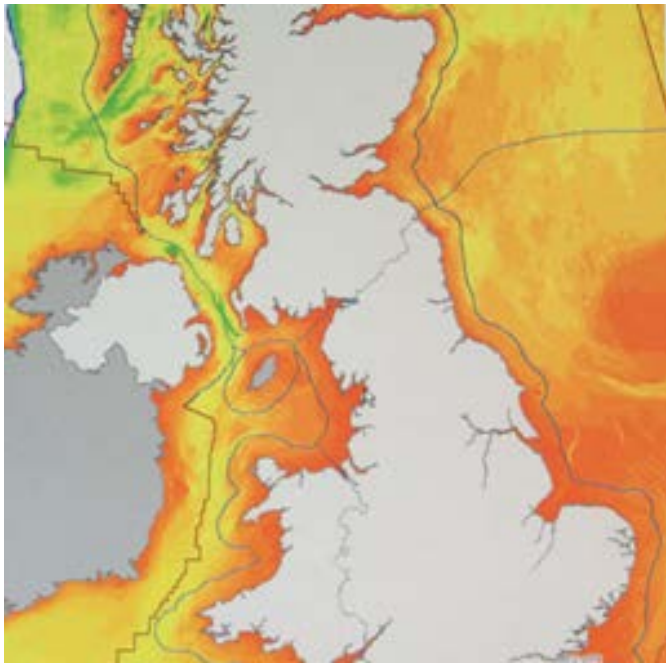

Figure 1

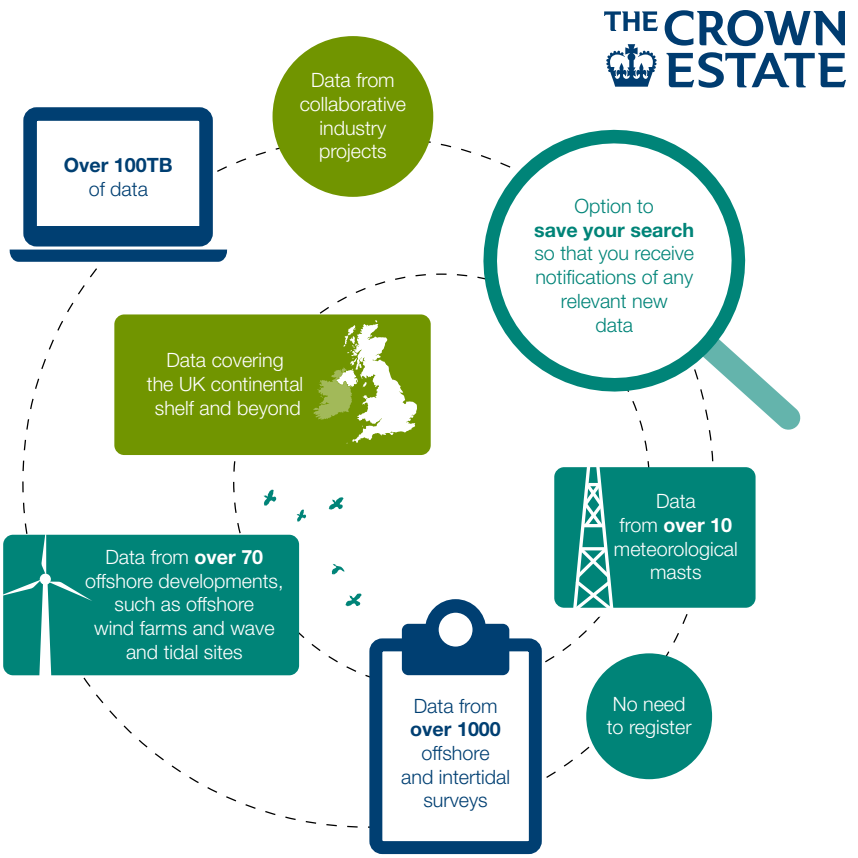

Figure 2

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Big Data and the Internet of Things: Changing Behaviours through a Focus on Value and Quality

Robert Elliot | National Physical Laboratory

Big Data and the Internet of Things is about the outcome; Changing Behaviors through a focus on Value and Quality.

The Internet of Things (sometimes called Internet of Sensors) and connected Big Data promises to be the next revolution in technology systems design and connectivity and a new area for economic growth and productivity. For people and companies working in remote sensing and earth observation industries, the IoT could represent one of the largest business growth opportunities ever to have wandered into our space, e.g. IDtechX calculates that 45% of the multi trillion dollar IoT market will be covered by the sensor market. There is some way to go before IoT achieves this and makes it's way into the mainstream market, Gartner (see figure) places IoT at the very top of the 'peak of inflated expectations' curve for emerging technologies with a predicted 5 to 10 year period to get to realizing true productivity gains.

This article discusses some of the key challenges for the various communities in order to realise the potential of the IoT enterprise over this 5 to 10 year period taking examples and inspiration from other related technology-intensive industries who have succeeded with a focus on; value creation, quality and trust. If these elements are not considered carefully in this timeframe, even whilst the technology giants move into the space with gusto, the mainstream use of Big Data and the IoT will not be maximized.

So why buy a connected big data sensing device or application over a non-connected one? They key to this decision is in the perceived value of that device, and positive outcome that is gained in the context of the user as result of that purchase. This idea of 'what is value?' is something that was clarified for me in a series of talks at the Royal Society in London in 2014. One speaker - the guru of value creation - Prof Irene Ng gave an inspiring talk on the value of a paper cup to hold water to quench thirst. She then compared this most basic of examples to when Rolls-Royce asked her to improve their aero engine business, where she developed the idea of selling aero engines as a connected service valued by hours of flying, rather than as a piece of complex technology.

Within the satellite industry where I am most familiar, I am impressed in how the satellite telecommunications industry succeeded in selling the outcome of *always being entertained* rather than the merits of the impressive technology itself (proved by my next door neighbor who had no idea the football match, and all his other subscribed channels, was being sent via a geostationary satellite in space). The same can be said of Navigation systems and the growth in location based services, the mainstream success of GPS (And soon other systems) technologies came not in the awesomeness of the GPS constellation, but in the realization of being able to know where you are in the context of everything else (so the world literally revolves around you), at any time. What a vast change to a map, where you manually work to calibrate your location to reference points, to find out where you are on it.

In the IoT and Big Data area, we are lucky in that many of the hardware elements exist and are constantly being improved in cost, size, mass and bandwidth. So why do these connected systems not exist already and how is the IoT and especially remote sensing and earth observation going to scale up to the mainstream market, or in an operational business to business service? Taking the above examples I think three critical success factors come into place: creating value through positive outcomes in the context of the user, quality and trust in the solution provided By creating a focus for enterprise on the positive outcome, this supports the mindset of interopable technologies, driven by common standards and frameworks, to deliver end user value, all of which are required within the Internet of Things.

The uniqueness of the IoT and Big Data is that it can give us a perfect, or more likely representative, insight of behavior to support decisions of a human, robot or machine – which could range from an environmental parameter, a city, or a human behavior. Only when that insight is used to create a positive action. i.e to change behavior thereby closing the loop on the new knowledge, is the full value realized. This tells us that the user (human or machine) is an inherent part of the IoT ecosystem and needs to be included in the design. A lot of this maybe be well outside the normal boundaries of a sensor manufacturer, telco, platform provider, data centre owner, EO satellite operator, or social scientist. However in this fully connected IoT world everyone will have to work together to create this positive outcome of changing behaviours, through a new ecosystem.

The resultant outcomes to deliver a value IoT are about quality and trust. Coming back to Gartner again, they predict 50% of the IoT market will be created by start-ups that are less than 3 years old, representing a very high level of growth in invention, innovation and private investment. It strikes me that a critical challenge for the sectors longevity will be in ensuring the quality, or data provenance (where has this data I am using come from?) and resulting trust (do I believe this data?), especially when the solution is to provide insight and knowledge for a service user to make or support a behavior change which may have a monetary value or legal consequence. This means that quality and trust needs to be designed into the IoT at an early stage, and worked into a common framework or standard.

In the US, this already appears to be taking shape, with the National Institute of Standards and Technology taking a leading role in the government supported programme US Ignite, which looks to develop a common framework of operation and forming a repository of many IoT projects across the country. In Europe we are still at the stage of investing in research and innovation to deliver essentially separate, siloed IoT and Big Data pilots and demonstrations, however the need and urgency to have a central repository or coordination activity is becoming increasingly needed.

In addition to this a system of best practice or a common framework to ensure or verify the quality of service provided by the IoT service providers would be a useful step forward to ensure the trust, and therefore perceived value in IoT, is maintained.

Again, this comes back to bringing people and communities together, which can be done in many ways through creation of new centres of excellence, trade associations, standards committees, workshop and conferences, providing a movement and level of coordination that is now needed to deliver the value of the IoT.

ROBERT ELLIOT

National Physical Laboratory

Key Points

In Summary:

- Focus on the Value of Big Data and the IoT to help design common frameworks, rather than the technology itself
- Develop a national or European Centre of excellence for IoT to bring a diverse set of skills together for the right ecosystem
- Source leaders in developing industry standards and best practice to bring together disparate Big Data / IoT pilots and demo's, to ensure quality and trust is delivered before mainstream scale up.

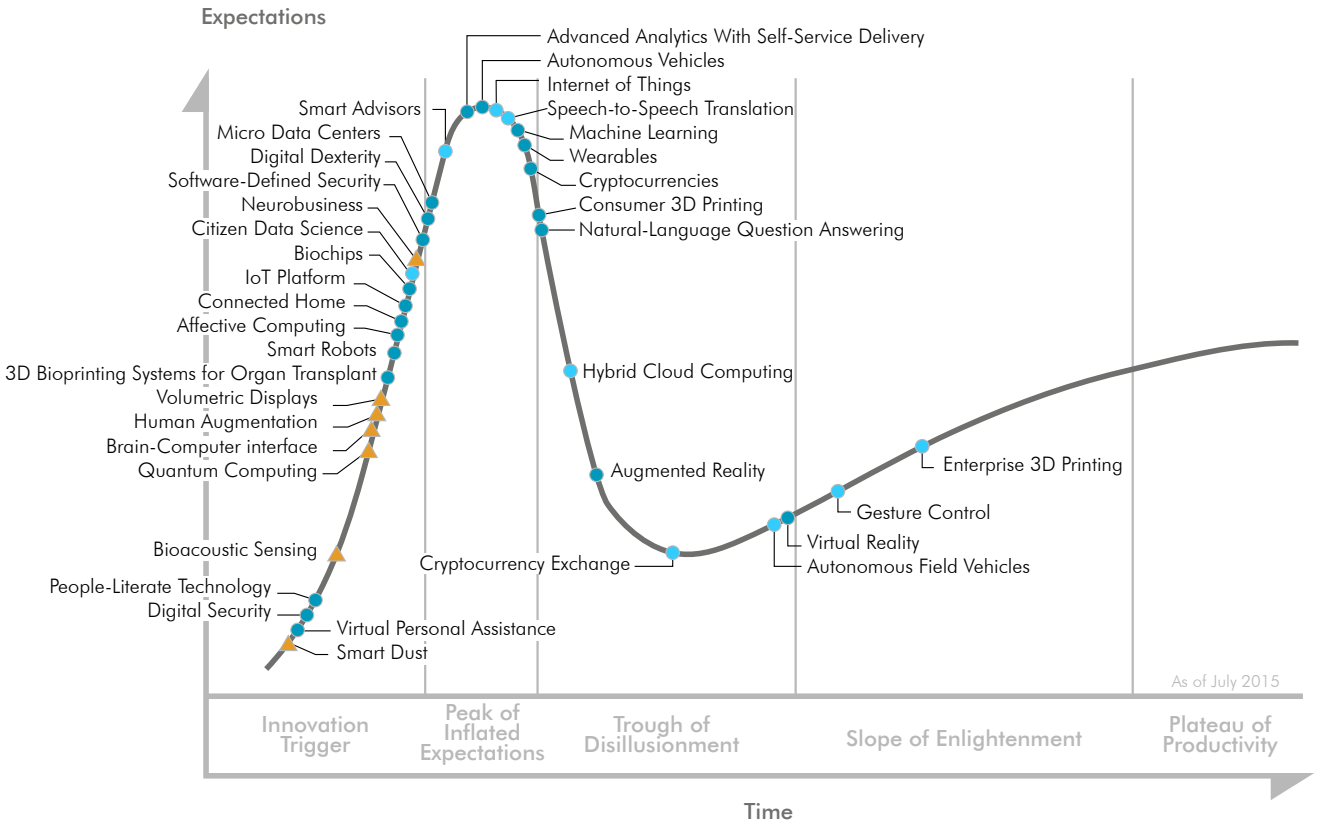

Figure 1 - Source - Gartner 2015

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Advances in 3D GIS

Claire Ellul and Kelvin Wong | University College London

Three-dimensional Geospatial Information (3D GI) is an area which is only now coming into its own, due to the increasing availability of 3D datasets and the ability of computers to store, manipulate, visualise and analyse this type of data. Rather than a view that '3D is nice to have but not very useful' there is an increasing expectation of 3D capability both among specialist geospatial users and the general public. The availability of Google's Streetview and increasing numbers of 3D indoor maps of shopping centres, hospitals and rail/underground stations is furthering this demand. Additionally, the younger generation has grown up with an expectation that models of the real world, and virtual worlds, will be 3D, no matter what device, as these are supported by the many gaming platforms and games such as Minecraft (the Ordnance Survey first released a GB Minecraft map in 2013). The rise in lower cost Virtual Reality and Augmented Reality technologies has put 3D into people's minds and the ability to rapidly generate 3D data (via extrusion) provides a 'wow' factor.

In parallel with this, the emergence of the Open Geospatial Consortium's CityGML standard for 3D data exchange has provided a useful framework to describe 3D datasets according to their 'Level of Detail' – with Level 0 being 2.5D surface models, Level 1 block models of buildings, with flat roofs, Level 2 including roof detail and moving through Levels 3 (doors and windows) and 4 (internal details). While these are very generic descriptions, having this descriptive language available has certainly facilitated the ability of the 3D community to describe data to non-specialists, and hence increase interest in this area. Indeed, as predicted in the previous foresight report, we now have height information available for buildings in Great Britain's major cities, as part of the Ordnance Survey's Mastermap dataset, providing good LoD 1 data coverage. Third-party vendors have also developed models for some cities to LoD 2. The UK (via the Ordnance Survey) is in the process of developing a 3D dataset, identifying both the geometry (e.g. doors, windows, chimneys, roof structures) to be modelled and the required semantic information. While traditionally 3D data has been provided by National Mapping Agencies and other specialist providers, crowd-sourced LoD 1 data is now available via the Open Street Map project (although coverage and completeness varies widely even within London). Tools such as Google Sketch-Up allow non-specialists to capture individual 3D buildings and include them in larger models generated online.

To handle this data, again driven by the gaming industry, modern technology (not only desktop PCs but also laptops, tablets and phones) come with specialist graphics cards designed to render 3D data very efficiently and provide good performance for visualisation. This means that it is now possible to display city models with greater levels of detail without performance degradation.

Looking at software, the main focus to date has been visualisation of 3D GI, providing tools to model change such as the impact of a proposed new sky scraper on a neighbourhood or supporting line of sight analysis. 3D visualisation is not only available as a component of most desktop GIS, but can also be provided to non-specialists via approaches such as 3D PDF or web-based visualisation. Although 3D GI tools tend, at the moment, to be separate from those designed for 2D GI, this is changing with ESRI's ArcMap 10.3 providing side-by-side 2D and 3D visualisation. Spatial databases (both Free and Open Source and proprietary) provide good support for 3D GI storage, and also increasingly incorporate both metric (distance, area, volume) and topological (adjacency, intersection) query capabilities.

Despite these advances, it would be fair to say that the current view on the need for 3D GI amongst professional GI users ranges from "yes – we must have 3D - we can't do any analysis properly in 2D" to "it's OK for visualisation but beyond that doesn't really add any value, but instead adds complexity", with some people not being aware of 3D GI at all. While the specific view point does depend on the user's specialist domain, many users are unsure as to where to source data and how 3D GI can best be utilised. Few know how to go beyond basic visualisation.

Use Cases

To address this issue in the next 5 years, there is an immediate need to develop a series of Use Cases to demonstrate the potential of 3D GIS in a UK setting, making use of available software and data and working with potential end users in a variety of context. These Use Cases will provide a clear understanding of the benefits of moving to 3D, the processes required and the costs (e.g. user training, data acquisition) involved. Developing Use Cases highlighting business benefits of location and geospatial functionality is certainly not new – the skills to do this already exist within the GI community – and the results will provide a much clearer understanding of the value to the UK of investing in 3D. Questions to be addressed include 'what potential uses of 3D GI exist, and who would benefit most from 3D GI?', 'do we need national 3D mapping for all buildings, or are city and town centres enough?', 'are users happy with LoD 1 block models, or do they require further detail?', 'do users need textures/images to make the 3D model look more realistic?'

3D Software

To overcome the current focus on visualisation, in parallel to Use Case development, there is a need and opportunity for both the proprietary and FOSS developers to greatly extend 3D analytical functionality. Basic editing tools, metric and topological analysis, standard in 2D GIS, are required in 3D – can we find a balance between the powerful 3D editing tools offered in CAD/BIM software and the need for simplicity in GIS to appeal to a broad user base? Questions such as 'what does a 3D inverse distance weighting interpolation look like?', 'how do we remove 3D slivers, undershoots and overshoots?' and 'how do we generalise 3D data?' are still very much open.

While these questions will no doubt only be addressed in part in the next five years, having this functionality is fundamental to the success of 3D GI. In all cases, due consideration needs to be given to usability and ease of Human Computer Interaction processes.

Modern web and mobile users of GI should also be taken into account, and may even be expected to be the dominant platform for 3D five years from now. While desktop hardware can generally handle fairly large 3D datasets, this is not the case for mobile devices. WebGL is increasingly become the 'go to' platform for 3D gaming and other 3D visualisations, and developers are now be able to take advantage of lessons from the gaming industry to develop mobile 3D GI platforms, in particular as navigating through a 3D map is more complex than using its 2D equivalent.

Open 3D Data and Other 3D Data Sources

To date, in the UK we don't have 3D open data available with complete city-wide coverage for our larger cities, unlike for example the datasets available for major cities such as Toronto, Berlin or Rotterdam. While it can be predicted that the 3D Open Street Map data will increase in coverage, and research will help to identify its quality, coverage and completeness (as has been done for 2D OSM), the potential of opening other datasets should also be explored, perhaps building on existing 2D data. Such free data would allow a wider involvement in the development of 3D-enabled software and Use Cases promoting 3D. Additionally, while CityGML is the official standard for 3D data exchange, in practice the lack of standardisation in 3D data formats is still frustrating for the user and presents a barrier to uptake.

While point clouds (LiDaR or laser-scanned) are becoming important sources of 3D data – both indoor and outdoor, fully automated feature extraction and the management of increasingly larger point cloud datasets is still at the research stage, as is change detection between cloud. The ultimate goal of this activity is to be able to carry out rapid, detailed scanning as required, store data as a point cloud and extract features depending on individual Use Cases. Within the next five years, it can be expected that the current ability to semi-automatically extract walls, ceilings and floors will be extended to features such as tables, chairs and windows. The 3D Use Cases mentioned above will perhaps help to identify which features to prioritise.

Indoors, Outdoors and Bridging the Gap

Building Information Models and 3D GIS

Currently, although CityGML includes the ability to represent building internals, such data is frequently not available, with many city-wide datasets being represented at LoD 1, 2 or a mixture of both. While it is not envisaged that internal details for every building in a city will be fully available within the next five years, there is increasing interest creating 3D representations of train stations, hospitals, shopping centres and other public spaces. The focus of this activity is primarily indoor routing and navigation, with research being carried out into indoor positioning using Wifi, radio and other signals. Seamless navigation between indoor and outdoor environments is also a key focus.

While research is being carried out into low cost approaches to crowd-sourcing the required 3D data using techniques including laser measurement or low resolution point cloud scanners, there is increasing interest in BIM as a source of indoor information, in particular given the UK Government requirement for collaborative 3D BIM by 2016 on its projects. This, however, raises integration and interoperability challenges, particularly relating to semantics. BIM are exchange using Industry Foundation Classes, with 3D GI using CityGML - research into both the theoretical and practical aspects of interoperability is at an advanced stage and it can be predicted that a more seamless exchange process will be available in the near future. The next release of CityGML, due in 2017, will go some way to bridging this gap, and will also include new additions such as the ability to model feature types beyond buildings and to model building sub-units.

Time, Sensors, Smart Cities and the Internet of Things

The additional incorporation of the ability to handle dynamic data, and versioning in the next release of City GML reflects the fact that in parallel with the development of 3D, time has become increasingly important in GIS, with growing interest in four dimensional systems (4D, 3D + time) driven by the opportunities offered by Smart Cities and the Internet of Things. NoSQL databases are increasingly being used to store the vast quantities of big spatial data from sensors (high quality or low cost such as those used by Citizen Scientists) and other smart devices. A 3D City Model, provides an ideal framework in which to integrate, analyse and visualise this data, with Smart Cities re-enforcing the need for integrated indoor/outdoor models in order to support integration of the data into one framework no matter its source.

Current research includes algorithm efficiency to facilitate real-time processing of this data, as well as methods to present the results of this analysis appropriately.

In Summary

The challenges listed here highlight the fact that the full potential of 3D GI is a long way from being reached. Additionally, general challenges relating to GI - data management, standards, data quality and its representation, trust and Spatial Data Infrastructure creation cannot be ignored.

However, these challenges are worth addressing - potential beneficiaries of 3D GI include town and transport planners, air quality experts, land ownership and rights managers, estate agents, utilities companies, tourism authorities, providers of navigation software (indoor and outdoor), facilities managers and many more. 3D GIS have the potential to unite multiple domains that are currently treated separately – building interiors and BIM, sensor data, street and city models, underground data, finite element models, geology – into one platform, across a range of scales and addressing a wide variety of contexts. While integrating all this information into a single system is not a realistic or useful aim, in the next five years the demand for some level of integrated information will only increase, with drivers including the sustainability gains to be made by combining BIM and GIS, and the need to support Smart Cities and the Internet of Things. Parallel trends – for example FOSS and Open Data– will also drive demand, and emerging technologies such as 3D printing will enable 3D maps to be produced with similar ease to 2D maps. These efforts will move access to 3D GI beyond the current specialist users and into the mainstream.

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Current status and future trends in crowd-sourcing geographic information

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"The human animal cannot be trusted for anything good except en masse. The combined thought and action of the whole people of any race, creed or nationality, will always point in the right direction."

Harry S. Truman (33rd President United States of America, 1884-1972).

"I have witnessed the tremendous energy of the masses. On this foundation it is possible to accomplish any task whatsoever."

Mao Zedong (Chairman of the Communist Party of China, 1893-1976).

"[C]ollaborative production is simple: no one person can take credit for what gets created, and the project could not come into being without the participation of many."

"[B]ecause the minimum costs of being an organization in the first place are relatively high, certain activities may have some value but not enough to make them worth pursuing in any organized way. New social tools are altering this equation by lowering the costs of coordinating group action."

Clay Shirky (Author, 1964-).

The last foresight report was written at a time of dramatic change. The report highlighted key issues and directions for the geographic information community. Over its medium term horizon, it saw geography as changing, notably with new players entering and shaping the geographic information sector, the increase in location-awareness, the growing trend for information to be available to the public and increasingly open approaches adopted. One particular area highlighted in the foresight report was the anticipated growth of crowd-sourcing geographic information.

Since the publication of the first foresight report in 2010 there have been considerable developments in the general topic that it outlined as crowd-sourcing. This activity is to some extent masked by the considerable variety of expressions used to describe the inputs of citizens to the geographic information sector. A wide variety of terms have been used, including crowdsourcing, neogeography, user generated content, and volunteered geographic information (VGI). These various terms are often used to help to differentiate between activity that is passive or active or perhaps truly volunteered as opposed to information provided for a modest, and possibly non-financial, reward. Here, there is no particular desire to distinguish between the different approaches, although the detail can be important, and the focus is simply on citizen-derived geographical data.

The citizens may potentially be anyone, they could be children or adults, they may be amateurs or experts, they may have differing motivations and may even be contributing without knowing so.

With the proliferation of location aware devices and opportunities of web 2.0, it is now possible for citizens to easily acquire, share and use geographical information. This has had a revolutionary effect across a broad spectrum of activity from routine daily life applications through retailing to science. Resources such as Google Earth, Bing maps and even citizen generated maps through activities such as OpenStreetMap (OSM) are now widely and routinely used by diverse amateur and professional communities. While this trend is set to continue there is likely to be further growth, much linked to the provision of free or at least inexpensive data associated with the launch of new Earth Observation satellites and access to official government resources. These tremendous opportunities do, of course, come with challenges. The latter include dealing with a variety of concerns with the data. This includes the data deluge (e.g. the Sentinel 2 satellite due for launch will produce ~1 TB of data per-day and is just one of over 350 Earth observing satellites are to be launched by some 40 different countries by 2023) but also problems linked to data emerging from variable sources, in inconsistent formats and often without reference to any form of standards. Moreover, the data generated may be poorly described and associated with little if any metadata. To realise the full potential of citizen sensing there is a need to establish good practices and perhaps even protocols for some activities. This will be a challenging task, not least due to issues such as the diversity of data sets generated, devices used and sensitivities to error and uncertainty.

There is also clearly a strong desire to 'not kill the golden goose' by laying down rules and procedures that end up make volunteering an onerous task that ultimately deters the provision of citizen data. A variety of priorities to address have been identified including issues such as standardisation and interoperability (Brown et al., 2013), especially in relation to issues such as the INSPIRE directive, and groups are working on defining good practices to encourage mapping related applications. In particular, COST Action TD1202 is working on the identification of good practices and, where appropriate, protocols for the acquisition, description, storage, dissemination and use of citizen derived data in relation to common mapping applications. Before looking to likely future trends it may be helpful to first focus on some of the main aspects of current citizen sensing activity.

The field of citizen mapping is currently dominated by OSM but geographical information is acquired in a range of projects which may ultimately be mapped. The most-established citizen science projects that acquire geographical information are in the general area of ecology and conservation but the range of application areas is expanding rapidly, facilitated by recent technological advances. But even in these relatively long-established areas of activity there are strongly contrasting approaches and priorities. For example, the free tagging of OSM and lack of protocols contrast sharply to the rigorous protocols often found in ecologically-orientated citizen science projects, perhaps reflecting differences in the original purpose of the projects and the usability of the data for other applications. Geotagged photographs are also widely used as a source of geographical information. The number of repositories for geotagged photographs is rising rapidly, including popular social media, and these photographs may be used for a range of applications.

For example, geotagged photographs may be interpreted to indicate the land cover at the location and used as reference data in the validation of land cover maps. The potential of such resources is, however, greatly limited by concerns such as the spatial distribution and nature of the data acquired. There are so many potential data sets and applications that may make use of citizen data it may be helpful to focus on some of the benefits and limitations in one growing area as an example: crowd-sourcing to aid disaster risk management.

The disaster domain has turned out to be an attractive field for citizen sensing, with the vast majority of projects focusing on the post-disaster response and management phase. There are good reasons for this development: disasters are exceptional, highly visible events that often generate tremendous compassion and generosity, with the provision of VGI offering an easy and non-monetary way for members of the general public to help. The aftermath of disastrous events, at least when measured by media attention, also tends to be of limited duration, hence VGI projects can be quickly established and long-term continuity challenges are not an issue. However, the disaster domain offers its own set of challenges. Ways for volunteers to contribute are manifold, as is the number of volunteer types. On one hand there have been many successes: voluntary mapping platforms such as OSM scored some of their most visible moments when disaster-torn places such as Port-au-Prince, Haiti, where comprehensively mapped in a matter of a few weeks following the 2010 earthquake. The data set this provided to the many disaster responders were immensely useful. Similarly, the platform Ushahidi provided an effective vehicle for people located in the disaster-affected area to report on the situation, be it on the state of roads, bridges or other critical infrastructure, or to file requests for specific assistance.

The above examples highlight what volunteers are very good at: base mapping and reporting of local knowledge, with OSM combining both very effectively. However, VGI has also been used in several disaster damage assessment projects where remotely located volunteers mapped features such as structural damage, landslides, or temporary shelters using remote sensing imagery. Some campaigns only made use of professional volunteers with a remote sensing background (e.g., the GEO-CAN campaign following the Haiti earthquake), while others allow anyone to participate (the most visible platform being Tomnod). A key issue of concern with these data sets is their quality. Research on the value of such contributions, and on the ideal approach to harness the assistance of volunteers, is ongoing, including in the COST Action TD1202. The main problems faced by volunteer-based damage mapping are how to identify suitable volunteers, how to instruct them, how to monitor (and when needed influence) their mapping, and how to integrate the contributions from many volunteers at a time marked by both urgency and a frequent lack of validation data. Research is ongoing on the modelling of different volunteers types (e.g., the able and well-meaning versus those that are challenged by the task, that are indifferent to the accuracy of the results, or even those that aim at sabotaging the campaign), but also on how to make optimal use of multiple damage labels for a given structure that individually may be of questionable accuracy.

Over the coming years more work will be required to maximise the utility of VGI in other phases of disaster risk management, such as for hazard assessment, monitoring of potentially hazardous situations, and early warning. The potential of volunteered information, especially when coupled with physical sensors, is enormous, but more work is needed to establish proper conceptual frameworks to generate meaningful and long-term contributions, much of this also requiring protocols, and clear guidance on how to engage and train volunteers. The disaster domain is clearly also a sensitive one, leading to legal and ethical concerns. These include ethical concerns related to post-disaster reporting of damage and potentially of victims. Volunteered information can also lead to the realisation of certain risks affecting a given area, which can influence property prices or insurance premiums. The above-mentioned Tomnod damage mapping platform highlights yet another ethical challenge: VGI is increasingly seen as valuable. Tomnod was recently bought by a large satellite operator, meaning now that the generous volunteered contributions by people trying to help in a disaster situation are at risk of being commercially exploited. For such situations clear transparency rules are needed.

Finally before highlighting anticipated future developments it should be noted that citizen data, although typically arising from amateurs, has potential impact on authoritative mapping bodies. While the activities of the various VGI communities has not substantially changed the way bodies such as national mapping agencies (NMAs) produce data, change in the future is anticipated. In particular, the economic models of NMAs are changing and need to be adapted to the new reality in which VGI is abundant by, for example, proposing paid services based on geographical data and not only data or 'win to win services'.

To-date only a few NMAs are significantly engaged with VGI and typically using it only for change detection and error reports. More NMAs are likely to exploit the substantial potential of VGI when current barriers to its use, such as concerns on VGI quality and heterogeneity, legal and ethical issues, and crowd motivation and sustainability, are broken down.

Over the next five years it is anticipated that citizen derived data will grow considerably and be used in increasingly diverse ways. Given that the amount of spatial data available is increasing exponentially (Craglia and Shanley, 2015) and diversity of data sources and types is also increasing, one key issue will be the assessment of the fitness for use, which is intimately related to data quality and uncertainty. Data harmonization may play an important role in the era of big data, since it may enable data comparison, allowing the application of the law of big numbers (Kuhn, 2007) and contribute to an automated and fast preliminary data quality assessment and even data conflation. When multiple sources of data are available that may potentially be useful, methodologies also need to be developed to assist the users with the selection of a data set, or combination of data sets, for use in a specific application. Decisions such as these will be aided by the provision of information about the data and hence meta-data is likely to become increasingly important with citizen derived data sets. It is anticipated that there will be considerable emphasis placed on addressing the various concerns that exist with the quality of VGI. Projects may generate their own quality assurance approaches to meet their specific needs. Similarly, bodies such as the NMAs may develop their own processes and methods for using citizen generated geographic data. Given the huge amount of data it is likely that there will be a focus on the development of automated approaches for the assessment of VGI quality.

This will be challenging given the greatly varied nature of the data, which can be unstructured and heterogeneous, but essential for many uses.

Future developments in citizen sensing will also require greater consideration of the citizen as well as the end use of the data generated. A greater understanding of the citizen sensors is required as is a two-way dialogue with those using the VGI, especially as the citizens may be the source of useful ideas. Feedback to citizen contributors is likely to become important, especially in developing the citizen's skill and maintaining motivation. Real-world benefits and motivating reasons for citizens to participate in the acquisition of VGI need to be developed, ranging from calls to altruistic spirit and helping achieve a common good to gamification. There also need to be developments in relation to a set of legal and ethical issues. Some concerns are already evident, such as those mentioned above in relation to crowd-sourcing to aid disaster risk management. The legal and ethical issues may, perhaps, be particularly apparent when VGI is used by a legally mandated organisation such as an NMA. A series of important questions arise and need to be answered in the near-term. For example, in relation to the fundamental issue of legal responsibility, is this a matter for the citizen or the NMA, or indeed for both? Cho (2014:10) argues that there must be legal protection for volunteers in VGI data collection and projects. Otherwise "the ensuing litigation may destroy the VGI model before it reaches its full potential". The nature of the exact VGI information or data used and which use-case it is applied to may help to determine which legal, ethical and privacy issues are most prominent.

When information about individual citizens is transferred and presented within a geographical context the resulting profile information could be both "highly revelatory and involuntary" (Scassa 2012:p5) and this can raise important ethical issues that need to be addressed. It is anticipated that VGI will increasingly be harvested from sources as diverse as social-media and wearable devices which while potentially yielding vast amounts of useful VGI, including human movement, it comes with a suite of concerns ranging from privacy to the legal and ethical issues touched on earlier. These are complex issues with, for example, privacy legislation appearing to lag behind technological advance and differing between countries.

There are also serious concerns with the re-use of VGI. In many instances, especially when VGI is mined from open resources, it may be used for applications the original provider is uncomfortable with. As the ability to integrate and fuse together greater numbers of complex and disparate data sets increases it is of crucial importance that the issue of data re-use is addressed. Data re-use also links to legal concerns. For example, if the VGI was acquired by digitising from a map or image without relevant permission, what are the implications to those that re-use the VGI?

One critical issue related to the diversity and quality of spatial data is the need to develop good practices. Here, there is a tension between the desire to encourage volunteers without constraints on their activities and the desire to acquire highly useful data. The latter could be aided by the specification of best practices or even protocols but if these become too onerous they may actually act to deter volunteers. So, for example, much current VGI is derived from geo-tagged photographs.

The latter vary greatly in their value as a source of geographical information and the adoption of some basic good practices could greatly expand the value of the photographs while following best practices could help meet demands of some communities that have demanding data requirements. Thus, for example, the value of photographs to some applications could be enhanced by simple actions such as the encouragement of acquisitions from multiple directions to convey information on the homogeneity of the landscape as well as the provision of basic meta-data on the location from which the photographs were taken and their date of acquisition.

It is likely that the cameras used by citizen sensors will help provide better photographs for derivation of VGI in the future. For example, trends in the photographic capability of mobile phones suggest that the accuracy of geolocation will be enhanced and the development of 3D systems may provide a step change in the useability of content in geotagged photographs. These developments combined with advances in image analysis and processing, including enhancement of automatic classification algorithms, as well as increasing access to hardware such as high quality unmanned aerial vehicles (UAVs) should greatly help exploit the potential of crowd-sourcing geographic information to support an increasing array of applications.

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Additional Resources

There is a vast array of material on the subject in the academic and popular literature as well as available on social media or web sites. Interested readers may wish to use the following resources as entry-points to the wide variety of resources available:

TED talks:

www.ted.com

Example of popular VGI initiatives:

www.openstreetmap.org

Example of key academic context:

Goodchild, M. F. (2007). Citizens as sensors: the world of volunteered geography, GeoJournal, 69, 211-221.

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Geo-Enable BIM: The Big5 Challenges - What are you prepared to do?

Barry Gleeson & Martin Penney | Survey4BIM

"There must be a beginning of any great matter, but the continuing unto the end, until it be thoroughly finished yields the true glory."
Sir Francis Drake, 1540 - 1596.

Over the next five years BIM will drive not just transformation of the built environment but the geospatial industry itself. Its successful implementation is dependent on collaboration across all participants. The survey profession needs to be at the forefront of Geo-Enabling BIM. So what are we prepared to do about it?

BIM is part of the digital revolution taking hold on the built environment. The Digital Built Britain vision[1] aligns with the rise of the Internet of Things (IoT), Big Data and a desire for SMART Cities. All of these are underpinned by spatial context and geo-location. The Geo-Enabling of the internet (e.g. Google Maps, Bing Maps etc) and smart devices (i.e. smart phones, tablets, satnavs) has taken hold over the last five years. Its impact has been incredible. Entrepreneurs and commercial ventures such as Uber are leveraging the maturity of the digital revolution in communications and commerce (mobile devices, user reviews/ratings, payment systems,) by simply adding geo-enabling (a live map), they have created something transformative and disruptive - necessary ingredients for change. Five years ago it was worth nothing; today it is valued at £50 Bn.

Geo-Enabling BIM may not have the same potential for an individual company, but it does have an impact on society and the taxpayer. George Osborne's recently announced National Infrastructure Commission[2] is looking at a future pipeline of £450Bn of infrastructure investment in the UK alone. The efficiency target to be delivered by BIM in capital/construction cost reduction of 20% equates to £90 Billion efficiency. The additional lifecycle and sustainability savings required are even greater. Geo-Enabling BIM is a key part of turning these goals into reality.

So what is Geo-Enabling BIM? As a newly formed partner of the UK BIM Task Group we have spent the last 6 months looking at this question. Our group, Survey4BIM, is an open collective of geospatial professionals that came up with five challenges to Geo-Enable BIM - "The Big5" - a phrase borrowed from the Association of Geographical Information (AGI). These are Accuracy, Meta-data, Interoperability, Level of Detail and Generalisation. At first glance a geospatial professional might think it's all in hand. But if you look in the wider context of the UK BIM industry (or indeed the international BIM context) all is not as it should be.

The vision for BIM is clear but its implementation in a geospatial context is not. These challenges are technical, and to a certain degree cultural, and ones where we believe the geospatial profession has a significant and unique contribution to add. There are other challenges such as education, behaviour, procurement which many are taking up the challenge on, including Survey4BIM[3] . But the Big5 technical challenges are pressing and neglected in a geospatial context. If BIM does not solve these there is a risk the geospatial industry will not only miss a huge opportunity to be a key player in BIM, but become complicit in watching it hit the rocks. Indeed, the analogy of the geospatial community building a lighthouse to keep BIM off the rocks is a good place to start thinking about what we need to do.

The Big5

Challenges to Geo-Enable BIM Level 2

WHAT ARE YOU PREPARED TO DO?

The challenges covered below require the input from a broad spectrum of expertise from within our Industry and wider professionals.

Figure 1 shows the Big5 challenges as building blocks in a lighthouse that will geo-enable BIM Level 2. The benefits of keeping off the rocks are clear - avoid risk, rework, delay, added cost and clash.

We have assessed each of these building blocks in three ways. Firstly, what is the maturity of each process in the UK BIM industry context, not just geospatially? Secondly, where should it be to enable BIM level 2? Thirdly, where on the BIM Road Map should this maturity be available?

Following this assessment we can see what efforts are now needed to either push this forward, or to catch up. In particular where the geospatial industry can focus its efforts and have the greatest impact on BIM's success. These opportunities are discussed later. Now let's take a brief look at each of the key areas.

Accuracy

Accuracy could be driven entirely by geospatial experts, as some standards are already established and these could be introduced to the wider BIM industry through influential groups. BIM introduces the wider challenge of design accuracy, but if it were handled in the same way as as-built accuracies and was adapted for construction or fabrication tolerances, a solution could be found. Merging data sets of different accuracies or files with different elements of differing accuracy is something the survey industry has dealt with for centuries.

The digital workflow can accommodate the math and the complications of combining various accuracies and tolerances allowing them to be consistently interpreted. For measurement science there is no single source of the truth, only our best estimate resulting from a controlled combination of multiple sources of information.

Interoperability

Interoperability continues to be an issue for the BIM Industry. Regardless of the differing software formats, two fundamental issues arise; firstly the handling of grids and spatial reference, and secondly the interchanging of formats. These issues continue to undermine geospatial geometry, accuracy, level of detail and even information content.

Surveyors are well versed in these issues already especially, for example, when it comes to setting-out. This example is made more critical as increasingly, the information they are presented with is digital and not readily usable by survey instruments. Yet digital information is automatically perceived as being correct, which highlights the differing perception and validity of design data versus as-constructed data.

This current status must be challenged and resolving it could lead to significant efficiencies. How many BIM projects have stalled because two data sets have coordinate systems which don't readily sit together, and the new owners lack the tools to resolve it? Of more concern is how many times that these differences have been handled inappropriately and may have gone unqualified?

An example of this type of risk is the matching of postcodes to point locations. Some postcodes can represent 80 sq. km on the ground in the UK which may be perfectly fit-for-purpose for that particular location and circumstances, yet a satnav or mobile phone may offer an alternative single point location solution - yet they aren't necessarily interoperable. If location was required urgently in an emergency, then the consequences could be costly in terms of time or even human life.

Meta-Data

Meta-data is critical to understanding digital information. In geospatial context legends, standards and attributes are all commonplace from a legacy perspective. But digital meta-data standards are less well known and understood, even in the geospatial industry. Here the GIS world leads but in a BIM and CAD world element-meta-data is still underdeveloped. Meta data can support the resolution of the other challenges such as accuracy, interoperability and level of detail, but in a data driven world it also requires its own solution. Many groups such as the Open Geospatial Consortium (OGC) are working at present to upgrade meta-data standards (i.e. Gemini 2.3). The UK geospatial industry needs to be more involved and broaden the discussion to support BIM and element-meta-data. This is an area where, the soon to become three tribes of BIM, namely CAD, GIS and CGI, need to come together to facilitate a holistic solution.

Level of Detail

Level of Detail appears highly developed in many countries and in a BIM sphere. Yet it continues to fall down on a "real-world" or as-is and as-built basis. You can define all the levels of detail you want in a design concept, but if asked for example, to map all the underground utilities, without the freedom to expose and analyse them fully, level of detail requires a different approach. PAS 128[4] for example, is a valiant effort in the utilities field to provide guidance and solution but is not wholly BIM ready when it comes to level of detail.

The acronym "LoD" continues to evolve and be used with different meanings and therefore outcomes. LoD is starting to be expanded as Level of Definition – a combination of Level of graphic representation and Level of Information. This can become very confusing, particularly where one aspect develops out of sync with the other.

There is also the challenge of comprehensive approaches developing independently in different countries, for example, by the American Institute of Architects (AIA). We cannot afford to ignore these differences in the UK and just hope they will go away. One of the key goals of BIM UK is to become an exporter of these services, to keep our knowledge and expertise aligned and current in an international context[5]. Some of us in the Geo-Industry already operate in this sphere.

Generalisation

Finally, the generalisation issue presents one of the most difficult challenges and yet one of the most exciting. The illustrations show two practical examples of what a geo-enabled BIM world could do. These maps help the reader decide where they can afford to live in the most expensive city in the world by applying rental values to the London Underground network, with each route capable of being interrogated individually producing a long section of place against cost.

Social BIM Users

While not one of the BIG5 issues, social BIM is a phenomenon worthy of mention. Users of BIM are growing at a much faster rate than the technical experts who create, manage and share the data. The trend from geo-enabling the internet is showing more users with less skills and limited interfaces. For example, mobile screens are a lot smaller than maps and scale is becoming less controllable and therefore less intelligible. The conflict here is that more and more information is being pushed out in digital space but isn't being regulated and can be misinterpreted by users. Some would say that any information is better than none, but using the maxim where do you draw the line in the rigour of available data, is greater Geospatial guidance required here? (**figure 3**)

These are huge challenges for BIM but if we want to reach all the potential beneficiaries then working towards solutions now is critical to success. In the digital transformation model above increasing the user base (network effect) is the first principle of survival. This should happen organically, though with Social BIM society has the appetite for Geo-enabled BIM data without knowing its name. Furthermore the relationship between IT and Geospatial Information is now symbiotic. Users drive change by demand for data applications; manufacturers drive change through innovation to entice users. BIM is for everyone. The kings of Silicon Valley are betting that virtual reality is the way forward for future user access[8]. From the gaming industry to the movie industry the tools are developing faster outside the geospatial and BIM industry. So we have an opportunity here to bring this expertise into CAD and GIS for our benefit.

SO WHAT'S NEXT?"

The Big5

Opportunities to Geo-Enable BIM Level 2

So what are the opportunities for BIM? By mapping out the maturity levels of the applications of geo-enabled data (see diagrams below) in stages and relating them to the BIM roadmap, we can clearly identify where the opportunities lie for development and in so doing also focus on what actions we need to take as a professional community.

Maturity Levels

We have identified where the Big5 challenges sit now (Red Bubbles) and should be (Green Bubbles). This assessment applies to processes and organisations. The required stage is not the same for each, nor the optimum, and this represents the opportunity to improve further as BIM evolves (**figure x**).

Again, it must be remembered this is in a UK BIM context as opposed to UK geospatial industry context only.

Applying this staged process of adoption to a BIM Roadmap helps to clearly identify the gaps and the steps necessary to achieve BIM level 2 (refer diagram below).

Roadmap

When placed on the BIM Roadmap it can be seen that some of these key factors should have reached their required maturity long before we reach BIM level 2. Accuracy, as an example, should have been quantitatively managed when BIM was conceived. There is little evidence in the BIM digital workflow how this is defined consistently or quantitatively managed. Yet Accuracy is a fundamental attribute in defining quality and certainty and its impact overlaps all the other challenges such as Interoperability, Meta Data, Level of Detail and Generalisation (**figure x**).

ooking at the Roadmap and the maturity gap together we can now see that a significant effort is needed to geo-enable BIM Level 2. The next step is to see what actions the geospatial industry can focus on, and which ones should we prioritise?

Actions

In reviewing each of the BIG5 challenges a list of actions and opportunities have been considered as shown above. Just two actions have been highlighted for each challenge that encourages professional engagement and action. An initial white paper has been drafted on each with more detail on the assessment and what the action could entail. The next step is to explore the opportunities in more detail with the Geo-community and decide what we are prepared to do and how (**figure x**).

Call to Arms

Survey4BIM is going to launch a call to action over the next few months. We are seeking expertise, leadership and sponsorship in each of these Big5 challenges. We believe geo-enabling BIM is a huge opportunity for the geospatial industry now. Not only to deliver commercial benefits, for clients, for your business, for the UK industry, but to deliver the social benefits which BIM can enable. The targets are hugely challenging and currently at risk . If we combine our efforts and get involved now we can play a huge part in turning this into a success for BIM and the geospatial industry. We have the chance to geo-enable BIM over the next 5 years. I truly hope you are going to be part of that.

Take the next step with your fingers and click here:
www.bimtaskgroup.org/survey4bim

About Survey4BIM

Survey4BIM is an open and influential geospatial group which aims to help unite geospatial professionals in Geo-enabling BIM. Two seminal papers have been issued – A client's guide to laser scanning- an early foray into the unknown and recently the DPoW- an insightful paper on the role as surveyor and client throughout the asset lifecycle. Join us and help Geo-Enable BIM. www.bimtaskgroup.org/survey4bim.

Special thanks for preparing and reviewing the Survey4BIM White Papers on the Big5 challenges go to Mark Lawton Skanska, Andrew Evans Topcon, Mark King Leica, Martin Penney TSA & Technics Group, Simon Navin Ordnance Survey, James Kavanagh RICS, Ian Bush ICES & Black & Veatch, Steven Eglinton GeoEnable, Paul Cruddace Ordnance Survey, Chris Preston RICS & Network Rail, and Anne Kemp AGI & Atkins.

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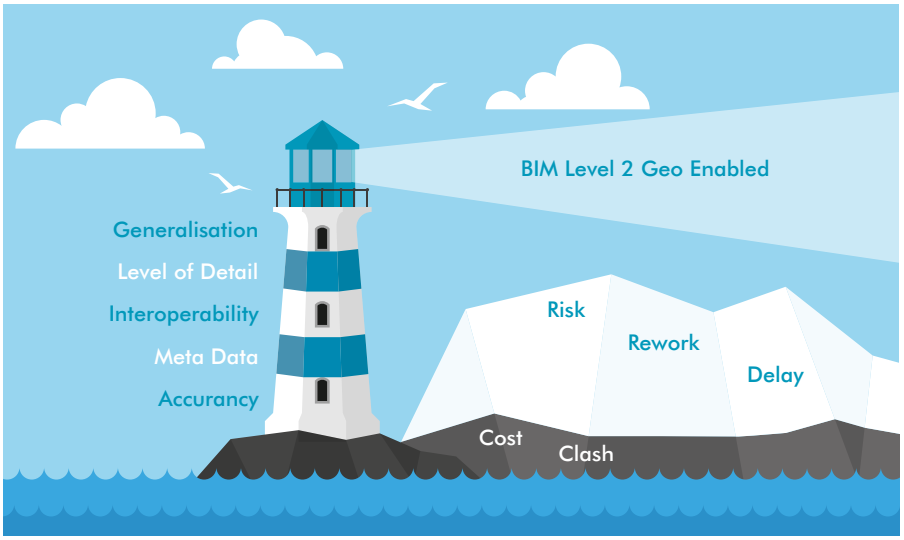


Figure 1 - The Big5 - Lighthouse. Illustration created for AGI based on Needles image

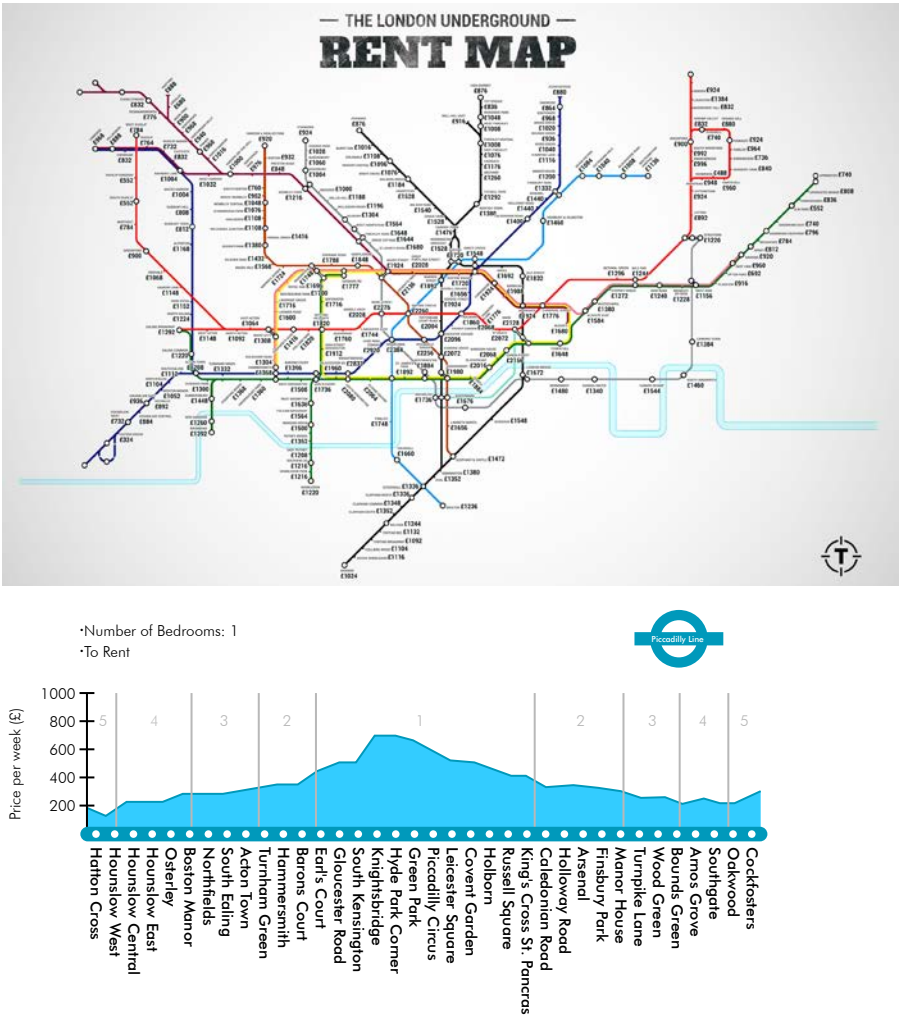
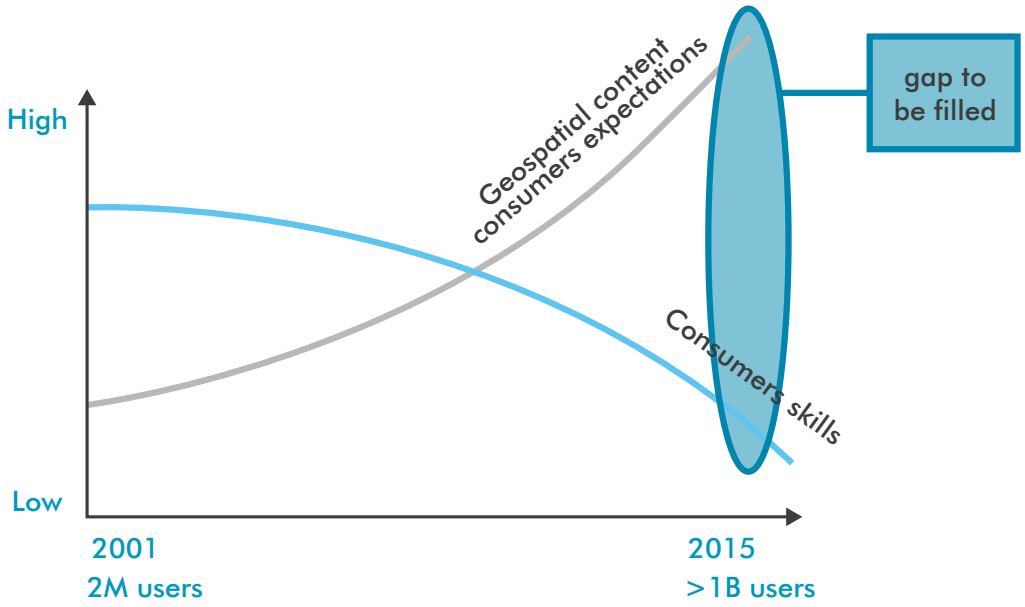


Figure 2 - Tube Station Rent Map Analyser (average 1 bed rental cost with 1km of station)[6]

INTERNET INFLUENCE ON GI USERS



INFLUENCE OF IT TRENDS ON GI

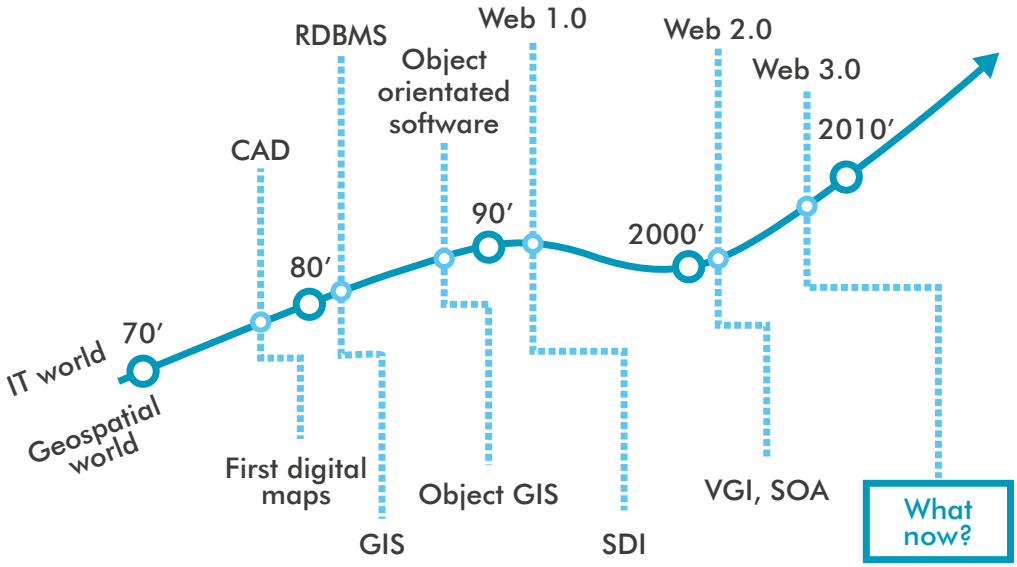


Figure 3 - Prof Adam Iwaniak - Presented at Geo Business 2015[7]

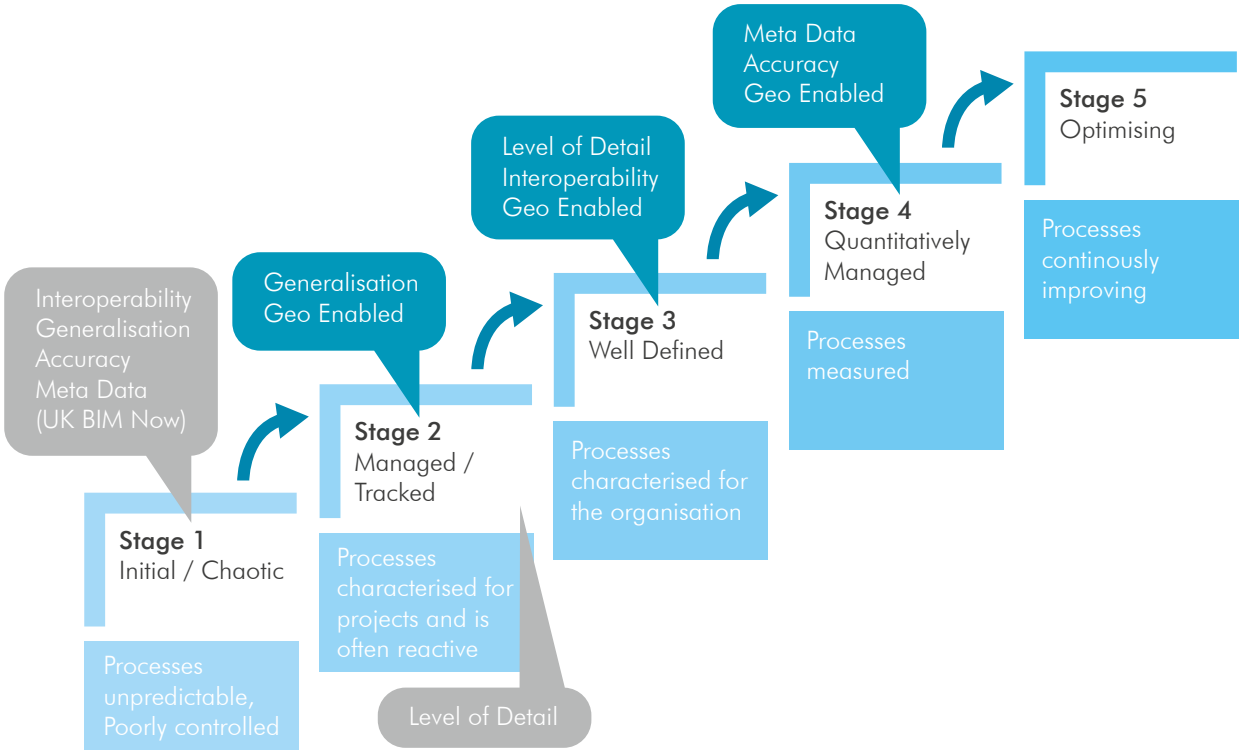


Figure 4 - Standard Maturity Model attributed to Nolan 1973, Watts Humphrey 1988 & Godfrey 2008

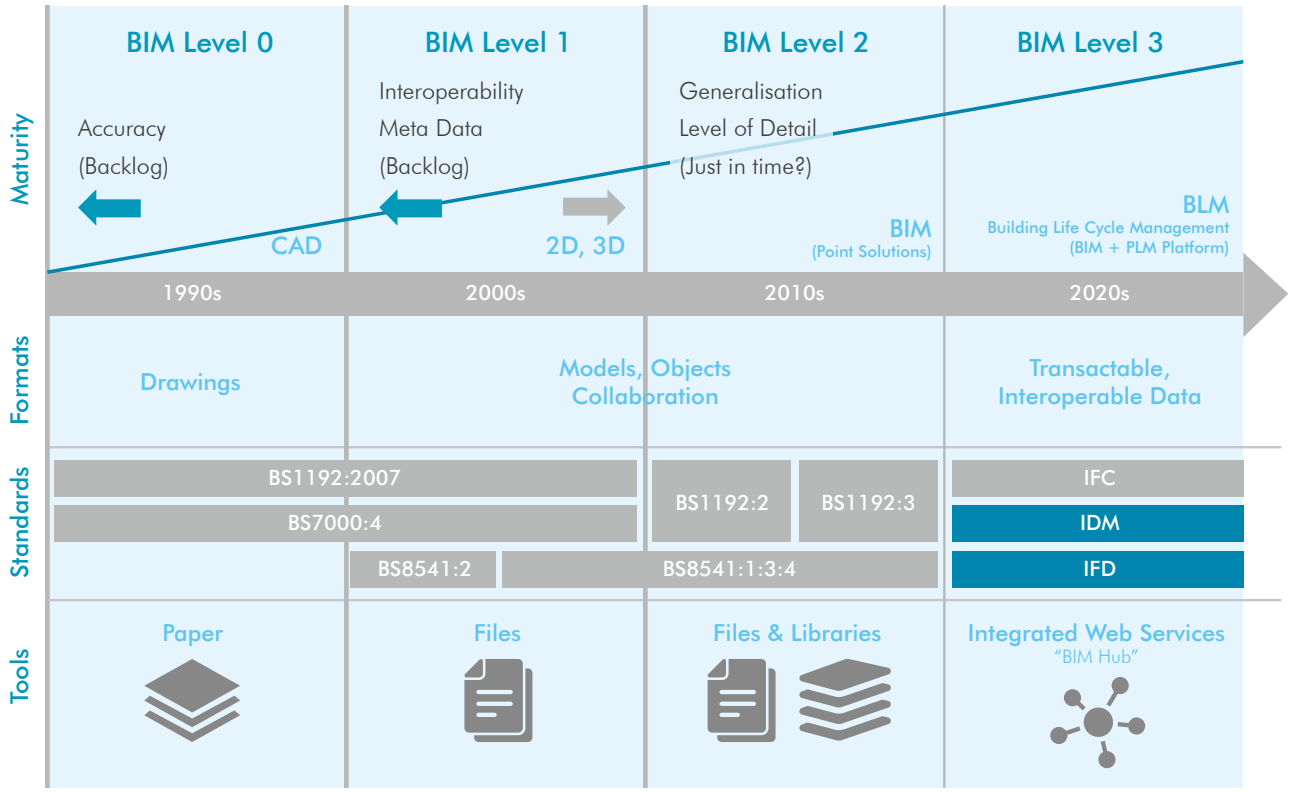


Figure 5 - The BIM Maturity Model by Mark Bew and Mervyn Richards adapted to reflect BLM's relationship to Level 3.

Headline Action Opportunity	Accuracy	Interoperability	Mata Data	Level of Detail	Generalisation	Resource Support
Carry out a controlled test		Yes				Internal
Carry out survey	Yes			Yes	Yes	Internal
Collate existing forum / group activity	Yes			Yes	Yes	Internal
Collate existing standards	Yes	Yes	Yes	Yes	Yes	Internal
Create Internal Workgroup Solution / Proposal	Yes		Yes	Yes	Yes	Internal
Join and influence existing forum / group	Yes		Yes	Yes	Yes	External
Produce case study		Yes				Internal
Produce guidance		Yes	Yes	Yes		Internal
Set challenge for software house	Yes	Yes				External
Develop a detailed Road Map			Yes		Yes	Internal

Table 1 - The Big5 Actions

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Is the 'where' there in our policy making?

Clare Hadley | Ordnance Survey

"Good government depends on good policy making. When policies fail the costs can be significant; repeated failure can erode confidence in government, and in the democratic process itself.[1]"

Making policy better, Institute for Government, 2011

Geospatial information can have a critical and valuable role in the creation and delivery of policy by administrations. However, there are many examples where this has not been the case. There are a number of reasons why and potential steps which could be taken to address those issues. This paper sets out some of them with thoughts on how AGI could help improve the situation to the benefit of the industry and the citizen.

What is the issue?

AGI members do not need to be told how important it is to consider geography when developing and implementing policy. It is clear to us that the spatial aspects need to be considered at every stage of what is known as the 'policy cycle' from the initial evidence base through delivery to the post-implementation evaluation. But there are many examples where this has not been the case leading to critical headlines, wasted public money and poor outcomes. Two examples: First, the 'Help to Buy' Scheme[2], which was applied to all parts of England equally. This ledg to criticism that the money had gone to the wrong places and the policy had not achieved what it had set out to do in others. The RICS argued that should be amended to reflect variations in the housing market across the country and only applied to certain postcodes. Somewhat ironically, the statistics on the take-up of the scheme have been published by HM Treasury as open data and a nice interactive map produced by totallymoney.com[3] showing the geographical inequity of the scheme. Secondly there is the European Commission's investment in airport capacity. This was roundly criticised by the Court of Auditors for, amongst other things, not having done appropriate catchment analysis[4] leading to over-capacity and airports too close together.

This is simple stuff to a GI analyst, so why is the 'where' not being sufficiently considered and what can we do about it? After all, as taxpayers, it's our money which is being wasted by a lack of spatial awareness on the part of our policy-makers. Conversely, there are potential benefits if policy which has been grounded on good spatial analysis delivers well.

Why is this the case?

It should be said at the outset that there are pockets in government in the UK, Devolved Administrations, the European Commission and internationally where they do include geographical thinking in policy making. One example would be the embedding of a geospatial specialist in the Digital Scotland policy team. However, this is by no means common yet. Factors appear to include:

1. Governments outwardly subscribe to 'evidence-based policy making' but do not always include GI as 'evidence' or use it[5].
2. A lack of 'spatial awareness' in the training for policy-makers. Standard policy training does not appear to include it, even in the 'evidence' sections.
3. Those trying to communicate the value of 'where' have poor understandings of both the policy-making processes and the players in that process. This leads to the wrong message being pitched to the wrong person at the wrong time.
4. A low professional profile and no professional structure for GI specialists – certainly in the in UK Government and probably elsewhere. This contrasts with, for example, statisticians and economists who are well regarded, have a career structure in UK Government and a 'Head of Profession' to champion the value of their input.
5. A lack of availability of easy-to-use consistent geographical tools for non-specialists to use. There are vast amounts of data available, especially since the growth of 'open data' initiatives across the globe and, closer to home, the PSMA, OSMA and NIMA but much of it is still effectively closed to the policy maker until there are appropriate tools available on their desks and the data is coherent and consistent enough to provide valuable answers for them.
6. A lack of appreciation of data and data management issues within government. This is not to say that those who manage data do not do it well – they mostly do as well as their resources permit – and there's the rub – the appreciation of why it is important in the minds of those holding the purse strings. With the public sector facing 10%, 25%, 40% cuts but with ring-fencing around certain departments and 'front line services' it is inevitable that what it seen as a back office nice-to-have comes under pressure due to lack of understanding.

What can we do?

So, what do we, as AGI, need to do?

1. Get closer to policy - understand the policy-making process and the players and keep up to date with policy initiatives which may have a geospatial element to them.
2. Build and maintain useful and effective relationships – it makes it easier to influence when needed. It's easier to get involved early on if you know what is happening[6].
3. Engage with the right person at the right time with a message they want to hear in a language they understand. Talk to the right people - depending on the situation, this may be policy advisors, analysts, GIS teams, or statisticians etc. We need to focus on what policy makers are concerned about – what stage of the cycle are they in, what is causing them problems? We also need to be aware of problems that they may not be aware of – but express them in their language. GIS is pretty meaningless to most.
4. Seek to raise the profile of geospatial professionals in government, supporting professional qualifications and networks. For UK Government, for example, there is an initiative coming from the Central Government Geography Interest Group which should be fully supported.
5. Seek to embed consideration of the 'Where' in the policy-making process through training, communications, big initiatives, case studies. Seek to make it as ubiquitous as statistics.
6. Ensure there is a solid consistent base of geospatial data to support the 'Where?'. The need for data which is about relevant spatial objects, appropriately structured, available, maintained, to a known quality etc. is rarely in doubt among AGI members. The UK Location Strategy[7] set this out many years ago, it forms the core of the INSPIRE legislation[8]. We need to communicate that more widely.
7. Move the use of geospatial data out from the specialist areas by providing tools that all levels of knowledge can use easily and link it to other techniques used by policy makers - such as collaborative policy making.
8. Press for a more joined up approach to geospatial data across government.

The Benefits

Solving this problem is complex and will involve many players and some considerable time to effect such a culture change. Policy-makers need to think differently, we have to provide the necessary data and tools to use geospatial data, and we need to co-operate with other data- and information-based professionals, such as statisticians, to achieve anything. Having said that, even small steps can help – raising awareness here, celebrating successes there – so this should not deter us. The benefits could include objective evidence-based policy, efficient and effective delivery and no unintended spatial inequalities for the citizen which is something to which we should aspire.

Call to Action

AGI could:

- Seek to raise awareness in governments that the 'where' is important in their policies
- Publicise case studies both good and bad of the use of geography in policy
- Support the 'professionalisation' of geography in Government and further promote the Chartered Geographer qualification
- Engage with other professional groups on this issue
- Work to ensure a solid geospatial data base for policy makers along with appropriate tools

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

To CAD or not to CAD? That is the Question

Barry Hall | Atkins

In recent times there has been an increased demand for information to be transferred from CAD to GIS platforms and back to CAD, this process brings many questions about the readiness of formats and skills required to perform this type of data transfer. When engaging in the transfer of data there are a number of considerations that need to be taken into account, the following will look to highlight three main key areas for concern; data degradation, software readiness and user skills.

The arrival of BIM has acted to push the question of information transfer to the front of the mind, with BIM having a requirement for the inclusion of procedures for approval and acceptance of shared spatial data, business as usual might not now be good enough. Validation and verification of spatial data is a key deliverable of a BIM CDE process, understanding the data transfer methodology is a key requirement of this process.

The data transfer process has both host and target applications, the host being the software used to create the feature and target being the recipient software. In some cases the target software may not be known, in this situation data from the host might be converted to an intermediate format like COBie/ XML that acts as a suitcase in the journey of data transfer.

The main function of a CAD application is to create designs from which manufacture or construction takes place, the information created within CAD maintains a high value for use in other application outside the core design application. Moving information between applications will require a data transfer action, this transfer can be a direct or indirect function. Direct transfers allow the host application to process the transfer utilising built in tools through an import/export function, indirect transfer would utilise 3rd party software to carry out an interim conversion process. Any transfer process has an acceptance requirement to verify that data output from the conversion process matches the input data and is suitable for purpose.

Within the world of infrastructure many tools exist within the CAD environment to assist engineers in developing their design work, some of these tools contain complex functionality. Outputs from these designs are held within the source CAD file. A simple question is, Will all this data be readily available for transfer to GIS? – No.

For example a highway alignment has a visual display of a linear feature, but within the CAD model this line may also contain the "maths" (transition curves etc.) required to develop the design of the alignment as a unique feature within the CAD file. The structure of an alignment can allow dynamic changes to take place, moving a node on the alignment will change the line to suit pre-set design parameters. Within an infrastructure project spatial data like an alignment is an important dataset required for inclusion in other applications such as GIS.

These unique features from the CAD world add complexity to how spatial features are converted to GIS, for example Arcs, spline curves, multi-lines are examples of features where conversion from CAD may encounter difficulties. The adoption of additional processes will be required to deliver this type of information in a compatible GIS format, each additional step in a conversion process adds risk of error and needs to be mitigated through robust checking procedures.

A key difference between CAD and GIS relates to how attribute, or non-graphical information, is handled. Within GIS attribution is a fundamental part of the data structure, all GIS features have a requirement to contain attribute features which have a direct link to a graphical feature. CAD handles attributes in a different way. Attributes are not compulsory to CAD. When used there are limitations on functionality with a high probability of data loss or corruption due to either software or user. Where attribution contains specific information, including metadata, about a feature it is important that the integrity is maintained through any conversion process and the structure remains whilst having temporary or permanent residency within another application.

As mentioned previously the traditional use of CAD is within a design environment, there are many add-on tools or "plug ins" available to allow CAD users to make the step into attribution and data management. Within the Autodesk world these tools include Civil 3D and AutoCAD Map 3D both extensions to the vanilla version of AutoCAD. Having tools available which are not a core part of the software does raise the question of skills being available to work with attribution within the CAD community, skills that will be able to utilise these tools to best effect.

Feature Data Objects (FDO) is an option within AutoCAD enabling CAD to connect to a spatial database allowing features within the database to be displayed as graphical and non-graphical features. With GIS able to connect to the same information this removes a requirement to convert data between the two interfaces. The master data remains in the spatial database and is represented within the CAD and GIS environment. Edits carried out within CAD or GIS will be recorded in the database and display directly in the other application. This has proved to be very successful when working with the key GIS feature types of points, lines and polygons – certainly an opportunity for further investigation.

In summary alignment of CAD and GIS for exchange of information is not yet available except for the simplest of graphical objects of points, lines and polygons which convert well as graphics. The use of attribution within CAD remains an issue, inexperienced users may introduce the potential high risk of data loss.

Alternatives where data is hosted external to the core application and delivered as Web Map Services (WMS) and Web Feature Services (WFS) should be given further investigated, they are valid options where reference data needs to be incorporated in a drawing/map as view only features.

BARRY HALL

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

The Future of Desktop GIS

Sarah Hitchcock | GeoLytix

"My advice to someone that wants to get into the GIS field is – don't, because it's not going to be around much longer. What you should do is – get into a profession you really enjoy, and learn how to apply the various GIS tools to your work."

Don Meltz, 25th October 2009 – owns an independent planning consulting firm

Typing 'Desktop GIS is dead' into Google brings up pages of blogs and conference notes discussing its demise and dating back to 2008. But seven years on the reality is that the majority of retailers, if not all, are still using a desktop GIS. So what happened – and what lessons does this give us when we forecast its use over the next five years?

Going back to 2008, many of the large retailers were starting to see movements in mobile applications technology and looking forward to a future where every location planner and surveyor was able to run a sales potential model while stood in the middle of a field or town, looking at plans for a new site.

While a handful of these competitors have implemented mobile systems to capture competitor information or review demographics in recent years, the vast majority still use a desktop GIS – and the reasons why this happened continue to be relevant and will inform what happens in this field in the next five years as well.

GIS in Retail Today

The issue of whether a desktop GIS will still be a relevant and useful part of a retailer's 'box of tools' has become part of a much bigger question in the last five years as retail has changed. As the sector continues to diversify and grow to keep track with consumer spending habits, so analytical systems themselves have to keep pace. To give some examples, as well as their impact on GIS systems:

- **The explosion of convenience stores** has resulted in a ten-fold increase in the number of sites being reviewed by retail property teams. Keeping track of all the data around a 100 – 200 store opening program requires a significant database as well as effective processes and systems for its use, with the ability for multiple people to slice and dice the data simultaneously
- **Growth of online** has muddied the waters significantly – we now have another channel to consider, with new sets of data to track and additional service needs. Retailers have the huge challenge of integrating their online and store experience for customers (how often do sales assistants in fashion retailers discuss their online facility as if it's a competing business?), which has meant that integrating analytical systems has often been pushed down the priority lists
- A Continual Pressure on Costs has resulted in many head offices relocating. This in turn means that regional offices and working from home are becoming the new norm, with the obvious knock-on requirement that colleagues need full **access to systems wherever they are**

Convenience, Online and Discount

Fastest growing channels in the grocery market

IGD RESEARCH 3RD JUNE 2015

- After years of rapid advances, sales growth in convenience will be more measured over the next five years, with IGD expecting sales growth of 17.0% between 2015 and 2020, vs the 27.4% achieved between 2010 and 2015.
- Online will continue to be the fastest growing channel over the next five years, with sales increasing by 92.9% to £17.2bn as the Internet becomes more widely used and relied upon by UK shoppers.

- **Higher Expectations** –Users expect forecasting models to run and produce results in minutes, whereas their predecessors accepted computers took a long time to crunch significant amounts of data. Gravity and forecasting models are becoming more complex as we add in more data, formats, channels – but – are still expected to run every bit as fast
- The amount of Data keeps growing, as does the number of users who want to access and interrogate it. Retailers have long realised the benefit of ensuring that the **whole business can access insight**, rather than just a small analytical team. Boards of Directors are now questioning why it this isn't happening effectively and so its priority is slowly increasing across the sector

Retailers have long acknowledged that a web-based system with one version of data (whether true or false) that can be accessed by all is a key requirement, but the all-important issue continues to be how this can be best provided. Therefore whether the desktop GIS exists in five years' time depends in huge part on whether it can be integrated into wider systems in a meaningful and effective way.

Looking forward to 2020

By 2020 most of the largest retailers will have established a web portal that allows access to all users, effectively linking property, marketing, online and location planning colleagues, as well as their knowledge and needs. The success of these portals, of course, will depend on the priority the retailers give to the information that is entered, the business processes that sit behind them, as well as ensuring everyone is fully bought into the system – which can only happen if it has universal usefulness.

These portals will facilitate large opening programmes, provide detailed insight for convenience locations and store vital information on the current estate, as retailers look for novel ways to optimise their current stores, given that the race for space for large boxes has slowed significantly.

The Desktop GIS Software providers recognised this long ago and do offer solutions that integrate web portals and Desktop GIS, but are now competing in a much larger playing field.

The high street retailers who use an 'off-the-shelf' desktop network potential model will have switched to a similar web-based product, of which many can be found in the current market.

The missing part of this equation rests in the answers to the business questions below, which continue to require complex analysis:

- Do we have too many stores? What is our optimal network given the growth in online?
- When will the market saturate?
- Where are our battlegrounds for direct marketing – what type of potential customers live there and what offers will be effective?

These questions require all possible data sources and modelling techniques to be thrown in (e.g. loyalty card, competitor locations, demographics, gravity modelling, mobile phone or financial data) and manipulated, and by 2020 the amount and volume of processing makes it likely that a web interface could not handle the transfer of data.

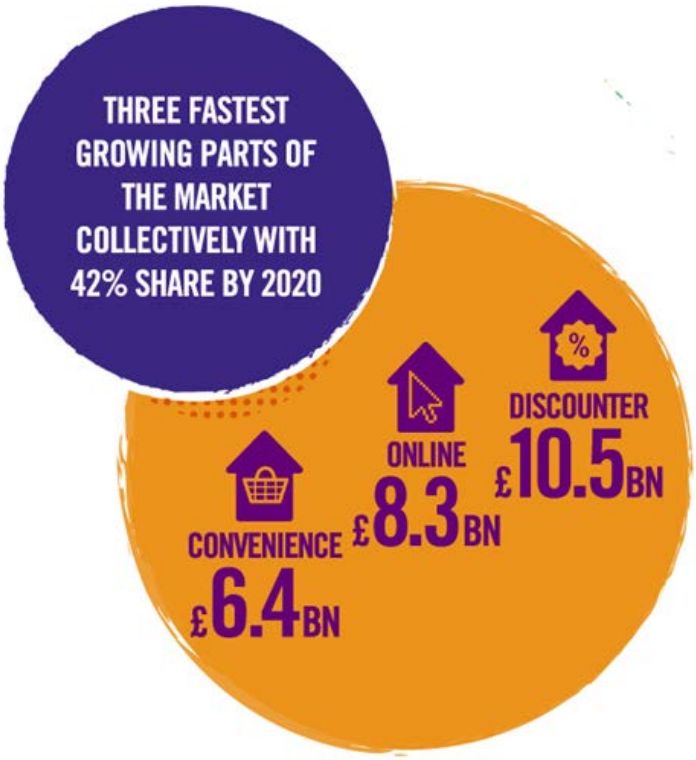
Whilst web is not currently an alternative solution to these meatier business issues, there is competition in the market from advanced ETL tools (Extract, transform, load) with enhanced geography and spatial awareness. This means we can now live without a desktop GIS.

Conclusion

In 2020, there will be still a place for desktop GIS but probably not for the retailers.

Retailers won't need to do any heavy lifting of data creation as this can be done by a consultant or a specified in-house analyst. Therefore, the majority of colleagues will use web-based systems and a dedicated resource will have the full-blown desktop or advanced ETL tool acting as a support for ad hoc requests. Companies can then switch the 10 – 50 desktop user licence costs (where the majority of users will only have the time to use 5% of the features) to a much larger number of web licences to reach a larger audience.

Linking back round to the starting quote, this will then lead to a better distinction between data scientists and analysts.



There will be companies, like us, that combine the two but generally the future of retail GIS users will fall into one or the other.

Looking out to beyond 2020, it's not so much about desktop GIS having more or fewer advantages over web GIS, but that the general trend of technological advancement can't be stopped. It doesn't matter that there will always be good reasons to use desktop GIS – no-one is going to continue buying them if everything else is on the web.

GeoLytix

GeoLytix solves business problems where location is critical; e.g. where to open stores, what to sell in them, and how to optimise home delivery and click & collect operations. GeoLytix work with organisations such as Boots, Camelot, Post Office and the major supermarkets. Solutions are a combination of data, algorithms and software, and rely on 'opendata' providing a competitive advantage from only charging for value-add analysis or custom novel datasets.

Blair is a world-class modeller and was previously Head of Analytics at Pitney Bowes Mapinfo. Sarah spent 11 years at Sainsbury's shaping the network and growth space strategy as head of the Network Planning department.

Most importantly, all the team members have experience from being the customer, and so understand clients' needs. Success is based on truly listening to customers and then providing an appropriate tailored solution. GeoLytix also advise on wider commercial strategy, working with the customer, and often up-skilling them so they become self-sufficient.

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

A Future View of Geospatial: Towards the Geography of Everything

Professor Andrew Hudson-Smith | The Bartlett Centre for Advanced Spatial Analysis, University College London

In the last five years the world of geographic information has taken a notable shift. Techniques for data tagging have advanced, data gathering costs are falling and those trained in data analysis and geographical information are increasingly being relabeled as Data Scientists. The shift is part of the data revolution, everyday we create 2.5 quintillion bytes of data — 90% of the data in the world today has been created in the last two years alone. This data comes from everywhere: sensors used to gather climate information, posts to social media sites, digital pictures and videos, purchase transaction records, and cell phone GPS signals to name a few (IBM, 2013). An increasing amount of this data is geographically tagged and is becoming easier to gather, track and tag data and objects. We are moving towards an era of Linked Data, The Internet of Things, Seamless Geographic and Built Environment Systems, Augmented Realities and ultimately the creation of the Geography of Everything.

The Internet of Things

The Internet of Things is arguably the current buzz phase in the technology industry. The concept is simple, everyday objects linked to a network allowing the ability to read, write and execute data. Along with the data exchange comes the ability to geographically locate objects. In 2015, 4,800 connected end points are added every minute. This number will grow to 7,900 by 2020. The installed base of the Internet of Things devices will grow from 10.3 billion devices in 2014 to 29.5 billion in 2020 (Forbes, 2015). An increasing amount of these objects will be geographically located, providing data from known locations. It is the new horizion of data gathering; we have not come close to the true meaning of big data in 2015. By 2020 and beyond 10.3 billion plus devices will be streaming data, data that can be collected, stored, analysed.

The Demise of the Data Store

In the same way as the 'things' join the network, data will become linked, either via common standards or simply via advances in data joining and archiving. At the moment cities, companies and research labs are actively building their own data stores.

Data stores are a slightly archaic take on the issue, we will look back and wonder why we created these new silos for information, locating data on central servers to download and analyse. Data will arguably become part of the search engine, located anywhere and everywhere but linked via standards and protocols, this is especially true of real-time data. Indeed, you can see it already happening with data systems beginning to cluster together to provide a single application programming interface in and out.

Augmented and Virtual Realities

The laptop style computer screen for any kind of geographic data with an x,y,z axis is arguably flawed. Augmented and Virtual Reality has reached a point to hit the mass market within the next year. Microsoft's Hololens is a key example of augmented reality that changes the field in terms of geospatial information. Early demos linked to 3D systems such as SketchUp and BIM style environments as well as geospatial gaming systems such as Minecraft provide but a glimpse of the future. Within the next 5 years Hololens style systems will become the norm for viewing and communicating spatial data, in a true three dimensional space yet also overlaid on the real-world. Virtual Reality, in various forms such as the Oculus Rift through to the Playstation 4 headset and the low cost Google Cardboard also has its place.

Early issues around motion sickness that plagued early Virtual Reality systems are largely solved. However, the current technology barrier is arguably the cable. Wire free Virtual Reality with spatial tracking is still 5 years away to become usable. That said, Virtual Reality systems will increasingly become the norm, indeed to take prediction to its wildest form, it has the potential to truly cause the death of distance, allowing one to be immersed, anyplace, anywhere with anyone.

The Internet of Me

The IBM quote at the beginning of the article is about self data, data shared via social networks. With the rise of the Internet of Things, alongside the rise of wearable computers, such as the Apple Watch, the amount of personal data shared and collated is another change on the horizon. Applications and sensors linked to our personal biological wellbeing are able to track our vital statistics and provide an overview of our level of health. From our heartbeat being measured every 15 minutes with smart watches through to glucose levels, amount of physical activity and mental wellbeing, a new level of data is being shared. We define this as the rise of the 'Internet of Me', personal information detailing not only social network style data but also physical and mental wellbeing is increasingly being collated and shared. Such data not only provides new insights into geospatial patterns but also provides insights into predictions that could be fed into health services and the wider concepts around the Smart Home.

The pattern is one of continuing advances in the collection, analysis and communication of data. We are moving into an era of ubiquitous data, visualized within three-dimensional environments. Geospatial is moving into the analysis of data worlds, we will look back at terms such as data store, smart and big data with wry amusement.

Yet it is these trends that mark early glimpses of the future of data and geospatial. In the same way that the QRCode is long gone in the fast moving world of the Internet of Things, we are at the start of a new data revolution and it's the most excited I have been about geospatial data in my life.

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

GI for Humanitarian Response

Chris Ewing, Liz Hughes & Matt Pennell | MapAction

Four years ago, the UK government's review of humanitarian response predicted increasing challenges[1]. Every three years a system-wide analysis of humanitarian assistance is completed. This year's report highlights the sobering point that coverage and capacity gaps in crises continue to exist and are worsening despite the investment in innovation, new technology and better coordination[2].

The gathering complexity of humanitarian crises and emergencies around the globe make it necessary to find new ways to respond. In May 2016 the World Humanitarian Summit will take place in Istanbul and will undoubtedly reflect on the place of innovation and collaboration to achieve change. It may also look at the interface between the private sector, government and the humanitarian world in shaping the aid response of the future.

As part of its five year strategy, MapAction has been reviewing these areas and here makes some suggestions on their relevance to AGI.

Humanitarian Context

There is wide agreement[3] on the reasons for the worsening humanitarian situation. Many of these are the same challenges reflected in the Foresight Report published in 2010. They include increased population growth and urbanisation combined with climate change and geopolitical conflicts. Such a mix of factors inevitably leads to increased stress and strain on governments around the world, especially newly-formed states, or developing nations which may have had a history of conflict, poor governance or reliance on external aid.

Each new emergency manifests itself differently, and the humanitarian system needs to be flexible in its response. This is challenging but there are new resources to help. The digital age has combined geography with technical applications and heralded the availability of software, data and technologies to enable the humanitarian system to do more and empower communities around the world to help themselves. Key to this has been the availability of free and open datasets, increased transparency from governments, and the availability of free and open-source software.

Further questions remain how to apply these new technologies and how to remain one step ahead of the next 'new' emergency with timely anticipation of this rapidly changing geography. In particular, there is a challenge of disaster response in disconnected environments where these new technologies could be disrupted, overwhelmed or simply insufficient to support the relief effort.

New ways to respond

To meet changing humanitarian needs there are a number of ways to respond through innovation, interfaces and competencies between stakeholders in humanitarian situations.

Innovation

Innovation has enabled a plethora of individuals to become involved in helping humanitarian crises from afar. Projects such as OpenStreetMap and TomNod allow an individual from anywhere in the world (perhaps sitting at a desk in an office in Manchester, or from a smart phone in Beijing) to contribute to solving issues as diverse as child slavery or displaced persons. The TomNod service allows users to view a series of images and classify the image into a category, thus helping the responders on the ground to better prioritise their work. With this and similar initiatives the idea is to help those on the ground, but despite good intentions it may not always help those most in need perhaps due to a lack of understanding of the situation, or lack of appreciation of the underlying historical or cultural issues. One must always consider the end user or community and ensure they are not overloaded with information which cannot be dealt with or understood. Ensuring such information is user-focused and harmonised with other providers on the ground is one way to overcome this.

With the ability to generate more data into the humanitarian context, we are seeing an increasing need for efficient information management. Information management covers *'the various stages of information processing from production to storage and retrieval to dissemination towards the better working of an organization; information can be from internal and external sources and in any format.'*[4]

Again the end users and/or beneficiaries of the information must be considered. There has been an increase in the use of infographics but these still sit alongside 40-page reports that do not transfer important information well. Due to the overall rise in technology, people expect to receive and interact with information at a much higher pace. It is clear tools, solutions and standards in the way information is shared will need to continue to develop over the next five years, although the place of the map and related geographic information in communicating key information quickly will remain relevant.

The Mediterranean crisis paints an interesting picture on how technology is used by affected communities, with migrants turning to social media to publish information about the crisis and routes across Europe. In this and other crises much is being done to look at the interface between the humanitarian agencies and the affected communities. UAVs or drones are being used to positive effect in the humanitarian sphere but there are a number of issues. Last year, the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) produced a report[5] which stated that the future of UAVs remains unclear given the regulatory issues with their use. OCHA gave the following recommendations on the use of UAVs for humanitarian response:

- Focus on using UAVs in natural disasters and avoid use in conflict settings
- Develop a supportive legal and regulatory framework
- Prioritize transparency and community engagement
- Ensure principled partnerships

Each of these recommendations could also be applied to using UAVs in other fields of interest. These solutions will take time to implement and in the meantime technology will continue to develop. Whether around the use of UAVs or other technology, it is important that humanitarian responders have a dialogue with technology developers to ensure any technical development is fit for use in the humanitarian sphere, can provide a more efficient response, and does not become burdensome.

Interfaces

A harmonisation process is essential to make the outputs of any responders – local or global – fit for purpose for the end user. Harmonisation also involves standardising tools and technologies, and finding ways to connect across different systems to ensure a 'common operational picture'. OCHA led a partnerships week in 2014 that set out this agenda for interoperability in crisis centres, across staffing, skills, procedures and technology. MapAction welcomes this as our own experience has already seen and predicts further growth in the user interfaces between responding agencies, everything from technical APIs between systems to simple data-sharing websites from which responders can access verified common datasets. There are however many ways to skin a cat and so it is essential to establish interfaces which are adaptable to the changing contexts in which humanitarian responders find themselves. To this end, lessons learned about the benefits of data sharing and of establishing common data standards (such the Humanitarian Exchange Language, HXL) should be widely promoted to stakeholders in the humanitarian sector and beyond.

A limit of any interface is communication technology. After a natural disaster there may be none but technology solutions are constantly improving to support responders in disconnected environments.

This will need to improve further. In the meantime operational models must scale to account for operating with no internet connectivity, to very good internet connectivity. This means making best use of the connection and tools available, whilst not being limited by what is not available.

Competencies

The demands of the changing humanitarian context require humanitarian providers to demonstrate a wide range of skills and competence. The growth of technology and the ability to share data more quickly require humanitarians to be competent in the use of these technologies. For example KoBo is an integrated suite of applications for handheld data collection that is becoming widely used. It means field assessments can be translated into spatial analysis products in near real time, where connectivity allows, providing a step change in the ability to plan relief responses. As with all tools, the real benefits can only be fully realised if users are well trained and know how to mitigate the limitations of their assessment design. Such understanding is based on having a broad understanding of the vulnerability of the affected population, based on the political, social, economic and geographic context of the emergency, with the knowledge that any spatial analysis is dependent on the accuracy of data received.

MapAction's use of technology

MapAction strives to be at the forefront of technology, and to use technology to provide situational overviews for disaster response and to support disaster preparedness.

Typically our base information products are used in paper format in the field during an emergency response by a wide variety of humanitarian professionals, civil defence, government and international aid agencies. In the recent Nepal earthquake, maps were especially useful for search and rescue efforts.

As well as paper form, digital maps are available from the MapAction map catalogue published on the charity's website. And more and more we are making use of the MapAction Kiosk, where anyone responding to a particular disaster can use their smartphone, tablet or computer to view maps of the disaster, and access information such as the locations of affected communities, resources and responders. The MapAction Kiosk was created based on the observed need for real time data-sharing even in sometime disconnected environments and not only by responders in the field. The demand for data and information comes from a global audience and supports key activities such as resource and response planning, as well as fundraising.

Over the next five years, the positive use of technology will continue to help affected communities. However the adequacy and context with which technology is used to aid humanitarian events should be considered carefully and should always focus on its end use. Better information management is also required in the humanitarian sphere, as well as in other domains, to allow more efficient use of resources and to help those in need.

MapAction believes that better information management can be obtained by:

- being user-focused and harmonised with other providers on the ground
- being focused on comprehensive analysis of the geopolitical context in which the disaster or crisis is occurring
- making best use of technologies but being pragmatic where and when these are disrupted
- being flexible, adaptive and delivering information in an agile, easy-to-use way
- collating data from different sources and ensuring data collectors are competent in the use of technologies and capable of analyzing the data they are collecting

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

A New Dimension in Creative Visualisation: Is it a new standard for tomorrow?

Richard Kemp Harper | ITO World

Approaches and technologies from the Creative Industries offer alternative, complementary tools and ways of thinking for the GIS community to use, bringing together three key contemporary trends.

The first trend is the growing movement towards the use of graphical design tools in data visualisation and the creation of complex infographics to turn data into impactful communications. These approaches are effective at communicating complex messages to audiences, and creative design techniques combined with data analysis are both important in order for the message to be meaningful.

The second trend is the rapid growth in the volumes of data being generated while the ability to interpret data and extract value is not keeping pace. The bandwidth of analysis is too low and new tools and techniques are required.

Finally, the third trend is the continuing exponential development of computing power, following Moore's law. This is well known and applied, but perhaps not all the aspects of this are necessarily fully exploited, and the Creative Industries offer examples of what is now possible.

As with other creative sectors, the film and gaming industries have their origins in story-telling and communication, but by inclination and commercial necessity use the latest and most powerful computing technologies. The combination of processing power and aesthetics offers a new perspective compared to the conventional development of GIS and potentially completely new analytical and presentational tools and techniques to handle the increasing volumes of available data. Here we explore those capabilities, the trends driving the emergence of new data visualisation techniques and the potential benefits and opportunities for the GIS industry.

As any GIS expert will know, for many geographical analytical problems, static snapshots of information or layouts of positions are not sufficient to be able to see what is going on or to communicate insights to the outside world. Many issues or applications concern flow and movement; changes in time as well as space. Even for features that are relatively static, representing change over time is vital. And presenting the output in a way which engages the audience, rather than just the analyst, is equally important, if not even more challenging.

> **Employees closer to their areas of responsibility often know the most about the data, but they lack the tools to interact with it effectively.**
>
> TDWI Data Visualisation & Discovery

The need is to use information to tell a story about the world, and to find the right tools to communicate this story to people to whom it matters. The rise of the infographic, particularly in the media, has shown how important the element of creative design is to effective data story-telling. The work of Hans Rosling in presentation of global historical trends in powerful charts and graphic presentations provides many excellent examples. This trend has led to the development of powerful tools to enable dynamic or interactive visualisation, presenting data in time and space. Businesses such as Tableau and Qlik are gaining traction though providing data handling and visualisation tools that go way beyond Excel charts. Visualisation of course is not new to the GIS industry; map representations are powerful and successful visualisation tools for geo-spatial data.

However, visualisation can be seen as just the end of a process, providing the pretty picture or presentational layer after the hard work of data analysis. Used in the right way though, visualisation is complementary to statistical or algorithmic approaches to data handling and number crunching.

> **Digital visualisation provides a powerful medium in which to abstract and to analyse and it is 'visual analytics' that is fast becoming the cutting edge....**
>
> Centre for Advanced Spatial Analysis at UCL, London

The requirement for visual analytics is made more urgent by another trend, the exponential growth in data volumes across all sectors, together with the increasing complexity of such data. Despite the ongoing developments in Big Data analytical and statistical tools such as Hadoop and R, the ability to gain actionable insight from the data is not keeping pace with its generation. New techniques are needed to explore, assess, evaluate, interpret the vast amounts of data, to enable analysts to gain insights and communicate those insights for business intelligence and decision-making.

Enter the Creative Industries, stage left.

The Creative Industries start from position of wanting to engage their customers in a story. Whether that's a film or a game, the story and the visual attractiveness of the output are everything in order to capture and retain the attention of an audience. There is a strong aesthetic driving the industry with the best people being "Digitally Aware Creatives" rather than "Creative Developers".

This leads to output which is visually compelling as well as telling the story.

To achieve this though the industry faces a continual arms race in technology, consistently developing and implementing new techniques and implementing the latest most powerful computing capabilities. The need is to build and manipulate high resolution images in real time, to model, manage and represent data capturing the features of entire worlds and the realistic movement of characters within them. Gaming technologies and graphics are now hyper-realistic and film Computer Generated Imagery (CGI) technologies immensely powerful.

This is enabled in part by the exponential growth in processing power that Moore's Law describes, a key trend that the film and gaming industries exploit more than many sectors. For obvious reasons the graphics technologies are as important as raw CPU power with advances in graphics cards and in-memory techniques enabling the real-time editing and run-time capabilities needed by the increasingly sophisticated software and games.

While the Creative Industries use these technologies to show actors or game characters moving and interacting in a simulated world it is not a huge step to see these techniques applied to the representation of geospatial data against a map or landscape, opening up these techniques to the GIS world.

Applied to data visualisation these techniques offer a potential step change in how tools can support the analysis of large datasets. The reason for this is actually biological. Of all the human senses, our sight has by far the greatest bandwidth; Danish Physicist Tor Nørretranders has estimated this at over a gigabit per second. To cope with the data overload the human brain's visual processing is also similarly powerful; images are processed up to 60,000 times faster than text. The result is an extraordinary ability of the human eye to interrogate and interpret complex images, filter

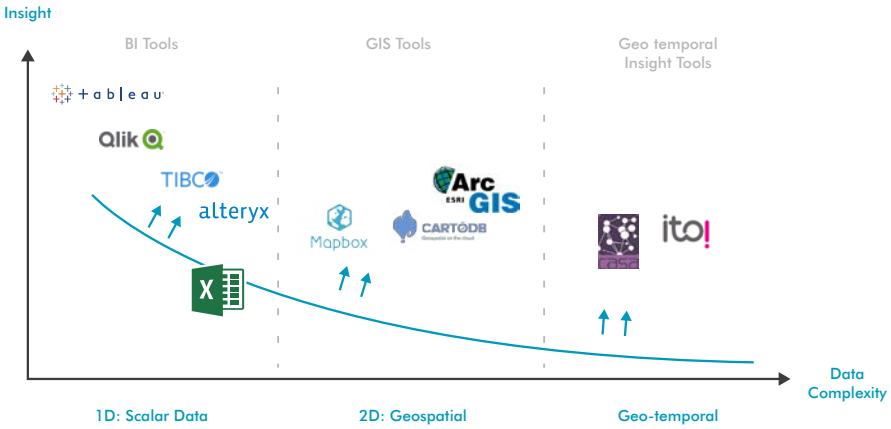
and exclude irrelevant information and identify patterns or anomalies in the information presented.

> Why should we be interested in visualisation? Because the human visual system is a pattern seeker of enormous power and subtlety. The eye and the visual cortex of the brain form a massively parallel processor that provides the highest bandwidth channelled into human cognitive centers.
>
> Colin Ware in Information Visualization, 2004

Visual analytics, therefore is the combination of the power of computing to process and present large amounts of data, with the abilities of the human analyst to interpret and gain intelligence and insight. For GIS professionals, this means that their existing capabilities are augmented, rather than replaced, by these powerful technologies. These approaches bring to bear the best of IT and the best of me to the complex business of data analysis.

The benefits include a great reduction in the time-to-insight for any given dataset or GIS problem. Visual analytics accelerates the process of exploring data, enabling the eye to see potential patterns in big data in an instant. It can tell the analyst quickly where to look closer, where there might be errors and anomalies and where the business intelligence might be found. Creative Industry techniques can reveal new insights by enabling data exploration and analysis in time and space, enabling viewing from different perspectives, zooming around and exploring a data landscape as well as a geographical one.

Business Intelligence & GIS Trends



But crucially, because of the creative origin of these technologies, the output is often elegant and visually compelling, enabling the same tools to be used for effective communications, not just analytics. This can allow the analyst to become a story-teller, presenting the insight from GIS data in a way which can capture the attention of the audience. The visualisation offers clarity and presentational power as well as analytic insight and allows the analyst to work.

Conclusions

Powerful creative industry techniques offer new capabilities in visual analytics for the GIS community to complement other methods. However, the development of tools based on these approaches is at an early stage, with a number of university research groups working in this area and a few early stage companies. The challenge for further development is finding the areas where these sorts of methods can add value for GIS customers and how they can complement both statistical approaches to analysis and conventional GIS tools.

Key Points

Highlights

- Powerful creative industry techniques offer new capabilities for GIS community
- This represents a new capability for business intelligence from big data
- For non-technical users, tools for data visualization, data discovery, and visual analysis help them make effective use of data and reduce their time to insight
- Expert analysts can use the creative capabilities to strengthen analysis and generate compelling stories to influence decision-makers and the public
- The use of computing power for advanced visualisation techniques augments the capability of the GIS professional, rather than reducing their role

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Cartographic and Education

Peter Jones | The British Cartographic Society

"The pupils had to choose their GCSE options the following week after your workshop. We have the largest uptake at GCSE that we have had in a long time and the pupils in particular that were undecided said that the workshop had helped them to decide to choose geography. A massive thank you!"

Introduction

The quote opposite was received from a school where the British Cartographic Society had recently run one of our Restless Earth workshops. The workshops comprise a scenario-based exercise in which students are asked to play the roles of a disaster recovery team with responsibility for producing maps in the wake of the earthquake and tsunami in Japan in 2011. They are given existing maps as source material and are encouraged to use the Internet to gather further relevant, and possibly more up-to-date information. Several of these workshops have used online GIS tools to generate the final outputs.

The Programme has been running for four years and shows no sign of losing its popularity among secondary schools. What it has highlighted is that until very recently the National Curriculum for Geography included very little on cartography beyond basic map reading skills. With a parallel demise in cartography courses at University level, certainly within the UK, there is an increasing concern that we are in danger of having a large cohort of people who are proficient in using GIS tools to create maps, but who have had no formal cartographic training or education and are cartographically unaware.

Discussion

Cartography, "The Art and Science of Mapmaking" is arguably as important now as it ever has been. The last few years have seen an explosion in the availability of online tools and applications for creating maps, so that anyone can now be a 'cartographer'. Whilst this increase in availability and participation is to be applauded it does mean that there is a huge range in the quality of output. A major concern of the BCS is that whilst some products just don't look nice, others are misleading or even dangerous in the message that they are trying to convey.

How can this be addressed? This is a complex problem and the level of intervention required varies on a case by case basis, hence it is very difficult to come up with any hard and fast rules. Recent changes to the A level curriculum do put more emphasis on cartographic skills and the fundamentals of elements such as scale are now covered. We need to build on this to ensure that the practitioners of the future don't just use the default settings but have an understanding of how scale affects representation; how projections can distort areas, distances and relative location; the need for generalisation to avoid clutter; and the appropriate use of colour to convey a clear and unambiguous message. Whilst some people will have a natural eye and appreciation of these factors, they will be in the minority and most will benefit from education and training. It is very unlikely that Universities can be persuaded to reintroduce cartography into their prospectus, hence it will probably fall to professional bodies to provide the necessary resources.

This is a requirement that will grow over the next 5 years as more and more industries and organisations recognise the power of GIS and what it can do for them. Central and Local Government, Utilities, Emergency Services and major corporations have all embraced GIS as a tool for planning, visualising and outputting a huge variety of data within a spatial context.

The demand is already out there and will only continue to grow. One of the main requests that the BCS receives at major exhibitions and conferences is for training in cartographic principles. We plan to address this through our programme of Better Mapping Seminars. These will be one day in length and will cater to varying levels of experience and expertise. At the beginner level we will emphasise key cartographic principles through both formal talks and practical exercises and will encourage participants to bring along examples of their outputs for critique. At the next level we will explore some more detailed aspects concentrating on the design aspects for multiple output formats. What works well on paper doesn't always work well on screen and designing for a specific output type is a key element. Given that increasing numbers of people now access 'maps' via a screen rather than paper the key design elements for both need to be clearly understood.

Paper mapping is not dead, despite several claims to the contrary in recent years. Whilst mobile devices may have overtaken paper as the primary means by which many people access maps, the demand for the paper product has not gone away. The flexibility offered by a digital rendering is very attractive to many users and with navigation aids built in, the requirement for map reading skills is decreasing. But the physical constraint of a screen does sometimes make it difficult to see the bigger picture and the paper map can offer a clear and tangible overview that its digital equivalent can struggle to match. Returning to our disaster recovery scenario, whilst much of the mapping to support the aid effort is generated using GIS tools, the final output is more often than not a paper product. By definition of the situation, electricity may be in short supply, mobile signals may be difficult to acquire and basic physical conditions such as heat, cold, dust, etc., may not be conducive to using mobile devices.

The next five years will see a further increase in the accessibility of Map Apps and the use of tablets and smart phones to collect and incorporate updates to mapping will move us towards 'real time' updating to show the very latest situation. Paper and digital will continue to work side by side and the basic cartographic principles will apply to both. Recognising the benefits of both and encouraging their use in tandem will be a key role for the broad GIS community as we move forward.

Conclusions

Now that anyone can make a map and the interest in spatially referenced data is continuing to grow, cartography needs to reassert itself as a key skill for the information age. The tools have changed, but the principles remain the same. More is not necessarily better and although we now have the capabilities to perform analysis and generate products much more quickly than before and in a huge range of formats, platforms and applications, there is a danger that we will be swamped with poor outputs. Failure to get the message across clearly could cost businesses money; incorrect portrayal of information for safety purposes could put lives at risk and an inappropriate use of settings such as colour, symbology and portrayal can seriously undermine a user's confidence in a product. All too frequently, default settings are used with no consideration of the aesthetic portrayal or how the output in hardcopy might be very different from what is viewed on the screen

The GI profession is well placed to be a key enabler of major initiatives across the whole spectrum of industry, commerce and government if we can dovetail the effective use of the tools with the effective portrayal of the information.

Key Points

- Engage with curriculum designers and providers to ensure that the key elements of cartographic skills remain within the National Curriculum, with emphasis on the importance of good design in communicating a clear message.
- Provide cartographic education at basic and intermediate levels to ensure that GIS practitioners have a good grounding in fundamental aspects of cartography.
- Encourage initiatives such as Open Street Map, Maptime and others, engaging with as broad a community as possible to publicise good cartography.
- Engage across the whole GIS spectrum to ensure that initiatives are fully aligned with broader activities to promote and grow the value of GIS, Cartography and Geography to as wide an audience as possible.

Key Resources

Cartography - an Introduction, published by the BCS

ISBN 978-0-904482-23-2

Figure 1 – Wolverhampton Parking Map, before and after

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

The State of the Geospatial Industry: What the potential, and the challenges are – and what we should be doing about it.

James Kavanagh | Land, RICS

The geo-state we're in (with apols to will hutton)

The UK geo-industries seemed to have reached a bit of an existential moment in the UK with the past certainties, or at least the belief, of our central role and importance being eroded by the almost sudden realisation that geo-technology and its use is now so ubiquitous as to be almost invisible or so integrated as to be taken for granted. The technology and software is no longer an issue, data availability is at an all-time high, interoperability and open source have become mainstream and many of the key skillsets that we have previously taken for granted as belonging to us and us alone are now shared by other professionals, users and even hobbists such as gamers, geo-cachers, travellers/ramblers and many more….

We are also faced with an unprecedented skills shortage with 100's of vacancies across the geo-industries and a rising awareness of the economic benefits of good geographic information and processes. Planners are using GIS and big data to drive urban solutions, engineers and architects now engage with BIM and 3d high accuracy models, property professionals grind and 'mash up' data from multiple sources and technologies that were previously out of reach to but a few (Drones, laser scanners, GNSS etc) are now in reach of many. So have all of the big geo-issues of previous years been dealt with? What new geo-issues have to be tackled? And just how does the geo-profession move forward?

One of the things that has really started to catch my eye in recent months is not only the enormous amount of work being done on interoperable geo-standards by the likes of ISO and OGC but the advent of real progress in 'open source' geo-related software and principles. BuildingSmart and 'open source' BIM is a case in point. Not a day goes by with another web based application and/or service becoming available which is focussed on geo-information of one sort or another. Open Government has also changed the game but Big Data can be confusing to the non-initiated and in many ways offers multiple answers but we're really that sure what the questions are.

In many ways, open data/big data/internet of things are just trying to solve quite mundane issues such as increasing traffic efficiency or making sure the bins are collected. In the developed world all we are really doing is trying to squeeze as much out of our creaking Victorian infrastructure as we can and now we have the technology, if not all of the necessary data.

Same old story

We in the geo-industries have several self-destructive but almost diametrically opposed impulses, one is to lament the arrival of new technologies as a threat to our current business practices but then adopt and buy into them 'en masse'. We also like new buzz terms such as BIM, Drones, Smart Cities, LoD, scanning etc etc and use them like 'geo-magpies' as we pick and choose what does and doesn't work. We do not invent any of this technology but are reactively taking it on rather than driving our own destiny. We have almost painted ourselves into a 'measurement/data capture' corner just as that element of the business becomes easier and then lament the fact that clients don't want what we want to give them – 2d floor plans when we have this lovely shiny 3d wireframe model available!

But do we really understand the true drivers behind what we doing and why?

The almost technical 'no mans land' between BIM and Smart City tech is a case in point, one (BIM) is privately financed and operated whilst the latter (Smart Cities) is usually publically financed and for the public good. Technically they will meet due to interoperable standards etc but the really difficult bit will be bringing them together from a policy point of view. I would suggest one of the more important BIM/Smart Cities documents of the past 12 months was PD8101 *Smart cities – Guide to the role of the planning and development process*.

Ok, not the usual geo-read but instead of focussing on the geo-technologies this document moves away from this much trodden path and looks at the policy and political drivers of Smart City adoption, in its own words '*to help the wider construction industry understand how they might better position their proposals to fit in with the local authority's wider strategic aims and, by adding value to the people and businesses that will be using their development, make it more desirable and profitable.*' Viability in urban planning is a major policy and economic issue, we really have something to bring to the party but our 'objective' geo-outputs are seen as wall paper by many of our clients so just how do we make that much vaunted move from data provider to service provider from objective to subjective?

One way is through education, both for the client and for us. Many of our courses need to be restructured with a return in emphasis to legal, policy and economic issues. Basically, it's a bit of case of 'back to the future' – the last few decades have seen the fragmentation of geography and in many ways a loss of generality. The planning and development profession is a key client base for the geo-industries and we could learn a lot from their subjective mind-set. The property profession is a very similar beast, in the last year or so the term 'proptech' has started to gain momentum but in reality this property data 'mash-up' (well it's a bit more than that really) sector is only doing things that the geo-industries have been doing for quite a while. Once again we have the skillsets but lack the language and the awareness of the sector. The big commercial property firms are enormous multinational entities and employ 1000's of professionals, including many GIS specialists, but again we in geo miss out due to not really understanding what they want or how markets and property economics work (which isn't really that difficult – I would suggest that the basics of valuation should be taught to every geo-professional).

We have seen several geo-economics studies (Google, ConsultingWhere, Oxera) which outline just what a big important and vibrant industry this is.

Are we victims of our own culture? do we love geo just that little bit too much? Can we move from objective to subjective and make those decisions that really count? How do we get it across that we act as 'de-risking' process and 'insurance' policy on projects?

A simple way forward is for our entire myriad professional, learned and trade bodies in the geo-industries to really come together. Through events like GeoBusiness, by supporting events like the AGI Big 5, by working on technical standards together and by opening debate to just what kind of future we really want for our geo-industries.

Me, I'm on the side of policy and economic development and understanding, with a side bet on legal, although I will still be messing around with geo-technology and in awe of the latest mobile laser scanning unit etc.

To come full circle, this does feel like the top of curve, the old certainties (lack of data, GIS/GNSS issues, geodesy etc) are falling away, standards and professional qualifications are in demand as the twins spectres of litigation and the effects of a deregulated market still stalk the land. Nobody likes Risk and we in geo have the potential to 'De-Risk' projects, let start trying that language out for size.

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

BIM Adoption within Infrastructure using a Risk Based Approach

Andy Kervell | Arup / Network Rail Infrastructure Projects

A significant obstacle to the uptake of BIM and GIS within the infrastructure project environment is sometimes because there appears to be limited benefit to the project itself. It is perceived that only the maintainer/operator, who receives the data at the end of the project, benefits. Whilst this, in itself, should be a valid argument for its adoption, the use of BIM is often considered an added complication and expense by some project managers. They do not therefore always support it unless specifically requested within the Terms of Reference. More focus should therefore be placed on the benefits to the project itself which can be significant especially for the mitigation of certain project risks.

Those benefits should also be expressed in terms which project managers are familiar with and not treated differently from the many project aspects they deal with. Expressing the BIM approach in the context of the risk mitigation and opportunity exploitation will both highlight how the project itself benefits. This can therefore be considered alongside other project issues and solutions within risk workshops and registers.

This approach has been adopted within Network Rail Infrastructure Projects (NRIP), to help projects identify where the use of BIM and/or GIS can assist their project and meet their maintainer/operator asset information delivery obligation. The reaction from project managers, not previously familiar with the BIM approach, has been more favourable as a result.

Problem / Opportunity Statement

A significant opportunity exists for Asset Managers of large physical infrastructure to improve information management as a result of the wider adoption of a BIM approach throughout an asset's lifecycle. A recent position paper published by the Institute of Civil Engineers (ICE) and the Institute of Asset Management (IAM) states:

> **The availability of appropriate and reliable information about assets is vital for effective asset management as it supports decision making, planning and execution of activities on assets. By providing a structured framework for the creation, collation and exchange of information about assets, BIM supports effective asset management. However, to enable this BIM must provide information covering the whole life cycle of assets.**
>
> ICE, ICES, IAM Position Paper "Leveraging the Relationship between BIM and Asset Management"

Better information management through the design and construction process allows for more accurate asset information to be delivered to the required level of detail, format, structure and quantity stated by the asset manager to populate systems and registers. There is also the opportunity for earlier engagement by asset managers in the planned infrastructure change, for it to be assessed from an asset management perspective.

This can enable design suggestions and improved asset operation and maintenance planning in readiness for the change.

However a tension remains between the asset manager and the capital works deliverer largely around the use of the model at the end of the construction phase of the project. The works deliverer will consider it is wasteful to not use the available detailed information once the asset information, with its more limited geometry, is extracted. The (sometimes 3D) construction model will usually be archived (see figure 1), but could or should more be made of it? (**figure 1**).

So why is this a problem? Well one of the major drivers for following a model based, collaborative approach is the perception that the asset managers will make full use the final model. However when project managers, designers and constructors realise this is not to be the case, the benefits of following a BIM approach appears to be reduced. Project managers do not always see any other project benefits for them, only difficulty and cost, and hence do not fully support its adoption.

There needs to be an equal focus on the benefits of model based collaborative working *throughout* the project lifecycle and not just for the asset information handover stage including the benefits of early 'virtual' inspection of the asset by asset managers. This is well understood by most BIM Practitioners but it is not always the general perception of project managers and senior management. It is critical that these individuals become engaged and understand the purpose of BIM as they ultimately make the decision about inclusion and funding within a project.

The same is true of the use of spatial technologies in addition to BIM such as the use of a web GIS for a project information portal during design & construction phases. Such technologies offer a significant benefits for centralizing project information to data and project documents which can be intuitively accessed via its location.

This paper hopes to provide some insight from a rail perspective into what current thinking exists within Network Rail. It will look at here the opportunities lie and how the perceptions could be changed to achieve the most practical benefits out of model based collaboration by a slightly different approach.

History

The need for accurate asset information within large infrastructure managers such as utility companies, Highways Agency, Network Rail etc. has long been regarded as an essential enabler for the safe and efficient operation and maintenance of those assets. Driven originally out of high risk industries such as oil and gas the storage, analysis and modelling of asset data is critical for decision support for asset managers[1]. As such asset registers and systems are already well established, including the processes and teams which support or update them. However owing to the nature and scale of the asset base in large infrastructure sectors the asset object geometry held in these registers (often in GIS) is fairly simple. This is because complex 3D geometry is not required for the asset management in many cases.

BIM and the delivery of asset information directly from the construction lifecycle phase is still quite early in its evolution, particularly within the infrastructure sector.

The benefits identified by various landmark projects highlight significant savings which can be gained by collaborative information sharing on projects[2]. The production of BS1192:2007 and subsequent standards PAS1192 Pt 2 -5, the establishment of the BIM Task Group are testament to the opportunities it provides. These opportunities have been highlighted in the previously referenced ICE/IAM position paper.

A Government mandate has been set that all government funded projects should be BIM level 2 compliant by 2016[3]. This has encouraged the take up of this approach within the supply chain and has gained a major foothold across the sector. However a significant amount of legacy infrastructure assets exist with a long life and stored within established management systems already. Therefore it is no surprise that the benefits of BIM adoption to asset managers in such industries appears to be low with the slow change over time of their asset base.

However the infrastructure does change steadily throughout road, rail and utility networks predominantly by capital projects. Where not captured this change slowly degrades the data quality and therefore its reliability for use in operations and maintenance planning. Keeping this data up to date and reliable will enable the effectiveness and efficiency of operation and maintenance, and the confidence and satisfaction of those working with the data on the ground. At a recent BIM Worldwide: Solutions for Canada Conference, Birgitta Foster, VDCO Tech, recommended that owners *"never ask for more [data] than you can maintain"*[4]. The approach of delivering and updating data directly from the construction process into asset systems should increase the trust in the data. The data comes from source, not a post construction survey where hidden objects can be missed or identification poor.

The Solution

A risk/opportunity related justification for a collaborative, model based approach.

A pragmatic approach needs to be followed for the gradual adoption of BIM within the infrastructure sector. The same terminology that project/programme managers understand should be used, as they are the ones who ultimately will approve and support this approach. The common vocabulary suggested is around the management of risk. Risk exists at all stages of a project (**figure 2**) and the purpose of capturing data and the use of modelling techniques are ultimately to mitigate the risk of making the wrong decision or action. Data and models enable teams to come together to understand or predict what may occur based on the known constraints. Therefore it is best to bring modelling tools in line with traditional ways of managing risk to a project i.e. the risk register and risk management strategies

Even if the full construction model doesn't have immediate use within the asset maintenance and operational function of the business, it will have been beneficial during the design and construction phase (see figure 2). Collaboration and modelling at each stage of the asset lifecycle should be mitigating some form of risk at that point. This is understood, but often not well communicated in these terms. For example collaborative working between disciplines in a common data environment mitigates risk of design changes not being communicated to others. Sequence modelling of the construction of a piece of infrastructure mitigates the risk of potential costly time delays, because you have tested and practiced the steps virtually before they are completed in real time.

It is critical that the Asset Information managers become engaged within the development of the Employers Information Requirements to effectively mitigate their risk of receiving the wrong or incomplete dataset required to populate and update asset registers. A key section of the EIR is the Asset Information Requirements (AIR) which needs to be included by project teams in order to ensure its delivery as part of the contract. Asset Information specialists are required to assist the project with the filtering and prioritisation of the asset information required. The asset management risk mitigation and the potential cost of their delivery to the project should be balanced as part of this exercise. If AIRs are better targeted then operator/maintainer will receive the information they really require at the appropriate timeframe and cost.

Within Network Rail, the Asset Information Group has been actively developing Asset Information Specifications (AIS) with the business which documents the data currently required for its operational and maintenance needs. At the moment however the AIS documents are quite large and complicated largely reflecting the current content of asset registers. Therefore, work will be required collectively to prioritise and limit the content to be delivered by projects in order to be usable and accessible within the EIR.

Network Rail have adopted a facilitated workshop approach to identify the benefit of collaboration and modelling on projects for risk mitigation and opportunity exploitation. This will then inform the content of the EIR. These workshops include participants from the project management, sponsor and asset management team for the project area. The workshop uses key documents such as the risk register to identify and explain which risks can be mitigated through use of modelling and/or collaborative approaches. (**see table 1**)

All tools should be considered by the workshop for risk mitigation including the use of GIS web portals and other specialist modelling software and not just CAD.

Once the risks to be mitigated have been identified, these workshops then looked at the information constraints categorised in the following areas:

- Time based constraint: can the data required be produced in the time available within the asset lifecycle phase in time to make the necessary project decisions.
- Capacity based constraint: does the provider have the capability to produce the model/data to the required specifications.
- Technology constraint: Does the provider have the appropriate software, data or technology to view, share or create the model to the required format/specifications.
- Commercial constraint: Is the commercial and contractual arrangement an impediment to the delivery of data?
- Resource constraint: is their suitable staff available for the project.

Based on this analysis the project will identify where certain risks cannot be mitigated because the modelling approach is not feasible due to the constraints identified. A management decision can then be made to either accept the risk, mitigate it in another way or tackle/work around the constraint which prevent the modelling or collaborative approach.

Asset owners can also mitigate their risk of missing, or out of date, asset information if they provide their information requirements to a capital project to ensure good information is returned. However would further opportunity for operational risk mitigation exist if they could make greater use of the data model? This opportunity may not always been investigated because they are not aware of what is capable or can be delivered out of the model.

Ideas such as improved visualization for safe operation or improved condition based information may all improve the understanding of the asset base at limited additional cost.

However, until these requirements are articulated to the constructor of the model, these additional opportunities may not be considered. However, by having a risk and opportunity focused workshop with constructors, maintainers and operators in the same meeting the modelling activities can be prioritised relative to their risk appetite. This is the approach prescribed in the Government Soft Landings[5] initiative, where by the asset owner/operator can understand what they will receive, and suggest design improvements to the capital works with maintenance and operation in mind.

The Benefits

The benefits of this risk focused approach to the adoption of BIM are principally as follows:

The identification of, and response to, risk is a well established and essential part of project/programme management to control uncertainty on a project[6]. Information Management and modelling should not be treated separately to other aspects of a project when addressing project risks. All risks, actions and owners will be recorded in the central risk register and can therefore be measured/monitored.

With the value of modelling and collaborative approaches being more targeted at every stage of the asset lifecycle its value to that stage will be highlighted. Therefore projects can focus on the value (or otherwise) of performing a modelling approach. Asset management risks over the longer lifespan of the asset can be evaluated on a par with project delivery risks, which should justify its inclusion as a minimum deliverable from a project IM process. However even though the asset managers may not use the full model after final delivery, the model/approaches value has been realised throughout the lifecycle justifying its inclusion in the project.

A project can therefore have a modelling approach whereby its priority is determined by the impact on projects risks. Risk assessment and evaluation techniques such as Pareto analysis or expected monetary valuation can be performed. When compared to the cost of modelling/collaborative working approaches, a cost/benefit analysis could potentially be performed. This could determine the correct modelling and information management strategy to be established on a project or programme.

This approach ensures that the provider of the modelling or collaborative approach has fully considered why they are performing the modelling or IM activity. They are not only completing it because there is a government mandate or company policy, but for project specific outcomes at each stage.

All parties involved with the project will hopefully have a better understanding about the purpose for the collaborative model based approaches. Where IM constraints have been identified to deliver such an approach their impact can be assessed. The cost of tackling the IM constraint can be weighed up against the cost of the risk occurring on the project.

Call to Action

This paper does not propose any ground breaking change to the BIM approach or to the project or programme manager. This is aimed at the modelling (including GIS) practitioner(s) to ensure that their outcomes and benefits are described in terms which are already understood and established on projects. In return you will hopefully receive greater understanding and support for your activities on the project.

Asset managers should also take this opportunity to engage with the project or programme earlier by again discussing their ongoing asset management requirements in risk and opportunity terms.

The risk to the operation and maintenance activity by not having up to date and complete asset data in the long run will be a larger value and thus prioritise its inclusion in the project approach.

As with so many other things, the route to success for the adoption of BIM is through better communication of what it is, and how it improves the delivery and operation of infrastructure. However, you have to be speaking in the same language at the time when key decision makers and influences are listening.

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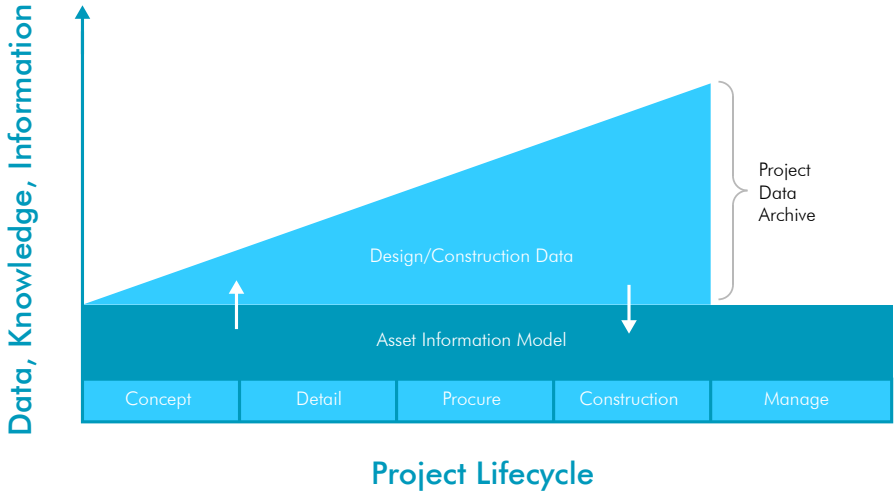

Figure 1: Illustrates how the Asset Information Model (AIM) within Infrastructure remains constant throughout the project lifecycle. Asset information is drawn from it throughout, and then the AIM should be updated at commissioning. The design and construction data and models increases gradually in detail and quantity, but at the moment this additional information forms the project data archive, some of which in the Health and Safety file at project end. The detailed design/construction model is rarely used for operations and maintenance.

Figure 2: Different types of risk which are common on rail infrastructure projects.

Project Location	Description of work and scope	Asset groups affected	Risk identified	Possible modelling approach for risk mitigation	How are risks mitigation	Data / IM risks and constraints
Gravesend Station	Refurbishment of station including new footbridge	Structures, Operational Property	Very limited possession time to complete large amount of work	Construction Sequencing modelling (4D) of the delivery of the project	Possible to schedule the works required virtually to determine if it can be completed on time. Find construction timing clashes to ensure the order of work is correct and site logistics plan is correct. Visualisation of the work to be done in advance of the possession by the workforce leading to improve more effective delivery and safer working.	The model was not delivered in 3D from the design stage and therefore had to be built by the contractors from the drawings/CAD.

Table 1: Example of a Model risk mitigation matrix which would be populated during an EIR development workshop. This example was written retrospectively based on a project at Gravesend Station which benefited from 4D (programme based) modelling to plan a significant activity during a limited possession period.

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SIM Cities: Why BIM and GIS fit together

Mark King | Leica Geosystems

The two worlds of BIM and GIS are both aimed at improving the way we design, plan, construct and manage our built environment. However interoperability allowing data to flow between these two is still very much in its infancy. Computer games like SIM City give players the tools to construct cities based on both physical and analytical data. In the future advancements in technology will allow us to 'build' in much the same way, using both BIM and GIS processes, seamlessly connected to help improve the quality, reliability and usage of data.

Problem / Opportunity Statement

The rapid adoption of BIM and the continued establishment of GIS are helping us to better design, plan, construct and manage the built environment around us. As people come to terms with how these will affect and improve the way they work, should we be connecting the dots between them sooner rather than later?

BIM is a process focused on improving the ways we design, construct and manage our physical assets, through digital models and improved collaboration. It is viewed by many, including Governments as the only way to improve the efficiency of the construction industry.

On the other hand GIS brings together information into a digital Geospatial database. Its aim is to visualise, link and represent data into a form that people can understand and make more informed decisions on.

As people and Governments look to the future, in particular Smartcities, surely the need to utilise both BIM and GIS in a more joined up way is just around the corner. They now play an integral part in many organisations but as they both preach collaboration, surely the collaboration between the two should improve. What are the barriers slowing us down? How do we utilise this digital data in and out of the office, and what will a project look like in the future?

History

With BIM being the relative 'new kid on the block' compared to GIS, they have both been developed in isolation. There is a visible segregation of the two with major software companies tending to focus on either BIM or GIS with minimal integration.

In the last few years there have been movements to improve this with the integration of the IFC format by the major GIS software vendor ESRI. There are also organisations including the Open Geospatial Consortium (OGC) and BuildingSMART running projects such as IFC Alignment to widen existing file formats to improve compatibility between building and infrastructure projects.

The Solution

In a future with Smarttechnology, Smartbuildings and Smartcities the way we design, construct and manage the built environment also needs to be 'Smart'. Many see the use of BIM and GIS as a method to achieve this, but what could the potential be if these two processes were much more harmonised?

By taking the world of gaming as our example, SIM city put the user in the position of chief planner, architect, master engineer and city manager not only for the city itself but also the citizens and how they grew and evolved over time.

The game required GIS and BIM type processes to understand how population growth and transport systems were required when constructing a building or piece of infrastructure. An experienced gamer would understand the impact of positioning a power station, choosing its size and scalability and what effect this would have on the growth of their expanding metropolis. They would also monitor and maintain their city, reacting to the data that was being received.

Back into reality, there is a future where BIM and GIS will be more closely integrated. An asset such as a railway station can be planned and designed within BIM software, something that is becoming more and more familiar in today's construction industry. This early stage design model can be used within a GIS system to analyse what impact it may have on its environment in terms of transportation, energy usage, criminal activity and so on. These factors can also influence design, with changes to geographical location to improve solar efficiencies and amendments to architectural design to reduce crime hotspots.

This interaction is happening in some projects today, but only in isolated pockets and not with the efficient workflow required. The future will see a much more collaborative approach between BIM and GIS, with data shared and coordinated much like a modern contractor coordinates and federates digital 3D models on their current BIM projects.

In parallel the lines between site and design office will become blurred. Automated construction will drive the demand for on-site 3D data to define tasks, locations and areas. Current trends towards Machine Control systems and digital construction layout are already demanding this kind of data.

Technological advances in cloud computing and mobile telecommunications will allow large datasets to reside remotely; processing can be left to server farms with users accessing their data via their social profile, only seeing the data that is applicable to them. With access to a wider dataset users are able to make better informed decisions, ensuring projects take into account all aspects leaving the need for massive, costly changes firmly in the past.

Improvements in connectivity and collaboration can however bring a risk of 'data obesity', with organisations gorging themselves on this easy to access but quite possibly 'bad data'. This necessitates the need for methods to validate the veracity of data to ensure models, systems and decisions are not made on poor data delivering bad results.

With the inclusion of sensors in the field, improved accessibility and quality of data, facilities managers are then able to manage their assets even more effectively. These sensors could range from simple devices to manage temperature and humidity within a building, to high accuracy total stations used to monitor the integrity of a large bridge. Through Geointelligence and the use of reliable and real-time information, FM teams like our gamer playing SIM City can make decisions and react to situations far more effectively. In the future these systems would even be able to learn and react automatically to changes in the environment. Train stations themselves would be able to manage the flow of trains into and out of the station, as well as the flow of cars and people into and out of the station, car parks and pick-up points.

The Benefits

By improving the collaboration and interoperability of data between BIM and GIS, architects, engineers and contractors will be able to improve the way assets interact with the environment around them. Connectivity between site and design office will further improve the quality and efficiency in which our assets are constructed. Connected devices will be able to share data, communicate progress and validate the completeness of a task. This means clients will obtain a more efficient and effective asset, with FM teams better equipped to monitor, manage and maintain their asset. The general public will inhabit better buildings and be able to take advantage of an improved infrastructure.

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Autonomous Vehicles, a Future of Opportunities for Geospatial

Philip Knight | ConsultingWhere

In March 2015 KPMG published a study on the future benefits of Connected and Autonomous vehicles to the UK economy. The report found that the overall economic and social benefit of connected and autonomous vehicles could be in the region of £51 billion per year by 2030 and that by 2030 the technology would create 320,000 jobs and save over 2500 lives[1]. These kind of predictions are now fairly commonplace. They are the reason that every big car manufacturer now has a programme to develop some level of autonomy and the reason that Hyundai are making astonishing announcements about investing $73.3 billion (the GDP of Lithuania) in the smart car industry over the next four years[2]. The only remaining sceptic seems to be Rolls Royce a spokesman for whom was recently quoted by the NY Times as stating "Most customers already have an autonomous driver. It's called a chauffeur."[3]

Governments also sense an opportunity. 2015 saw governments across the globe announce investment in research, the setting up of incubators, sponsoring of contests, and removal of regulatory barriers. The latter trend quashes early fears that the technology would fall foul of the regulator. The UK for its part developed a code of practice for testing on public roads and allocated £100million (£200 million matched) for research into intelligent mobility in the spring 2015 budget[4].

New tech entrants are also showing their hands. Uber announced a strategic partnership with Carnegie Mellon University to develop autonomous vehicles at a new facility in Pittsburgh[5]. Silicon Valley electric car manufacturer Tesla released an auto-pilot feature for the Tesla Model S that allows hands free driving on the highway, auto lane change and auto-park[6].

Apple on the other hand are not talking. News of a secret electric car project has been leaked[7]. The leak was followed by reports of meetings with California's autonomous vehicle regulation team[8], and moves to secure a test facility[9]. The scant evidence suggests that Apple may be working on autonomy, but there are no official statements.

Meanwhile first movers Google carried on moving. At last count (Oct. 2015) the company's 48 self-driving prototypes had driven 1.2 million miles in "Autonomous Mode" since 2009[10]. A confident Chris Urmson, the project's Director and former leader, told the TED audience that Google were committed to a fully autonomous initial product and that cars, using Google technology, would be self-driving on the road by 2020[11].

With this R&D free-for-all as a background it was no surprise when the 2015 Garner Hype Cycle put 'Autonomous Vehicles' at the peak of inflated expectations[12]. However, although Gartner warn of upcoming disillusionment they also predict that the technology will reach maturity in 5-10 years. This is in line with the general consensus among published predictions, that fully autonomous vehicles will be on the road in 5-10 years, but that the transition to a transport system dominated by robo-cars will be gradual. Morgan Stanley for example predict 100% market penetration will not take place until 2046.

For those that cannot wait that long Advanced Driver Assistance Systems such as the one released by Tesla this year are expected to proliferate in the next 12 months according to the company that provides the necessary computer vision chips, Mobileye[13]. Full Autonomy is further away, and much more difficult to achieve, due to the order of magnitude difference in reliability required when there is no human back up. But it is Full Autonomy that is the truly revolutionary technology because it enables fleets of robo-taxis that will radically affect patterns of transportation and entirely change the economics of vehicle ownership. Models show every Shared Autonomous Vehicle on the road replaces 11 conventional cars[14].

The Role of Geospatial in Autonomous Vehicles

This foresight study covers the next five years, but the consensus is that if this technology is developed at all within this time period it will still be in its infancy at the end, so why include it? Firstly, the geospatial industry has a role to play over the next five years in making autonomous cars a reality, secondly the impact of this technology will be so significant that those within the geospatial industry that are playing a part in planning the transport systems of the future need to plan for it now.

Autonomous vehicles rely on detailed maps to locate themselves. They do not rely entirely on GNSS, but instead constantly calculate their position by referencing their sensor data against pre-loaded, highly detailed, maps of the areas they are travel through[15]. Google's system uses a 10cm resolution infrared remittance ground map on top of which is overlaid a map with information about the positions of lanes, traffic lights etc. and the logical rules that govern the interaction between the car and these road features[16]. Inevitably there are a number of different techniques being developed, with one departure being whether the high cost Lidar used by Google is necessary with the alternative being much lower cost cameras and computer vision. A computer vision solution would create less spatial data (no point clouds) but it would still need accurate maps to reference the sensor data against.

This new and significant requirement for spatial data is an opportunity for the Geospatial sector to position itself at the heart of the future transport system, not as a nice to have, but as a crucial piece of infrastructure. Existing map data companies HERE and Tom Tom have already recognised this requirement.

They've moved fast to develop maps of the highly detailed nature that autonomous vehicles need. The car industry has also recognised maps as a crucial area, one in which Google has an advantage. This was partly addressed in August by the acquisition of HERE by a trio of German automakers (BMW, Daimler, and Audi) for around 2.71 billion euros.

This initial big push to map the world at much higher resolution is only the first phase. As the cars become more numerous they themselves will begin to collect the data. This approach is already working at Tesla where Elon Musk has described the process of mass data collection from the Model S autopilot feature as a "fleet learning network"[17]. Google already build their infrared remittance ground maps using multiple passes of the self-driving car prototypes. The logical maps are built on top using a mixture of human input and algorithmic and machine learning to pick out road features. Artificial Intelligence (AI) that can identify road features is a big part of the technology that makes autonomous driving possible. Engineers now working for Google have been publishing papers on the subject as far back as 2011[18] and Google currently hold a number of patents on the subject[19].

The sum of the information provided by the cars, potentially filtered at source into meaningful road features by the cars' own AI, will be maintained in a central data store, which will in turn provide the cars in its network with up to date detailed mapping. However, this type of mass data collection will provide clumped and clustered data around the main transport hubs. The map data companies that maintain these systems will need to fill the gaps, either through additional surveying, or an incentive scheme to send vehicles to those parts of the network that are under-utilised.

In a recent interview with Directions Magazine the Ordnance Survey's Chief Geospatial Scientist Jeremy Morley asks a pertinent question about the future of connected and autonomous vehicles: "Will we see a series of closed ecosystems from each manufacturing group or technology provider, or will some interoperability or national infrastructures emerge?"

Google are initially planning for a closed ecosystem. This is to ensure that their new product 'scales'; that roll-out and rapid adoption is not dependent on smart infrastructure or other connected car systems. However the German consortium that acquired HERE have signalled an alternative approach with talk of an 'open' platform[20].

In researching this article the author visited the Bristol Robotics Laboratory, home of the Venturer Consortium, one of three projects selected by InnovateUK for its Introducing Driverless Cars to UK Roads competition . Deputy Director, Professor Tony Pip[21], does not believe that Google's closed approach will persist, although he admits it has short term advantages, particularly in terms of cyber security. In the long run vehicle to vehicle, vehicle to infrastructure and vehicle to cloud communication has such great potential that it will inevitably become an important part of how future transport systems operate.

Shared open and interoperable systems allow for concepts such as Virtual Infrastructure, one way streets, traffic lights, stop signs and even tolls that exist only in the cloud perhaps controlled by another level of AI that provides systems level analysis and oversight. If this benign AI overseer concept is a little too Orwellian for you, Professor Chris Melhuish, Director of Bristol Robotics Lab, suggests an entirely decentralised system could emerge with each individual vehicle passing information about the state of the network to nearby vehicles.

The result is a decision making system similar to those found in social insects where routing information is passed from ant to ant via pheromone signals.

The connected car concept will likely make an impact well before the advent of full vehicle autonomy within the types of semi-autonomous cars that are expected to hit the road within the next couple of years[22]. Similarly the smart routing that will one day control fleets of fully autonomous taxis is already making an impact in the ride-sharing industry with Uber's smart routes, suggested pick up points and car-pooling already being likened to a hybrid mass-transit system by some commentators[23]. Uber's requirement for advanced routing is thought to be behind its March 2015 acquisition of DeCarta for $56million[24].

Conclusions

- The levels of investment in autonomous cars make it hard for the geospatial industry to ignore.
- Full autonomy will be developed within 5-10 years, but adoption will be gradual. Semi-autonomy is closer, but considerably less impactful.
- Geospatial is key to the initial development of fully autonomous vehicles as they need highly detailed maps for localisation and to augment the information obtained from their sensors.
- Crowd sourcing from vehicle sensors will become the largest source of data. The role for the geospatial industry will be to collect, maintain and make sense of this data infrastructure.
- Control over these data sets, whether they are closed or open, will have significant impact on the way the technology develops.
- Autonomous vehicles are part of a number of converging trends including connected cars and integrated transport systems all of which the geospatial industry has a significant part to play in.

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

The Future of Drones and the Development of Micro-Robotic UAV Technology

Dr Mirko Kovac | Aerial Robotics Laboratory, Department of Aeronautics, Imperial College London

Unmanned Aerial Vehicles (UAVs) have gained in popularity, and are used widely for Air Photography and 3D imaging. They make a good alternative to Satellites with better resolution and detail, however they are limited in flight times and payload, with typical endurance of 20-30min and payloads of up to 5kg for consumer level systems. They are also limited in that they cannot operate close to structures such as cliffs and water. So the challenge is how to make them operate in the real world and close to the environment they will operate in. This is where micro-robotic UAVs can take a lead.

How long have you been involved in this area of work and what is your current research focus?

I have been involved for around 12 years. Following an MSc in Mechanical Engineering at ETH Zurich, a PhD at EPFL in Switzerland and Post-Doc at Harvard University in Robotics, I started the Aerial Robotics Lab at Imperial College 3 years ago.

At Imperial I currently have two main focus areas: The first is the development of next generation UAVs for autonomous inspection and repair for the built environment, such as bridges, buildings and infrastructure. The second focus is on the creation of UAVs that can move robustly in complex real world environments to, for example sample water after urban floods or in hard to reach coastal areas or the arctic sea. At the moment my research groups has 13 members and works across the spectrum from basic robotic science to industrial applications and pilot testing.

What is it that first interested you in this area of research?

I am personally interested in mobility and how to make robots move effectively in complex environments – on land, on water and in the air, and seamlessly between these, and carry sensors or sample the environment. That's my fascination with this area.

Where do you see the application for UAVs?

Society at large is interested in UAVs as a platform for various sensors – usually a camera does the job, however there are other sensors which can be used – multi-spectral imaging devices, pollution, temperature or humidity sensors, or microphones which can be used for a myriad of applications. These can then be applied to areas such as:

- Next generation 'Smart Farming' and precision agriculture
- Geological measurements & inspections
- Ecological research in forests studying plants and ecosystems
- Environmental sensing in hard to access areas such as oceans
- For urban delivery, but also for infrastructure inspection or for repair

Where do UAVs sit between the research areas you are involved with and commercial applications?

UAVs have reached a level where they are having an impact across the technology readiness spectrum. Some are already available commercially and can carry sensors or cameras and can fly along GPS co-ordinates – this is already solved. On the research level there is a lot of effort on 'Sense & Avoid' strategies, or to make them 'Crash Robust'.

Then there is effort to give them 'multi-modal mobility, so not only fly, but also move on ground or perch on objects for long periods of time. The third area where many research groups focus on is aero-structures of aerodynamics and optimisation. Then finally there is communication and electronics and swarm control. So this research spans the full spectrum from basic research to very applied research for commercial systems.

Do you see a time when autonomous drones are used by most members of society, or do you think they will be a controlled technology with specific use-case rules?

Drones are already impacting many areas of society, for example many people buying them as toys. The next step will be to use them for 'Selfies' or sports photography, and the first autonomous drones are already available which can follow you either mountain biking or snow-boarding, part-funded through kick starter campaigns. In next 10 years, drones will become very common place, for leisure activities or for inspecting damage to the roof of your home, or for inspecting farm fields and fields in agriculture - so drones will become quite normal and part of our lives.

The robots are becoming miniaturised, but are the sensor systems keeping pace with these developments?

The sensing technology is very important and is being developed in parallel. There is a large question of how to use sensing to avoid obstacles and follow features in the environment, but there is also a challenge of not only how to develop new sensors, but also how to integrate and co-develop the sensors with the platform. If we look at nature, it's always co-developing the **Sensing** along with the **Platform** and the **Control** which leads to high performance systems. We as technologists can greatly benefit if we think like Nature and follow inter-disciplinary approaches – on its own the Sensor isn't enough, and the platform isn't enough. They have to be co-developed and that's where I think one of the breakthrough's in the future will happen.

Photo © Imperial College London

What do you see as the Next Generation sensor systems coming from the research arena which are relevant to your work?

One area are Neuro-Morphic sensors and cameras, which don't just take pictures at fixed time intervals but observe the change in an image and can then be used as ultra-high speed vision systems for flying robots. Another example are advanced ultra-light-weight chemical sensors which are being developed for water or biological contamination and are coming through from research onto platforms.

Are these working with real-time communication, or do they need to be collected and returned for analysis?

It depends on the sensor and can be a hybrid systems. For example, temperature or humidity can quite easily be measured in-situ, whereas for more complex chemical investigations the robot would bring the sample back to a base station for laboratory analysis.

Looking at Autonomous qualities, do you see a time when drones will not only learn about the environment, but also learn from each other and gain a 'Swarm Mentality', so rather than working independently, they are working and learning from each other?

This really connects to the future vision of where everything is going. I believe we will soon have swarms of drones living in nature, in the forests and the cities, completely autonomous, not just on a control level, but also on the energy supply & repair and maintenance level. These robot colonies will live and provide us with information which will not only make our lives safer, but also less difficult, and provide information to improve farming or inspection and repair for example.

This is not only Physical Autonomy with the environment, but Control Autonomy and Swarm Autonomy with each other. Whilst this sounds like a scary prospect to some, it may actually be a blessing.

How long till we see this?

THIS IS DIFFICULT TO SAY, BUT MAYBE 10-20 YEARS OR SO.

To raise the topic of power, how long can the micro-drones operate for before they need re-energising and where do they get this power from?

The robotic bees can operate in the order of seconds to minutes at present; a 50cm quad rotor type UAV up to 30 minutes then the much larger solar operated drones in the order of 24 hours. The energy question is very essential, but can be addressed in a number of ways:

- Better batteries
- Better aerodynamics
- Better computation
- Better ways how to fly e.g. perch instead of hover, or walk instead of fly

Would you see energy supply as one of the major areas which need solving within your research area?

I would see the following as key areas which need solved and addressed:

- Energy supply
- Better aero-dynamics and aero-structure design
- Avoidance of obstacles
- Safe interaction with the environment and people

We are working on intermittent flight, so not just flying in a straight line, but intermittent flight with soaring and gliding phases so better use energy harvesting. Height is being used as a battery – an almost perfect battery. Other researchers are looking at energy harvesting through solar cells.

Privacy

The issue over UAVs and Privacy is quite topical at present, and you have contributed to a report to the House of Lords on this subject. Do you see that there will be any increased concern over Micro-UAVs, especially those operating in swarms? How do you see this being addressed, or do you see it as an issue?

There is a potential for misuse of this technology in different ways, however other technologies such as Smartphones, WiFi, hacking of computers or Google Glass, can be much more intrusive than UAVs are at the moment. Having said that, there are still areas to be addressed. This could be done by having restrictions on flying in certain areas where there are privacy issues, or not being allowed away from 'Drone Highways' through a city. Users might also be restricted from accessing certain data on the UAV, such as that generated by the collision avoidance cameras.

Education

Do you see any skills gaps in the students wanting to come into this area, especially when we look at the future potential of the technology?

The students we get at Imperial are excellently educated in areas such as Maths and Physics which are a good basis for technology, but we need to reinforce inter-disciplinary education by exposing students to other areas such as materials science, biology or design engineering and bring in a more creative approach. So just as Bio-Engineering started a few decades ago, Bionic-Engineering & Bio-robotics are fields which are getting more momentum in R&D and education and this can not only reinforce skill development, but also lead to higher performing systems.

Whilst students have the base skills, there is a mindset which needs to be developed not just within University, but also within schools. Inter-disciplinary is the key, with collaborative working across the disciplines.

Is this an issue that you or your colleagues have always experienced, or is it something that you are increasingly finding with each generation of students?

At a society level, we could look at the likes of Michelangelo or Leonardo da Vinci who were Universal Scientists and looked at many different aspects, whereas now there is a tendency (and also a danger) to become too specialised, and we have to bear in mind that we need to integrate between different disciplines to advance and create the knowledge needed for a better life.

What areas of pre-university education should be better funded or encouraged to allow this research area to grow?

One way we could encourage this inter-disciplinary approach or collaborative working is through Hackathons, Design Competitions or robot build competitions. There is an important role for Universities or technology to be brought to Pre-University students to play with the technology and see the inter-relationship and complexity of robotics or UAVs, so compared to some other more traditional subjects, these are very much inter-disciplinary. So if we want the next generation of genetic engineers to navigate this space, we need to start early and get them to understand the connectedness.

Any other final thoughts?

If we look at methodologies, how can we build the next generation of UAV? One thing is to look at nature and how nature functions. Nature often builds in an integrated way, and it co-develops several technologies, but it has also ways to save energy, be more agile and better performing, faster, more versatile, more robust. However, we have to be careful not to blindly copy natural systems but to use the working principles and implement them with the best of our engineering knowledge. This approach I call the Bio-Inspired Robot Design Paradigm.

With thanks to Dr. Mirko Kovac for sparing his time and giving his insight for the interview.

Alistair Graham of Geoger Ltd for assistance fielding questions.

Interview by Simon Wheeler of AGI Council

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About the Laboratory

The Aerial Robotics Laboratory at Imperial College London focuses on the design, fabrication and testing of next generation flying robots and it employs biological inspiration as a key design methodology to achieve high performance systems.

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Global Trends: How will they impact the UK geospatial market

Dr Vanessa Lawrence

Extreme poverty is defined by the World Bank as anyone living on less than $1.90 per day. Since 2012, 200 million people have moved out of extreme poverty but that still leaves 700 million people living in the terrible conditions of extreme poverty.

Global trends of expanding urbanization, concerns about food production, climate change issues, the need for sustainable land management and development and growing inequality are putting the globe under stress.

The fact that 'everything happens somewhere' is now becoming so important to governments and the private sector alike, it is vital that to solve some of the global, national, regional and local issues, comprehensive analysis needs to take place. Decision-makers really need to understand not only 'what' is happening, but now 'where' is it happening.

The context of this growing awareness can easily be seen when statistics are considered such as in 1970, 63% of the world's population lived in rural environments, by 2000 that had been reduced to 53%, and it is estimated that by 2030 less than 40% of people will live in rural environments. This expansion of the urban environment is estimated to require 1.2 million km2 of new urban build by 2030, and an additional 2 billion people are likely to move to cities around the world between 2000 and 2030 leaving large tracts of rural land unpopulated and uncultivated.

As 80% of global economic activity is generated in cities, it is not surprising that currently over 1 billion people live today in slums to be near job opportunities; but at the same time 80% of Greenhouse Gas emissions and 70% of energy consumption is attributable to cities.

During this last year, the use of 'geospatial' to underpin some of the biggest questions facing the world has been understood by some of the leading institutions who work with governments and organisations at their highest levels; these include the United Nations, the World Bank and World Economic Forum.

Geospatial information and the 2030 development agenda

As a result of greater understanding that you cannot measure and monitor global systems without understanding the 'where' component, it was good to see the inclusion of the need for earth observation and geospatial information in the Resolution of the General Assembly of the United Nations signed by the leaders of the world on 25th September 2015 known as 'Transforming our World; the 2030 agenda for Sustainable Development'. The use of geospatial is stated twice in the Resolution but this statement sums up the sentiment:

> **We will promote transparent and accountable scaling-up of appropriate public-private cooperation to exploit the contribution to be made by a wide range of data, including earth observation and geospatial information, while ensuring national ownership in supporting and tracking progress.**
>
> *An extract from paragraph 76 of the United Nations Resolution 'Transforming our World; the 2030 agenda for Sustainable Development'*

The 2030 agenda is an agreed global policy to manage and transform the social, economic and environmental dimensions of humanity and our planet – it is known as 'the blueprint' to guide us for the next 15 years, and contains an accountability framework that includes 17 goals, 169 targets, and at least as many indicators. It will be much mentioned during the UN Climate Change Conference in Paris from 30th November until 11th December 2015.

Looking at 17 Sustainable Development Goals (SDGs), it is clear in most that 'fit for purpose' geospatial data is required; a sub-sample of the 17 goals is in figure 1.

Ede Jorge Ijjasz-Vasquez, a Senior Director of the World Bank Group said at a conference in Lisbon in May 2015 "that the use of geospatial information provides great opportunities to accelerate development and address global, national and local challenges but no longer are even more sophisticated maps needed, but the development of spatial data infrastructures are required to underpin all decision-making of countries". The good thing for the industry is that the World Bank always ensures that they work in partnership with the private sector.

New infrastructure needs for the next generation geospatial information

Taking the challenges facing the globe, the signing of the SDGs by the United Nations and the increased interest taken by the World Bank Group, it is clear that the spatial data infrastructures of many countries around the globe need strengthening in order that their governments are able to adequately measure and monitor the SDGs in their country and in their region.

The changes are quickly establishing themselves and are being reflected in the agreed work-plans and guidelines that the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) have established. Through its mandate it 'provides a platform for the development of effective strategies on how to build and strengthen national capacity on geospatial information, as well as disseminating best practices and experiences of national, regional and international bodies on geospatial information related to legal instruments, management models and technical standards'.

Established in July 2011, by the United Nations Economic and Social Council (ECOSOC), UN-GGIM is a formal global inter-governmental body tasked with making joint decisions and setting directions on the production and use of geospatial information within national and global policy frameworks. The priorities and work programmes are driven by the 193 Member States of the United Nations.

UN-GGIM is led by the Committee of Experts; those that attend are senior representatives from Member States either at Director General or Ministerial level. A Regional Committees' structure has now been established. The regions cover the Americas, Europe, Arab States, Africa and Asia-Pacific. The regional committees' play an important role in promoting UN-GGIM to Member States in their region on a regular basis, and in strengthening and supporting the work being undertaken by the Committee of Experts.

So what are these changes? If one lists them, they make a simple but comprehensive list of change taking place at policy level. They include:

- The change by many governments to the use of mandated international Standards
- The changes taking place with institutional arrangements
- The recognition of the economic value of using 'place-based data' to enhance decisions being made at the highest levels of countries
- The change by many governments as to their thinking about how to add a level of 'authority' into citizen collected data
- The understanding that spatial data infrastructures underpin the information systems of countries and assist the decision-making of the governments and the private sector
- An understanding that 'place-based data' is a vital component of the SDG agenda

Working together as Member States at the highest levels of governments and institutions is making a real difference in how geospatial is perceived by global leaders.

I do not think anyone involved in our industry could have imagined that Cabinet Ministers of Countries would now talk about 'accurate geospatial being a key differentiator for their economy' or that a resolution put forward by the Member States on the formation of the Global Geodetic Reference Frame (GGRF) would pass all the hurdles so that on 26th February 2015, a Resolution to strengthen the GGRF was not only discussed but endorsed at the most senior forum of the United Nations, the General Assembly. A very exciting moment for our industry and a landmark moment for all those who believe that accurate location information enhances global society.

Implications for the United Kingdom

So how does all this impact the UK industry? Globally, Europe and the UK in particular, are often looked at as excellent exemplars as to how the geospatial information underpins so many of the daily decisions made, not only by policy makers, but also by citizens. The INSPIRE initiative and local country strategies are examined across the world by governments and the private sector and often they are adopted with relatively little change, as the under-pinning strategic policy for their countries. Hence those UK businesses that wish to export their expertise in these areas now have over 100 countries interested in engaging with them.

At the same time, the UK is known and admired for its very developed applications businesses and all these countries will be looking for their own private sector to work in partnership with private sector counterparts who have already undertaken the 'learning' needed to launch successfully applications.

It is clear that the opportunities are there to be developed - but also it requires often collaboration between UK companies to be able to put together a total offering for a country that is large enough for them to consider. We also must use all the available technologies as many nations wish to have similar outcomes but to use the rapidly evolving technologies to do so. Other nations outside Europe are doing this and so should the UK, if the industry wishes to grow and benefit from the ever-growing use of geospatial around the World.

So looking to 2020, the UK geospatial industry has much potential to grow by exporting its expertise and licensing its intellectual property. But the key questions are, 'can we all grow to meet this exponential global need for geospatial?', 'can we partner successfully with each other to create a credible UK offering?' and 'will we outpace other nations who also are spotting this as a new growth opportunity for their private sector?'; only time will tell!

DR VANESSA LAWRENCE CB

Former Director General and CEO Ordnance Survey (2000-2014) and was the inaugural Co-Chair of UN-GGIM (2011-2014)

She is now working, for the next two years, as a strategic advisor working globally with an aim to expand the use of geospatial globally and to bring new partners and organisations into using geospatial strategically.

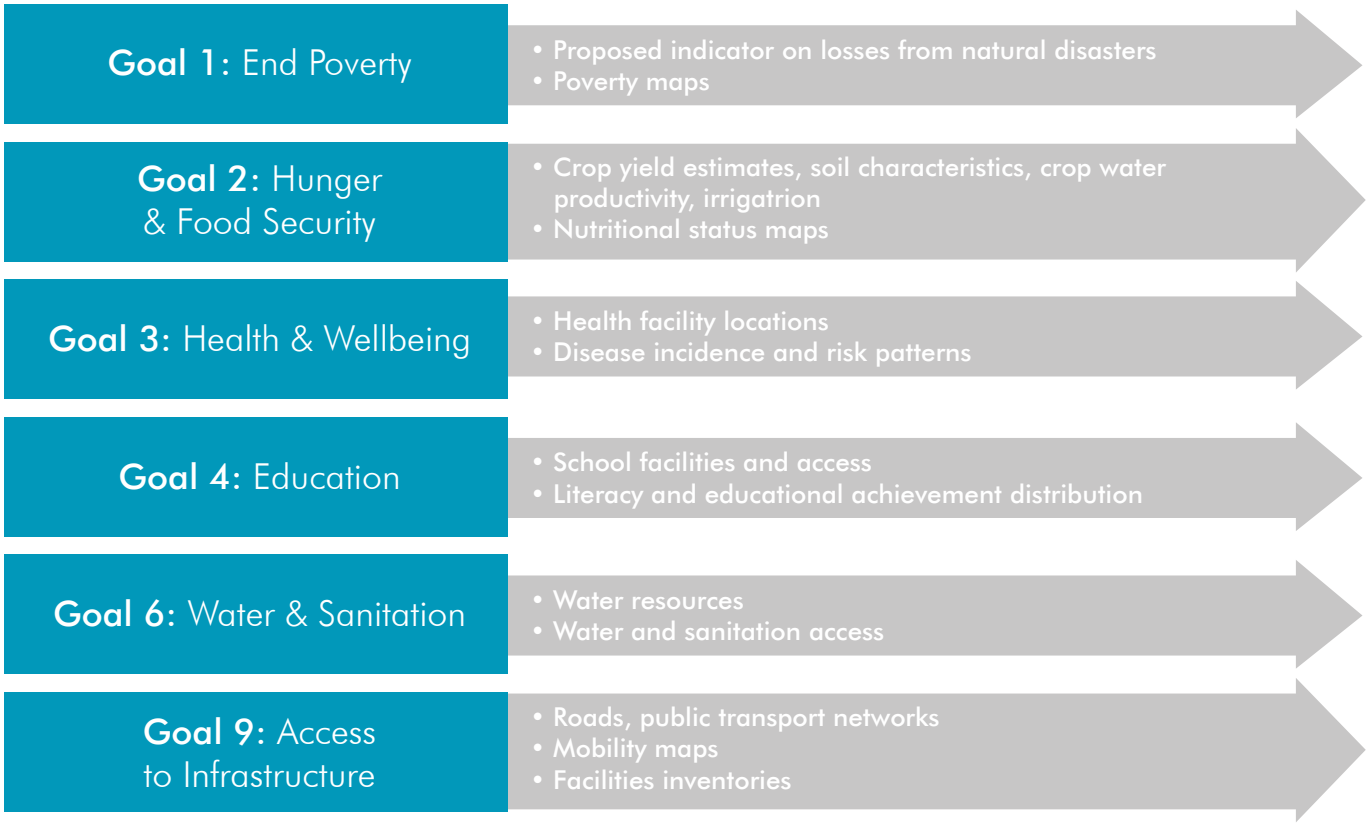

Figure 1 - Slide content courtesy of Greg Scott, UN-GGIM, 2015

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

"The trouble with geographers is that they think the world is 2D, flat and doesn't change!"

Chris Little | UK Meteorological Office

I, rather exasperatedly, said this at a recent OGC (Open Geospatial Consortium) Technical Conference somewhere. Before you stop reading, let me explain where I am coming from, and hopefully you might agree that there is some work to be done over the next years.

I am a mathematician by training and for many years, a meteorologist by profession. Meteorology has been agreeing global standards for observations, data exchange, processing and dissemination for about 150 years. We routinely think of the world as 2 dimensional (2-D), 3-D, and undoubtedly 4-D. It gets worse, as weather forecasting 'Best Practice' is to make many forecasts (more than 10, less than 100, usually about 50) in parallel simultaneously. This is a form of spread betting, trying to estimate the most likely outcome, but also acknowledging the possible extreme events, which can be dangerous. These probability distributions of the forecasts, known as ensembles, can be thought of as another dimension of our world, bringing us up to a 5 dimensional hypercube of data.

Forecasters routinely talk about two different time dimensions/axes (real time and forecast time), and of course, a later forecast, using more up to date data, is usually better than an earlier forecast, though not always. So there is yet another time dimension of available forecasts, bringing us up to 6-D. And if we consider the various parameter of interest, such a pressure, wind velocity, temperature, humidity, air quality, rain rate and accumulation, clear air turbulence, cloud cover, solar radiation, etc., we daily generate 7-D arrays of data.

Similar aspects apply to climate prediction, though a computation may take many months rather than hours.

Of course, most weather forecasting software (Numerical Weather Prediction models), and all climate prediction models, sit 'on top of' an ocean model, so we also have extra parameters and a second vertical axis - down.

Having said that, the traditional 2-D paper map with accurately registered overlaid layers of different contours and symbols of various parameters, displayed on a 'light table', was the standard forecasting tool until about 50 years ago, when computers and their various output devices started to become more capable. So the 2-D view is still useful, especially as some of us struggle with thinking in three dimensions, never mind seven, but only as one slice, usually horizontal, of the data cube.

This 2-D approach breaks down when many dimensions are available for consideration, because the map layer paradigm assumes a simple choice of which layers to consider, perhaps from an on-screen menu, or a GetCapabilities response in GIS software. However, when there are hundreds, thousands or many more layers to consider, this approach seems problematic. This is akin to the 'Google search result' problem: "Here are the first 10 results of 12,345,678. Do you want to see the next 10?"

So there needs to be standard ways of exposing the internal structure of these environmental data hyper-cubes, which are usually multi-dimensional coverages. The revision of the OGC Web Coverage Service standard to Version 2.0, with its extensions for slicing and trimming are a good start.

Earlier this year, there was an joint meeting in London of AGI and the BCS Locations Specialist Group entitled "3-D or not 3-D, that is the question". The speakers were practitioners struggling to join up existing 2-D applications with ones that were ostensibly 3-D, such as CAD (Computer Aided Design), such as to design the new Cross-Rail underground station at Tottenham Court.

As buildings and structures transition from project orientated construction to sustainable maintenance and the use of standards like BIM, there is a need to interface to wider environmental monitoring and management systems too.

Here I suggest an example of this lack of joined-up-ness with the real 3-D world. Imagine navigating your way, with a single phone app, from your 15th floor hotel room to a conference centre in Tokyo, via the Metro and a short walk through some streets and an Imperial Palace park.

Firstly, the hotel starts on the 6th floor of its building (actually the 5th, as there is no 4th floor, and as it is an American chain, there is no 13th flood either) which then gives onto a shopping centre.

Secondly, having found what seems to be the ground surface, you descend into the metro and locate yourself on a topological network map, which only bears a slight resemblance to geographical reality. The app locates you on the correct metro or suburban line and tracks your position between stations.

Thirdly, emerging into daylight again, GPS kicks in and you wend your way through the streets, trusting the app and a real-time augmented reality translation service to read the street names, and the delightful park, which has no street names, to the Conference Centre.

Finally, the conference centre is about 1/2 km long and spread over several floors, excluding the fourth, in several towers. The app directs you up and down the correct lifts and escalators and into the correct wing/tower, bypassing all the other fascinating conferences on at the same time.

As a bonus, your Japanese conference organisers issue you with an Internet of Things enabled badge which records continually, at your behest, where you are, to the nearest 50cm, inside the building, and records who you stand opposite, facing, having a conversation for more than 10 seconds. It also records your journeys on the Metro, and offers discounted travel.

This latter badge did exist last year, but the integrated 3-D app for navigating in, around, inside and under a city is still in the 4+D future of geo-informatics, as are fully integrated design and management systems.

CHRIS LITTLE

PS. The Tokyo public transport system is probably the busiest and most complex in the world, but is remarkably easy to find your way around, even if you do not read or hear Japanese. Its precision, punctuality and timetable must surely take into account leap seconds!

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

The Value Chain of BIM Data in a Smart City Context

Ilka May | Arup

Smart Cities seek to satisfy the needs of a growing number of citizens without using exponentially more resources through a better use of technology. This applies to natural resources, i.e. energy, water or food, but also in a commercial sense: build more for less and operate and maintain our built environment more efficiently.

City leaders around the world are turning to integrated and intelligent smart systems and sub-systems and associated big-data concepts to deliver what can be defined by the sev-en critical infrastructure components of a city:

- City administration: Streamline management
- Education: Increase access, improve quality, and reduce costs
- Healthcare: Increase the availability and provide more rapid, accurate diagnosis
- Public safety: Use real-time information to respond rapidly to emergencies and threats
- Real estate: Reduce operating costs, increase the value, and improve occupancy rates
- Transportation: Reduce traffic congestion while encouraging the use of public transportation
- Utilities: Deliver only as much energy or water as is required while reducing waste

(Washburn & Sindhu, 2010: pp.5-8; Department for Business, Innovation & Skills, 2015).

In a smart city, the systems and sub-systems that Washburn & Sindhu describe are not just silos of technology; they are linked under a common framework. Metrics and meth-ods for measuring, analysing and evaluating the performance of these systems are usual-ly system specific, for instance energy consumption and losses within a smart grid and congestion and travel times in a mobility system.

More data and better information will help to improve the individual systems and sub-systems of a city. But infusing intelligence into each subsystem of a city, one by one – transport, energy, education, health care, buildings, physical infrastructure, food, water, public safety, etc., is not necessarily leading to a smarter city that functions as an organic whole, or a network of linked and interconnected systems (Kanter & Litow, 2009: p.2). City leaders and decision makers need to be able to assess the interdependencies of vari-ous systems and how they impact each other and contribute to city-wide aims of econom-ic development, livability and environmental sustainability.

In the rush to embrace big data and the Internet of Things we need to challenge why we are doing this and who pays for it – and thereby better understanding the appropriate 'where-with-all' to deliver on the promise of better insight. Through Building Information Modelling (BIM) we observe the merger of two spatial worlds in the construction industry – Geographic Information Systems (GIS) and Computer Aided Design (CAD). Whilst each of these technologies has something to contribute, we need to identify what is required for the future, and look impartially at what should be drawn in from past methods, and what needs to be newly developed.

To do this requires a fundamental and deep understanding of our relationship with digital data, and how we can draw out intelligence from that data, to inform better dialogue, and derive better decisions – setting the context for whole lifecycle information management and improved asset performance management.

Aim

The aim of this essay is to examine the value chain of BIM data in a Smart City context and the relationship between Smart City data and BIM data.

The paper will describe what we need from data and what we need to do to unlock its real value and avoid untrusted and unmanageable information overload.

Methodology

The UK Digital Built Britain (DBB) strategy was launched in February 2015. This strategy brings together the Industrial Strategy – Construction 2025 (HM Government, 2013), the Business and Professional Services Strategy (Department for Business, Innovation & Skills, 2013b), the Smart Cities Strategy (Department for Business, Innovation & Skills, 2013c) and the Information Economy Strategy (Department for Business, Innovation & Skills, 2013d) to provide a consistent vision as to how we can create a high performing, transparent economy that efficiently delivers services to all of its citizens.

This paper addresses selected questions and research needs raised and identified in the DBB strategy. It uses the following statement in the context of new business models ena-bled by digital technology as a starting point:

The DBB strategy identifies asset availability as one of the main challenges for sustainable economic growth, pressure on resources and the emergence of the Digital Economy:

> **The ability to bring together through open data standards from design, construction and operations and across market sectors - offering the ability to analyse and create the learning feedback loops that industry needs to be able to deliver sustainable long-term improvements in asset performance.**
>
> *(Department for Business, Innovation & Skills, 2015: p.14)*

This paper deals with the following three specific questions arising from the statements above:

1. What are the differences and similarities between Smart City data and BIM data?
2. How can BIM data help to improve asset performance and extend the life of as-sets?
3. What is the role of standards in Smart City data?

The research pathway combines primary sources, i.e. published papers or presentations with secondary sources, mainly interviews with thought leaders in this field.

Smart City data and BIM data

Differences and similarities

> Smart city data is any data that can be captured in or relates to a city or urban envi-ronment; it won't be inherently smart in itself, but can be applied to make the city smart. The range of areas of impact of smart city initiatives are so great that all data is in scope.
>
> *(Heath, 2015)*

All the systems and sub-systems of a city generate and collect enormous amounts of data – referred to as big data. Bew (2015) describes it as "looking top down, from a sky view." Much if not most of big data is produced automatically, routinely, and by various forms of sensors (Batty, 2013), i.e. in buildings, transport systems, mobile phones, etc. Other, more static data sources include geospatial or geo-located data, such as Google Earth or Google Maps.

Guo (2014) compares big data with 'soil, rather than oil', given that its characteristics are:

- 'Ubiquitous: available anytime and anywhere
- Non-rivalrous: one person's use of it does not impede another's
- Hyper-renewable: data do not diminish when it is used; it can be processed again and again and its consumption creates even more data
- Cumulative: Data's value usually increases when it is used'

Integrated city data comes from a variety of data sources, combining real-time and static data and can be used for:

- Leveraging information across all city agencies and departments
- Anticipating problems and minimizing the impact of disruptions
- Coordinating resources to respond to issues rapidly and effectively (Banavar, 2011; Gann, 2014)

Data science uses methods like mining, analysis, extraction, experiments and transduction for creating value, finding patterns, understanding correlations and causalities, transform-ing and combining big data in order to turn it into usable and valuable information (Guo, 2014).

In contrast to this top-down view of smart city data, BIM is a method for collaborative working, aiming to deliver accurate, validated and controlled information about individual assets. BIM data is predominantly engineering derived, highly accurate and with a concept of state with respect to time. This model for data creation and aggregation is looking bot-tom up (Bew, 2015), created for individual assets and multiplied over portfolios.

BIM comprises geometry and attributes of objects in a common template or schema called IFC (Industry Foundation Classes), which is an ISO standard developed over the last 16 years, to facilitate and enable facility data exchange and re-use between parties, sys-tems or software throughout the asset lifecycle (Nisbet, 2013: p. 8).

Irrespective of a top-down or bottom-up view, there is a connection between Smart City data and BIM data, both providing data about our built environment for further use in op-erations, maintenance and performance management.

UK Government for example, in the role of a client for built infrastructure, is requiring their supply chain to deliver asset information in a standardised format and structure through BIM (Whyte et al., 2015).

The Digital Built Britain strategy confirms the connection between BIM and Smart City da-ta: 'Delivery of the transformation required to enable a Smart connected high performing built environment is a long-term project. In line with the Level 2 BIM strategy of 2011 we will continue the approach by taking progressive steps. [...] It has defined new working methods and has created new controls for procuring, validating and processing standard open data.'(Department for Business, Innovation & Skills, 2015: p.14).

The interpretation of the latest "BIM Heat Map Survey", carried out by the ICE BIM Action Group in the UK, suggests that this connection is not yet commonly understood: 'We gen-erally found that while there is a good understanding of the benefits of 3D modelling, this is not converted into a deeper technical understanding of how to exploit all digital data as the lowest and re-usable common denominator of information, beyond just the graphical output.' (Kemp, 2015). Tom Heath, Head of Research at the Open Data Institute in the UK, confirms this lack of widely used solutions to enable the efficient utilisation of BIM da-ta by other parties: 'Building and other built assets represent one area of application of smart city ideas, and given their capital and operational costs, there are clear incentives to make better use of them that can be facilitated by data. Still to date we have not seen much consideration of the role of data in making connections across buildings, apart from centralised estates management' (Heath, 2015).

Connecting the information value chains

How can BIM data help to improve asset performance?

The Digital Built Britain strategy identifies the ability to measure 'in service' performance and compare it to 'as briefed' and 'as delivered' assets as the single biggest opportunity to improve both asset cost and carbon performance. The traditional, linear process for delivering assets starts with client's needs that get translated into the brief, passing through design, procurement, delivery and operations. The feedback loop from in-service perfor-mance data, which has the potential to improve the understanding and knowledge about assets and components and their behaviour and performance in operation, is currently missing (Department for Business, Innovation & Skills, 2015: pp. 9, 14, 17).

The following section uses the condition-based maintenance example to investigate the information value chain methodology of BIM and smart city data for improving asset per-formance in order to understand the role of BIM data for performance management.

Condition-based maintenance is a strategy in which maintenance of an asset or compo-nent is performed in accordance with its state or condition. The approach is based on the concept of a P-F curve shown at **figure 1**, which plots the condition (or failure re-sistance) of an asset against the operating time. The first evidence of deterioration of an asset is marked as point P on the curve (potential failure), whereas point F (functional failure) is the moment when the asset loses its operability. Appropriate, predictive mainte-nance in the P-F interval is seen as one means for delaying the failure point in time and thereby extend the life of the asset at high performance.

The concept of condition-based maintenance is based on controlling trends of change with respect to normal or initial condition. Hence the success of the method fully relies on the appropriate quantity, quality and timely delivery of information (Kamei & Takei, 2011; Pennells, 2013). System-related performance indicators are used to evaluate the perfor-mance of asset components, sub-systems or systems. Parameters for the condition eval-uation can be either compiled from sensors or other monitoring systems, i.e. meters and sub-meters or from actuators.

The data provides absolute measurements in near real-time, which is why this type of da-ta is often classified as dynamic data. In order to allow benchmarking or a more cross-functional performance evaluation, it might be desirable to relate absolute measurements to other values or to normalise the monitored values. The so called descriptive or static data that is required to achieve this can be derived from Building Information Models. The entirety of building performance data can be used for different purposes, including:

- Condition-based or other maintenance activities, decision support
- Operational support and building automation
- Verification that national, European or international legislative requirements are ful-filled
- Verification that contractual obligations defined in service level agreements are ful-filled

(Menzel, Hryshchenko & Mo, 2014: p. 769)

The illustration of this information value chain, describing the relationship between static and dynamic data from various sources through to the creation of a viable 'information product' is show in the graphic below. The red arrow indicates the currently missing feed-back loop back to the asset brief.

Given the complexity and consequences of decisions based on information as indicated above, there is a clear risk associated with low quality data or errors in data evaluation and analysis. Raw data does not provide answers or value straightaway. Generally sensor-derived data comes uncleansed, with no provenance, security or controls and often ques-tionable accuracy and fidelity (Bew, 2015; Gawer, 2014). Different generations of sensors deliver different quality of data (Whyte, 2015). Conclusions are drawn from a large varie-ty of data and data sources that are subject to random variation, e.g. observational er-rors or sampling variation.

Google's chief economist Varian (2013) highlights in particular the importance of experi-ments in the context of correlation and causality. 'Observational data – no matter how big it is – can usually only measure correlation, not causality'. High quality, yet small volume data and sophisticated learning algorithms are used for exploring causality relationships. Correlation relationships are explored using big data with messy data tolerance and simple or scalable learning algorithms (Guo, 2014).

The role of standards for Smart City data

This paper has identified two main issues related to data in a smart city context:

1. The need for linked or interconnected systems and sub-systems instead of silos of information, activity and governance, and
2. A missing overall paradigm for management of interrelated asset information in-cluding the feedback loop from in-service performance data.

The question how different parties or systems can efficiently share and use data produced by others in order to help the smart city to meet its potential quickly leads to standards. A lot of work has already gone into the development of standards at different levels and addressing different issues, i.e. strategic, process or technical standards.

Figure 3 shows the need of a future work programme on standards in a smart city context as identified by the British Standard Institute (2014).

A gap analysis in the standards strategy, initiated by the British Standards Institute in 2013, has revealed a lack of overall interoperable framework standards that work across systems. An interoperability committee has been established to scope and develop an in-teroperability standardisation roadmap. This committee will liaise with other national and international standards bodies including ISO and CEN (British Standard Institute, 2014).

At a technical standards level, the aforementioned IFC standard provides a common on-tology for BIM data, including detailed geometry and export functions. This enables in-teroperability and exchange of data within the BIM environment.

So far it has not enabled efficient cross-sector activities and model access, aggregation of data or management of changes. It also does not include relevant external information, i.e. building codes, urban plans, specifications or geospatial information. Some aspects of it may be covered by other standards such as CityGML or IndoorGML.

Most of the external information, which is growing at fast pace, is available in various formats on the Web of Data. Törmä (2014: p.143) describes the Web of Data as 'a set of technologies to create a space of interlinked data objects', in the same way as the Inter-net in its early days was used as a repository to store and retrieve documents. The Web of Data comprises the Semantic Web, addressing the conceptual meaning of objects, and Linked Data, looking at their contextual meaning. Both are useful and complementary in the context of understanding and managing our built environment. Further work is re-quired to develop and standardise the relationship between the Web of Data and IFC.

Conclusion

This essay has shown the relationship between the 'top-down looking' smart city and the 'bottom-up' looking BIM data. It also demonstrated the great potential to improve the val-ue chain of BIM data in a Smart City context, using condition-based maintenance as an example.

The paper has also illustrated that the mutual impact and value between the two types of data is not yet commonly understood and utilised. This is less a technical than a cultural, commercial and process issue that needs to be resolved.

The condition-based maintenance example demonstrates the added value of combining dynamic big data and more static BIM data in two ways:

1. A better understanding of the existing asset and better decision making for maintenance and operations, and – over time and in a bigger picture more importantly.
2. With the feedback loop in place, knowledge derived from data will improve the quality of the brief and the design of assets; new built or refurbishments.

The methodology of the combined value chains applied on building operations or energy saving might reveal further research needs and new business models. We need to explore and experiment further how the value that the hierarchical, structured and object-based BIM approach brings can be unlocked and value added to smart cities, for example through standardised feedback loops from in-service data, better use of linked data and the Semantic Web.

At a more technical level, further research is needed to develop and improve hierarchical, re-usable and standardised templates for capturing and sharing big data across the entire market (Watson, 2015). These templates or standards need to be flexible enough to cater for the pace in which new data sources and technologies develop, yet robust enough to provide sufficient long-term reliability in order to justify the investment required.

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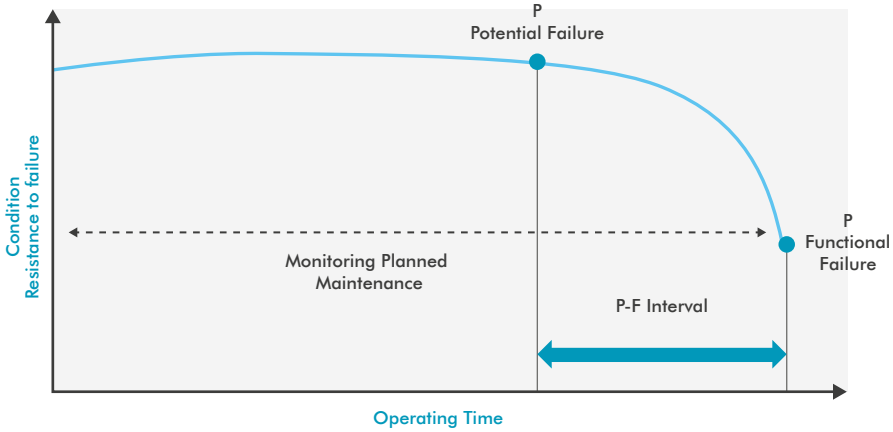

Figure 1 – P-F Curve (Kamei & Takei, 2011: p. 15)

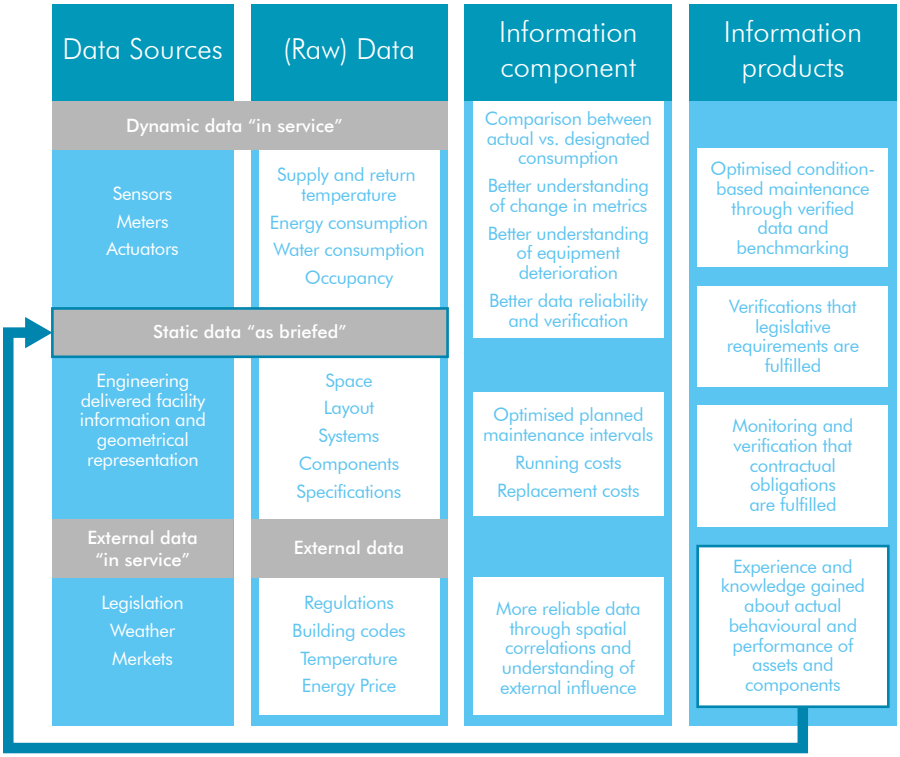

Figure 2 – Indicative Information Value Chain for condition-based maintenance

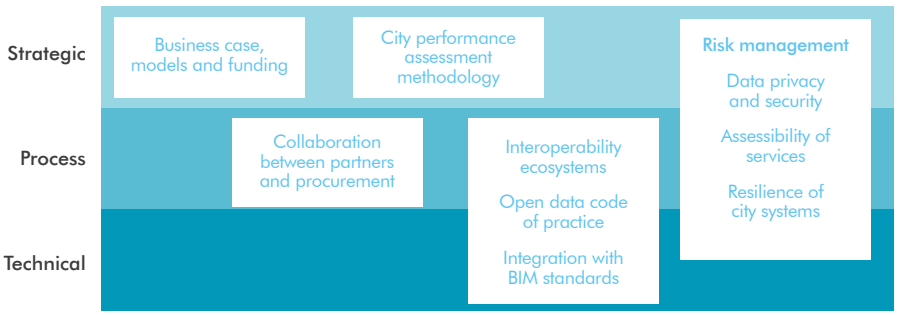

Figure 3 – Future work programme on standards in Smart Cities (British Standards Institute, 2014: p. 7

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Open-Source GIS in Local Government: Current Trends & Future Predictions

Simon Miles | Royal Borough of Windsor & Maidenhead

Open-Source GIS, FOSS4G (OS-GIS) or even FOSS is here, it's here to stay and Local Authorities are starting to use it and develop with it. Arguments for and against the use of Open-Source geospatial technologies have been discussed extensively over the last 5 years but beyond these discussions there is now a need to focus on the direction OS-GIS is taking over the next 5 years. The remit of the GIS professional is now growing beyond map production and data management. They are now required to understand more about how GIS (in its broadest of senses) fits into the wider IT infrastructure spurred on by the drive to overhaul the delivery of IT in Local Authorities.

In 2010 Jo Cook wrote for the AGI Foresight Report on Open Source Software[1] that "In 5 years time, Open Source Geospatial won't be a niche or a specialism, it will be the standard way that things are done." Perhaps Open Source Geospatial has not quite become the standard way GIS is practiced in the Public Section and Local Government, however it is fair to say that in general it has become more mainstream and is no longer a niche or specialist subject. Noteworthy is the fact that there are pockets of Local Authorities that now predominantly deliver GIS through Open-Source software, with many more trialling the use of it. By 2020 OS-GIS (in some form) will be mainstream in Local Government.

Within the last 5 years OS-GIS software has come a long way and as such now stands shoulder to shoulder with its proprietary siblings, undoubtedly one of the reason why many Local Authorities are now using OS-GIS. This may also explain why the likes of Postgres/PostGIS, GDAL, Leaflet js and Openlayers web mapping libraries and Geoserver (to name but a few) are starting to creep into proprietary and mainstream GIS software solutions and architectures.

Companies that now integrate or build software applications on Open-Source (including GIS) are having a dramatic effect within the Local Government arena. Not only are they financially more attractive but frequently these companies are built on cloud / hosted solutions, which are key agenda points to Local Authorities. Over the next 5 years those companies that are built on hosted / cloud platforms, such as Force.com / Salesforce.com are likely to make even greater inroads into Local Governement and the intergration with GIS will be made even tighter due to the collaborative work of OGC and W3C 'to improve interoperability and integration of spatial data on the Web'[2].

Hosted data and web mapping services have come a long way in the last few years and the number of companies offering such services have increased. Many of these services are based on Open-Source technologies, such as the Ordnance Survey OS OnDemand service. Amongst the benefits, is that they are based on subscription payments, a fact that hasn't been missed by cash-strapped Local Authorities. Over the coming 5 years, with the growth of hosted data service and the drive by some Local Authorities for shared services, large hosted data stores perhaps shared between two or more Local Authorities will start to emerge.

Hosted web mapping applications, such as those offered by CartoDB, MangoMap and MapBox have not yet made a march into Local Government but the reasons for this are unclear. Perhaps these services are still too young for adoption by Local Authorities, perhaps they lack deep integration with onsite backend databases, there may even be some nervousness of such a public SaaS with regards to security or perhaps the ability to estimate and budget costs. Undoubtedly the offerings of these SaaS companies will grow also over the next 5 years which will make them more appealing to Local Government.

It is clear to see the whole model of the procurement of software and licensing for GIS is changing, as a result of Open-Source technologies. Historically the GIS market was once dominated by 2-3 GIS vendors focused on selling a small range of desktop GIS software with additional packages to extend productivity at cost. Today the marketplace is peppered with small to medium sized GIS companies offering a wider range of software, solutions, services and bespoke development which have strong Open-Source foundations. These small to medium sized companies can often offer greater value for money. Costs may be based on population size of the Local Authority or on a sliding of services required, some even add in 'use as you want' consultancy days into contracts and more often than not offer integration with existing (or emerging) software, solutions or software used by Local Authority.

Over the coming 5 years more companies offering these agile GIS services will emerge. Noted by the AGI, the changing market place will be 'highly disruptive to businesses focused on licensing and maintenance models'[3]. Further more the UK government is also pushing home the Open-Source mantra, stating "Where appropriate, government will procure open source solutions" over proprietary software[4]. Change is therefore inevitable over the next 5 years in how GIS is used and delivered.

The Open-Source relational database Postgres and its spatial extension PostGIS combined with the desktop GIS QGIS are perhaps the main winners in the OS-GIS encroachment into Local Government. PostGIS and QGIS go hand in hand as part of the modern GIS enterprise stack built on Open-Source. The development of QGIS and PostGIS over the last few years has been rapid. However this development has not been guided by Local Government needs or requirements, but purely by individuals across the globe collaborating to enhance the software on a near daily basis.

The fast turn around in development of or bug fixes to features and functionality of Open-Source GIS is an element that Local Authorities find or will find attractive, compared to the slower development life-cycle and sometimes costly implementation beyond the software of proprietary solutions. Over the next 5 years, the use of QGIS and PostGIS will ultimately increase. QGIS will continue to grow and its position in the desktop GIS league table will see it jockey for 1st place with the world's leading GIS vendor.

The growth of QGIS in Local Government in the UK has been spearheaded through a small but growing band of Local Authorities that have or are in the process of migrating to it from proprietary GIS solutions. It could be argued that the catalyst to this growth was "Maptember 2013" when the UK AGI GeoCom and international FOSS4G conferences[5] were held in Nottingham in September 2013 and played an important role in raising the profile of free and open source software.

FOSS4G'13 was a defining moment in UK OS-GIS history. For the first time it provided a major event for GIS officers from Local Government (plus individuals for the private sector, academic bodies and people interested in OS-GIS) to see, hear and train exclusively on Open Source GIS. Its importance should not be understated; the event was so well attended and anticipated that more traditional GI events fell victim to its draw.

In the time since FOSS4G'13 , the OSgeo (UK chapter) and the UK QGIS user groups have seen an increase in participation from Local Government GIS professionals on online discussion forums and events organised by these groups. The role of OSgeo (UK Chapter) over the next 5 years will become more high profile amongst the Local Government GIS community, as they seek it out as a means to find out more about Open-Source GIS.

Over the next 5 years, the establishment of professional body or user group, dedicated to 'Open Source GIS in Local Government' needs to be nurtured. There are two natural contenders to provide this; the OSgeo UK chapter or the formation of an AGI Special Interest Group for Open Source GIS in Local Government. The specifics of such a body or group are beyond the scope of this report, however broadly speaking it would focus on promoting OS-GIS in Local Government, organise events and conferences, potentially raise funds to finance Open-Source projects and steer/contribute towards the development of OS-GIS technologies and projects with a Local Government slant.

During 2014, Steven Feldman, buoyed by the success of FOSS4G and the general enthusiasm for OS-GIS, wrote and presented upon the title of 'There is no such thing as a free lunch'[6] which amongst many points, challenged the end-user of OS-GIS to think about themselves as either a contributor or a user. For OS-GIS in Local Government to succeed then it has a role to play in contributing to OS-GIS projects, as it has the potential to become the largest industry in the UK to use OS-GIS over the next 5 years. Contributing to OS-GIS projects, which could be financially orientated or via other means[6] will help keep OS-GIS fresh, current and relevant to Local Authorities requirements of GIS.

Councils like Windsor and Maidenhead, Surrey Heath, Plymouth, Dartmoor National Park, Angus, Neath and Port Talbot and Warwickshire county council have all donated small sums of money to collectively procure development work for aspects of the QGIS project. This joint collaboration is likely to continue to grow over the coming 5 years as Councils spend little to gain a lot of functionality. Collaborative working and sharing of costs makes financial and economic scene to Local Authorities and plays on the community spirit of sharing that Open-Source promotes.

As already highlighted, over the next 5 years the numbers of individuals or small to medium companies that offer development services based on OS-GIS technologies will grow. This will not only benefit Local Authorities and OS-GIS users, it will have a wider positive effect on the UK economy. Adversely it may also have detrimental effects on established GIS vendors.

The use of Open-Data & Open-Standards in Local Government is still in its infancy despite the UK Government's 'need to have a platform for government that allows us to share appropriate data effectively and that gives us flexibility and choice'[7]. UK Open-Standards and those set out by the OGC may not be reaching their target audience; not due to a software issue but more of an educational/awareness issue for GIS professionals and wider Local Authority management. The growth of OS-GIS has stimulated the use of alternative file types and storage techniques beyond those that have been traditionally used in Local Government, a fact missed by some.

Web mapping libraries such as Leaflet js and OpenLayers have not been built to primarily integrate with the traditional ESRI SHP files or proprietary relational databases, but are designed to use such file types as JSON, GEOJSON, TOPOJSON and KML, all of which can be, if required, by created and edited in a text editor. The push by the UK Government to publish Open-Data[8] means that data has to be in formats that members of the public can consume at home on PCs/Laptops/Tablets without the need for specialist software. This is something that the EU INSPIRE directive has potentially overlooked, unless the end user knows how to consume WMS/WFS services in a Desktop GIS. Over the next 5 years, Local Authorities will start to publish data in alternative 'open' formats and ways (like APIs) which will take some GIS professionals out of their comfort zones.

This growth in data publication will stimulate interest in Open-Source ETL (Extract, Transform and Load) software, such as GeoKettle, Talend and the command-line GDAL.

The 'domestication' of GIS via Open-Source into the home environment is now huge, a fact that may have been overlooked by many Local Authorities. QGIS for example is now starting to make an appearance in Parish and Town councils for data creation means. The Ascot and Sunningdale Neighbourhood Action plan group, for example, used a combination of Ordnance Survey Open-Data, along with base mapping from OpenStreetMap to capture its aspirations for the Parish as part of the Neighbourhood Action plan (Localism Act of 2011). The use of GIS as part of the Neighbourhood Action Plan allowed the group to present their ideas and data back to the local council in a geographic way, for consideration and review. Over the coming 5 years more community and indeed interest groups, along with parish/town councils will start to use OS-GIS as a means to communicate ideas geospatially to Local Authorities and beyond.

For Local Authorities to be able to deal with such a growth in GIS consumerism, awareness of the bigger picture of OS-GIS, Open-Data and Open-Standards outside of the confines of the council building is required. Over the next 5 years, more needs to be done to encourage all GIS professionals and their associated managers from Local Government to be made aware of the potential of Openess. Although the silos within Local Authorities that once existed between departments have been broken down by GIS; there is now a danger the GIS will become a silo again. Some Local Authorities are struggling to become open and not realising the many benefits that this brings, while others are racing at speed to release, consume and communicate with spatial data to everyone and anyone.

Key Points

- Open-Source GIS is growing and Local Authorities stand on the brink of being the biggest industry in the UK to use it over the next 5 years
- Hosted / Cloud / SaaS Web Mapping GIS services will steadily start to increase in use in Local Governments over the coming years and this will shift the GIS market place away from software
- GIS vendors will be increasingly integrating and building upon Open-Source (including GIS) technologies over the next 5 years which will impact on traditional licensing models
- Councils will start to share costs and collaborate more on bespoke Open Source development and the pooling of data into hosted services
- The formation of a Open-Source GIS user group or professional body will develop, responsible for steering, promoting and organising events for Open-Source in Local Government

In summary

Over the last 5 years the conversations about GIS have changed towards Openness. OS-GIS delivers the age old fundamentals of GIS; those of create once share many, data analysis, cartographic principles, map production etc but there are wider subjects to take into considerations beyond the cost savings and for/against debate. The question is now "What can the array of Open-Source and Open-Source Geospatial technologies out in the marketplace and off the shelf offer a Local Authority to help deliver services to the public more efficiently and effectively?". For Local Authorities at least, the attitude of the UK government towards 'open' is a strong one which will help drive Open-Source, Open-Data & Open-Standards over the next 5 years. The change towards Openness, will see the role of the GIS officer in Local Authorities change more towards understanding a wider range of technologies, infrastructure and integration practices and data requirements beyond those associated with spatial. Open-Source GIS technologies have truly opened up access to all things GIS. Does this all means that spatial is no longer special, is GIS just another tool to disseminate and communicate information in an open world? Is the map dead? Long live spatial databases?

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

The Rise of Open Data and How It's shaping Marine GI Analytics

Fiona Miller | ABP Marine Environmental Research Ltd

Marine GI analysis, like all GI analysis, can only provide results as good as the data that is input. Additionally, the analysis of the marine environment has always had the added complication that many parts of it are inaccessible making data collection time and cost intensive. However 'Open Data' is creating a tide of change for marine science; public bodies and private companies are now making available data for use by all. Never before has so much data been at our fingertips. And it couldn't come at a better time, when an increased interest in the marine environment with an emphasis on marine spatial planning has become evident in the UK, Europe and the world.

'Open Data' widens the possibilities to complete new and innovative research, providing fresh solutions to old issues, redefining the opportunities available to the whole GI community. We need to now think about how we can maximize the use of 'Open Data' in the future and consider how to clear the path to finding the best available data. Every marine GI user needs to keep the current trend of data sharing and openness moving forward.

The History of Open Data

'Open Data' is the far right of the data spectrum; data which are open to everyone and are freely available to use and republish without restrictions beyond attribution to the source provider[1]. The last five years have seen an increase in the availability of 'Open Data' in the UK, which has been spearheaded by the government through the creation of the Open Government Licence (OGL) in 2010. At the same time the marine environment was becoming a higher priority for the European Union and the UK government. Both the EU Marine Strategy Framework Directive (MSFD) 2008 and the Marine and Coastal Act 2009 came into force, with overarching goals to achieve Good Environmental Status (GES) within the marine environment. To achieve GES an onus was put on the use of marine GI data to inform decision-making through spatial planning, increasing the need for accurate, up to date and wide ranging spatial data for the marine environment. It was inescapable that this would highlight the huge hole that exists where up to date and readily available marine GI data should be.

Historically, the collection and processing of marine data was costly due to the equipment and expertise required, and was generally obtained for a specific project or area. Many people can relate to being charged inexplicably high costs for data which were classed as fundamental for marine planning and expected to be included in projects. The increase in 'Open Data' and a shift in the UK government's mentality have resulted in a wealth of data becoming available, such as bathymetry, benthic samples and metocean recordings, allowing a much greater volume of analysis of marine data to be carried out. At the same time there has been a rapid increase in open source software allowing everyone the chance to process and analyse spatial data. Marine spatial analysis is no longer only available to those who can afford to complete data collection and own expensive technical software.

The same year in which the UK government created the OGL, the Ordnance Survey (OS) created the OS open data portal which provides a wide range of OS products for free under the OGL licence. This was quickly followed by other public bodies making data available through web portals like the Environment Agency (EA) and its Geostore data portal which now also holds data from the Marine Management Organisation (MMO) including, fisheries landings and shipping AIS data. This year (2015) the EA has also released all EA LiDAR data for England, marking a big change in the government's stance on sharing data, as previously this data was only available at cost. Other public body data portals developed recently include the United Kingdom Hydrographic Office (UKHO) INSPIRE bathymetry data portal and The Crown Estate's Marine Data Exchange (MDE) which houses data from offshore renewable energy developments.

The Opportunities and Issues for Marine GI Users

The rise of 'Open Data' and increased access of marine GI data to all has not come without its issues. The size, both extent and volume of data, now available is so large that without processing it can be too great for many off the shelf software programs to handle and store, so how do we find a 'work around' using the software we have? Creating new innovative solutions is the only way to succeed, with all the information and software now available the possibilities are endless.

With each public body creating its own web portals and industry collaborations creating even more access points to share data, how can marine GI users find what they need? The Marine Environmental Data Information Network (MEDIN) was formed in 2008 with the aim of improving access to marine data and is a partnership of UK organisations (public and private). In 2010 MEDIN released a data discovery portal providing links to large volumes of marine environmental data, helping to point people in the direction of marine GI data although this does not always help to identify the 'best available' data from hundreds of data sources. UK 'Open Data' providers need to work together to make sure that data are made available in the most efficient way possible.

Using Open Data

The benefits of open source data can be seen by all marine spatial data consumers and consequently the whole marine science community. It is clear to all that, with more up to date reliable data available, better spatial analysis will be completed, however the phrase 'rubbish in, rubbish out' still applies to any GI analysis. We need, therefore, to have good data going in to get reliable answers coming out. Such a need creates a mass of opportunities to further our knowledge of marine communities and processes as well as to apply findings which will guide future marine science objectives.

Multiple uses

In 2011 the Marine and Coastguard Agency (MCA) made available AIS data from shipping around the UK to the MMO. The MMO then processed the data[2] and released spatial layers for public consumption of shipping density grids through the EA Geostore portal. These data have since been used to inform multiple marine planning studies and Environmental Impact Assessments in UK waters. Further opportunities existed to use the processed data in 2015 study[3] where AIS shipping density was used to predict underwater noise distribution from shipping. This demonstrates that GI data can be used for multiple studies beyond the obvious and by making data available for wider re-use it could result in new innovative ways of conducting marine GI analysis.

Trend analysis

As part of the MSFD the UK wants to establish GES in its waters, this can be achieved through the informed designation of protected sites based on an understanding of the past and present distributions of marine species and habitats. During the MCZ consultation process, UK industries contributed to the data sharing movement by providing benthic GI data to public bodies, thus giving them a larger set of base data. The collection of data over many years to the same standards and the provision of these data to all interested parties will help identify trends which can go on to help target monitoring of impacts on the marine environment. This will only be achieved where industry and public bodies work together to share data and understanding.

Added value

The winter of 2013 to 2014 was not one people in the UK are likely to forget any time soon, it was one of the wettest winters on record and resulted in storm surges and extensive flooding causing major damage to parts of the UK. Following this event there was a renewed interest in creating precise and dependable metocean predictions, which rely on the availability of complete and reliable observation data for UK and Global waters. Metocean models are able to fill in the spatial gaps left by observations at discrete points, and predictions from such models are available from multiple sources. Innovative new models will be created where more reliable data are available to all i.e. 'Open Data'.

The Future

The next five years will see even more marine GI data become available; there will be more marine GI users and probably a lot of confusion over how all the data link together.

As more information is made available and more research and analysis can and will be done, then the marine GI community will develop and gain more and more knowledge helping to make informed decisions.

However, we have to be careful that searching for GI data doesn't become a harder task than processing the data. This will happen if each public body and private organisation creates its own data portal without taking into account what is already available. At present the UK public bodies have over a handful of data portals and in some cases provide access to duplicate data sets. Speaking from experience, this leads to the marine GI user being confused about which is the authoritative data source and uncertain of where to start looking.

Call to Action

It is a simple call to action, "Encourage the use of 'Open data' to complete spatial analysis". This can be achieved by making it clearer to the GI community what data exist and where they can be sourced from. Organisations, such as MEDIN, are trying to make this happen, however it is not a simple task. All marine GI users need to take responsibility for understanding the data they use and encourage their re-use by making them and any processed outputs available.

The last five years have seen dramatic change to the availability of marine spatial data, this has already resulted in a greater understanding of the marine environment. The increased focus on marine spatial planning has been buoyed by the availability of data allowing plans to be drafted on the best available data.

The marine GI community now needs to think outside the box and use all this open data to its fullest potential going into areas of research which were not previously possible without costly data collection over multiple years.

Commercial companies and academia are now able to bid for projects which were previously out of reach due to high costs for buying spatial data from competitors and public bodies. This opens up a new source of expertise, where work would have been previously won by those with access to the data, it is now won by those with the best expertise to complete the analysis.

The GI community needs to keep these trends moving forward to allow further data to become available including data from marine industries. This will see a large improvement in the spatial analysis completed, and will further our understanding of the marine environment. Identifying other data sources, currently not available, and understanding how these data can be made available will build on the wealth of marine data open to all.

About your Company

ABPmer is a leading UK marine environmental consultancy with an excellent track record in managing and contributing to integrated environmental projects across a wide range of industries as well as undertaking strategic work for government departments, devolved administrations and related agencies. ABPmer's Data and GIS team has worked on multiple large scale data collation and analysis projects which has led to in-depth understanding of marine GI analysis techniques and how these have changed over the last two decades.

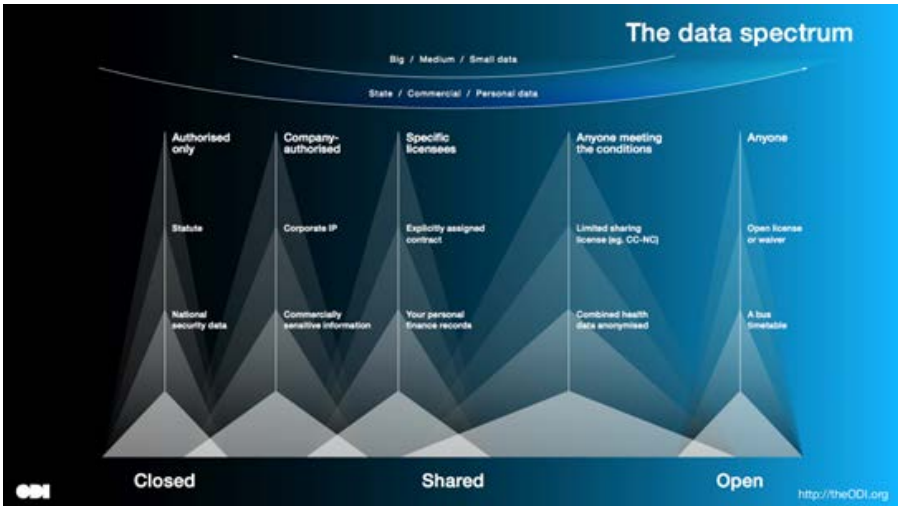

Figure 1 – The Data Spectrum. ODI copyright, 2015.

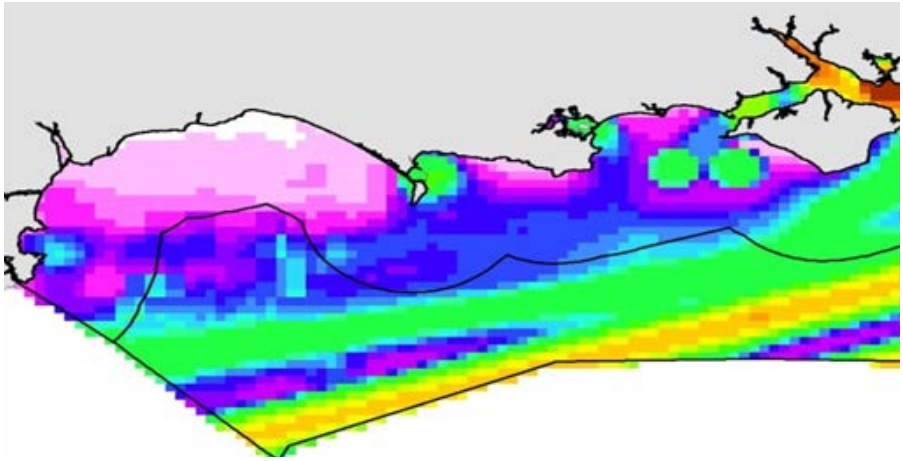

Figure 2 – Image of Underwater Noise Distribution. ABPmer copyright 2015.

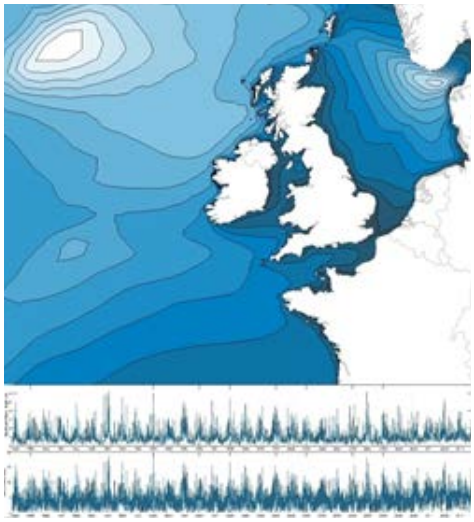

Figure 3 – Image of Metocean Models. ABPmer copyright 2015. All rights reserved.

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Future Trends in Geospatial Information Management

James Norris | Ordnance Survey on behalf of the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM)

This short paper looks at some of the emerging trends in the geospatial world over the next five to ten years. When the United Nations Committee of Experts in Global Geospatial Information Management (UN-GGIM) was set-up in 2011 it set out to identify, at a global level, the challenges and opportunities for geospatial information in the short- to mid-term.

The first edition of the report "Future trends in geospatial information management: the five to ten year vision focused on the big challenges facing national mapping authorities throughout the world. These included the challenge of open data and funding models, the future direction of data creation and management and the role of the private and non-governmental sector. The second edition of the report which was presented to UN-GGIM in August 2015 focused on the previous topics, but also took a wider view of the geospatial industry. It was clear from the response that the most significant changes would not come from a single technology, or organisation, but from the linking of multiple technologies and policies.

The updated report explores these ideas through a series of themes, focusing on four emerging and developing trends: Smart Cities and Internet of Things; Artificial Intelligence and Big Data; Indoor positioning and mapping, and: Integrating statistical and geospatial information.

What does the report say?

Due to increased global urbanization, it is expected that more focus will be placed on urban environments. The integration of smart technologies and efficient governance models will increase and the mantra of 'doing more for less' is more relevant than ever before. The emerging trends of Smart Cities and the Internet of Things, coupled with of smart resource management and interoperable services, will lead to a focus on citizen services, better land management, and the sustainability of resources.

The development of intelligent information-processing technologies, will provide easier access to a wide range of different services which were previously used for separate applications. These include home and industrial automation, medical aids, mobile healthcare, intelligent energy management, automotive and traffic management, to name only a few.

The next five to ten years will see significant developments in the architecture of the internet. Currently the internet is human-orientated; the shift towards machine learning and the adoption of the Internet of Things will bring into play devices which are, to all intents and purposes, autonomous and act independently whether or not anyone, or any system, is actively using them.

There is an increasing tendency to bring together data from multiple sources: official statistics, geospatial information, satellite data, big data and crowd-sourced data among them. For the full potential of these data sources to be realised, it is agreed that data needs to be accessible, interoperable and standardised. This theme is repeated throughout the chapters of the report, and stems from the need for users to be able to integrate different sources and types of information.

The role of National Spatial Data Infrastructures is more important than ever before. They can provide the means to organise and deliver core geographies for many national and global challenges including sustainable development. The paradigm of data availability is changing; there is a huge increase in the tracking and availability of real-time data. It is no longer just for mapping and delivery, but for integration, analytics, modelling and aggregation.

Work continues at a global level with international standards. The widespread and effective application of standards in many digital information fields is crucial not only for the continual effective use of internet-based products and services, but also for collaborations between different data organisations.

Although views on policies for the use of authoritative data are fairly consistent around the world, culture has a big influence. Governments are moving towards being commissioners of information rather than creating it themselves.

They are working increasingly closely with private sector organisations and are able to add a stamp of authority to data and services provided through public private partnerships.

New data sources and new data collection technologies must be carefully applied to avoid a bias that favours countries that are wealthier and with established data infrastructures. The use of innovative tools might also favour those who have greater means to access technology, thus widening the gap between the "data poor" and the "data rich".

Governments 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. The exact role a government chooses to take in geospatial information management, the challenges faced, and the changes made will vary from country to country. Governments retain a key role in ensuring that comprehensive and robust frameworks are put in place with related policies, resources and structures to ensure that geospatial information is easily accessible to decision makers in a coordinated way.

How was the paper created?

What are going to be the biggest changes facing our industry in the next five to ten years? This is the question that was asked to UN Member States and industry experts as part of the research for the report. The question was posed to all United Nations Member States, contributors to the previous report and published in geospatial magazines. A wide range of responses were received. The most common responses were prioritized and researched in more detail, leading to chapters on Smart Cities and Internet of Things; Artificial Intelligence and Big Data; Indoor positioning and mapping; and, Integrating statistical and geospatial information.

The information was analysed by the Policy and Engagement Team within Ordnance Survey who were asked, on behalf of the United Kingdom, to lead on the revision of the report. 30 UN Member States and observer states, spanning each of the UN-GGIM regional bodies contributed to the report, as did 7 different international organisations and 17 individuals either in their own right, or on behalf of their employer.

What's next for UN-GGIM and the Future Trends report?

UN-GGIM is a formal part of the United Nations system with a mandate from the Economic and Social Council (which alongside General Assembly, the Security Council and the International Court of Justice make up the main bodies of the UN). The ECOSOC are meeting in February 2016 to discuss and agree the future direction of the UN-GGIM.

The final draft version of the Future Trends in geospatial information management: the five to ten year vision report was presented to UN-GGIM in August 2015 and the Committee of Experts agreed that the paper should be finalized ahead of the next Economic and Social Council meeting of the UN.

The finalized version of the paper will be published around mid-December 2015 and will be available on the UN-GGIM website. The authors of the report can be contacted via email at ftrends@os.uk.

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Open Standards

Peter Parslow | AGI Standards

What can we know about the world in five years' time? Other sections in this report are considering that, and will identify various trends and expectations. Some of the things which are buzz words now will have settled down to business as usual; in some cases, the phrases themselves will have fallen away, but the concepts will be embedded in 'the way the world is'. Five years ago, we used the phrase 'Smarter Government'[1], from a 2009 White Paper; that phrase appears in one of the catapult programmes, but seems to have disappeared outside of the world of space & satellites. But the ideas of transparency and availability of public sector data have become – more or less – business as usual.

In the same way, in 2020, we may not talk about Smart Cities, the Internet of Things, or Big Data, but we will be living and working in a world where a wider variety of devices with varying degrees of intelligence are providing a large amount of data in ways that can be used to make our communities more sustainable – physically, socially, and economically. Some of the development required to achieve this will be planned, traditional, projects. But increasingly the work is quick, light weight projects, carried out by small companies, individual entrepreneurs and volunteers. This change is recognised in the government catapults, which foster deliberately unpredictable work.

All that interoperability will be eased by the adoption of open specifications and standards. Some of them already exist, others will emerge in the next few years, many will still have not settled down by 2020.

The challenge for the geographic open standards community is to make relevant contributions to that process. Five years and more ago, it was reasonable to set standards within our own community. Five years ago, we could say *'it seems likely that by 2015 we will be saying that "spatial is not special"*. We haven't got there yet, but we are working increasingly together with other domains.

Example domain areas

BIM

This acronym originally stood for Building Information Modelling, and was all about reducing the cost of construction. That work is currently the emphasis for the construction industry, but the forward looking parts concern other infrastructure projects, through life asset management[2], and the 'built environment' in the context of the surrounding geography. Unusually in comparison to recent years, the standards development organisations are involved in this forward looking work which is evolving rapidly. It seems very likely that 'BIM' won't be the appropriate phrase for this, well before five years have passed – and it's already in danger of being misunderstood.

The UK is recognised as a leader in BIM, alongside some in the US, South Korea, and elsewhere. So the time is right, and the British Standards Institution (BSI) now has a formal liaison between B/555 *Construction design, modelling and data exchange, and IST/36 Geographic information/ geomatics* (the AGI Standards Committee). Internationally, there is liaison between ISO TC59/SC13 and ISO TC211; Building Smart International (bSI[3]) are in touch with ISO TC211, building on the work they are doing with the Open Geospatial Consortium (OGC). Since I drafted this, OGC and bSI have established a memorandum of understanding, and will be working together on 'Integrated Digital Built Environment'. The learning will go both ways: the geographic community has much to be proud of, and much to learn. Within the next few years, we should have an interoperable set of data and service standards, that allow new constructions to be evaluated within a model of the current environment, and allow those newly constructed 'buildings' to be managed within that geographical context too.

By 2020, there will be rich asset management information available in open specifications about significant buildings and structures. It will be some time before information about older buildings is anywhere near as rich.

Because of the relation to the construction industry, and hence to large capital projects, BIM is more nearly related to the 'traditional' software development and information management processes than some of the existing GI standards are.

Smart Cities

'Smart Cities' is currently a loose concept – a group of discussions about using technology to make urban communities function more effectively. The discussion is beginning to recognise that geography provides a framework in which this can function. Within the next year or so, as Smart Cities thinking distils into specific activities, the challenge for the geographic open standards community is to spot the places to get involved. We also seem to be taking a lead in pointing out that 'BIM', i.e. detailed information about the built environment, is an important part of a 'smart city'.

For example, BSI participated in an ISO study group on standardisation for Smart Cities (ISO/IEC JTC 1 / SG 1) throughout 2014. The summary report includes an Esri GIS image, highlighting GIS as an 'enabler technology'. But the GIS column in their 'standard relevant to Smart Cities' only has ticks for graphics, IOT, Big data. That is because it was a JTC1 report, so focussed on IT, not geography. The report proposed a new Smart Cities 'special working group' to liaise with SDOs & advise city leaders. The door is open for the geo standards organisations to be involved.

OGC published a white paper[4] in February 2015, and is currently planning a pilot project. "To be successful, a Smart City must enable better choices by its citizens, organizations and governments."

An OGC led consortium has just been granted European Commission 'Horizon 2020' funding to identify the existing standards that will support 'smart cities', and the gaps. This puts 'geo' at the heart of the conversation.

By 2020, it will not be unusual to have geo-located sensors feeding live information for live decision making in a variety of urban situations. We should also have a better evidence base for decision making, whether at the planning or operational level. All this will be built on a core of open specifications.

Internet of Things

The 'Internet of Things' (IoT) seems more likely to build from the bottom up – networks of sensors and other semi-intelligent devices work together when they're from the same manufacturer. Making the information available 'on the net' in open formats will enable interoperability – whilst raising many concerns. BSI are just setting up a technical committee for IoT[5].

Much of the necessary development is not geospatial. For example, HyperCat[6] is widely seen as a core enabler for IoT. It had some BSI involvement, but no geo input. 'HyperCat is an open, lightweight JSON-based hypermedia catalogue format for exposing collections of URLs', intended to make web-connected devices discoverable. It builds on a couple of W3C things (HTTPS, URI) & a couple of open specifications that are not official standards yet (REST, JSON); doesn't quite use RDF, and nothing about it is geo-spatial: there's no standard way to find the physical location of the 'thing'. Similarly, 'If This Then That' is well placed to provide the glue, with sensor based triggers activating web accessible systems.

Development here may well be fast and 'light', and less of it is specifically geographical – although the OGC has existing specifications to contribute to the discussion. Perhaps by 2020, good practice will have emerged, and the geo-world can begin to reap the benefit.

Challenges for the standards development organisations

Underlying all of these is the general challenge to the standards community – to be responsive to new expectations both in software development and wide participation. On the one hand, we need to find out how to work with the wide range of existing standards bodies; on the other hand, how to listen to people who 'just want to get on with the job' and are not interested in common specifications.

bSI and OGC have a memorandum of understanding, but British work on future 'BIM' may move ahead faster than the standards bodies, with their international concerns, can manage. Conversely, the non-British participants are concerned that what we build here may not work for them.

OGC and W3C have just set up what is in all but name a joint working group[7]; this will reduce some of the duplication that could occur in developing standards for delivering geography over the web. But plenty of systems work over the web without waiting for W3C to show them how!

The IETF standardises the layer below the web, and occasionally discuss areas where geographic understanding would help – partitioning the TCP/IP space geographically, to improve the efficiency of the internet; sharing an understanding of time zones; encoding data about place.

When it comes to connecting intelligent sensors (the Internet of Things), the ITU is working on common specifications, potential independent of 'the internet'. And BSI are looking to work with OfCom.

The challenge for 'open standards' as a whole is to become a community of trust, where work is done in the most appropriate space, rather than in competition.

Building the future on the present

Some things are easier to foresee, as they will be the fruit of work already in progress. The INSPIRE Directive has set in motion an overhaul of the way that public sector environmental and geographic information is made available. There are key deadlines in 2017 and 2020. Even if not all organisations meet the deadline, we can be sure that more information will be available to a common structure (both semantic and syntactic) and delivered via common services. These data and services are built on open specifications, mostly from OGC. Some of this will be free to use, but much will be available under licence. In many cases, the open semantics and specifications outweigh any licence cost – 'free' data in a proprietary format can be quite expensive to use.

Applications will be built on this infrastructure, for example EuroGeographic's European Location Framework[8]; the Environmental Sciences to Services Partnership[9].

The INSPIRE specifications and recommendations will change over time, but the trend towards information being available in open standard ways seems secure.

Building with people

Standards by themselves don't solve problems; it requires people to implement them. One of the biggest challenges for the standards development organisations will still be to demonstrate to programmers and people who specify IT systems the idea that the value of an open specification outweighs the 'not designed here' concerns about understanding and implementing it.

People will still make mistakes – location APIs will be built with no understanding of reference systems, so positions will be out of alignment. Much will be 'good enough', and many will work without "standards".

Closing thoughts

By 2020, I reckon we'll still be wondering about RDF, whilst the light weight developers may have moved on from JSON to whatever they think of next – don't get caught up on language/syntax!

As we've spread out to other domains, we – geo professionals - realise we aren't the only group who need to grow out of thinking ourselves special.

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Emergency and Disaster Management

James Penman | UK Meteorological Office

The purpose of Emergency and Disaster Management is to

- **Minimise loss of life**
- **Minimise other impacts**
- **Facilitate recovery**

This paper considers how best to facilitate information handling and hence planning and decision making for emergencies and disasters.

A key aspect of emergency and disaster management is the ability to plan for, and make timely decisions in a fluid and at times rapidly evolving situation. This requires a clear understanding of the key facts of the situation and how they are evolving – in other words it requires situational awareness.

This means that management of emergencies and disasters requires reliable data and information from diverse sources to facilitate decision making. Ideally the types data sources and data streams will be pre-defined and pre-planned, with sufficient resilience and contingencies in place to allow the effective flow of information even when telecommunication infrastructure is disrupted. However during a crisis it will often be necessary to facilitate the inclusion of data from new and unforeseen sources.

To use the data wisely often requires expert guidance. Just as judicious use of data can lead to well informed and good decision making, misunderstanding by non-experts can lead to mis-representation of the data and thus to poor decisions.

In any crisis situation it is necessary for decision making to be coordinated. This in turn requires those involved in an incident to have a common understanding of the key facts. This is provided by the common operating picture.

The UK government defines the common operational picture as:

Single display of information collected from and shared by more than one agency or organisation that contributes to a common understanding of a situation and its associated hazards and risks along with the position of resources and other overlays of information that support individual and collective decision making.[1]

From an information perspective the decision making process consists of :

5D/4D -> 2D -> Go/NoGo

A commonly used model for EDM systems intended to support this process is to produce a single monolithic system. This system aggregates all the necessary information into a single data repository that can then be queried by an equally monolithic visualisation system. This has a number of issues including:

- Lack of scalability
- Lack of control for originators of data
- Single point of failure
- Expensive to build and upgrade

Instead it is proposed that a better approach is to support an ecosystem of tools for multiple functions from a common information service layer. This approach includes:

- An ecosystem of small tools tailored for specific purposes – thus easily maintainable.
- Tools decoupled from data sources by standards based APIs – enabling flexible access to multiple data sources.
- The authoritative data providers make their data available through standards compliant APIs thus maintaining control and authority over their information.
- Additional federated data sources can be readily added.
- Thematic curation layers – including federated access control and discovery services ensure that the best data for specific purposes can be found.
- The curation layer can be used to throttle lower priority uses ensuring the availability to high priority uses

In short by using a federated approach for the information layer the authoritative sources for each category of information maintain control and authority over their information, while permitting flexible access and use from an ecosystem of tools, which can be optimised for specific purposes. The federated approach and exploitation of linked data will also permit the inclusion of new and ad-hoc sources of information.

This approach is illustrated in **figures 2 and 3**.

Conclusions

Systems for EDM should follow the following principles:

1. Abstract tools for data – use same source of data for multiple purposes
2. Ensure authoritative data sources maintain authority over their information
3. Facilitate an ecosystem of tools.
4. Facilitate access to federated data sources.
5. Facilitate new data sources through open standards for APIs and data formats.
6. Record provenance of data
7. Preserve audit trail of information used for decision making in order to improve future incident handling and to respond to legal challenge
8. Capture scenarios that can be replayed for training purposes.

Resources

The text and diagrams for this paper are taken from the OGC Emergency and Disaster Management Information Framework Discussion Paper which is currently being prepared by the Open Geospatial Consortium's Emergency and Disaster Management Domain Working Group co-chairs Jaci Knudson, Gianluca Luraschi and James Penman.

[1] https://www.gov.uk/government/publications/emergency-responder-interoperability-lexicon

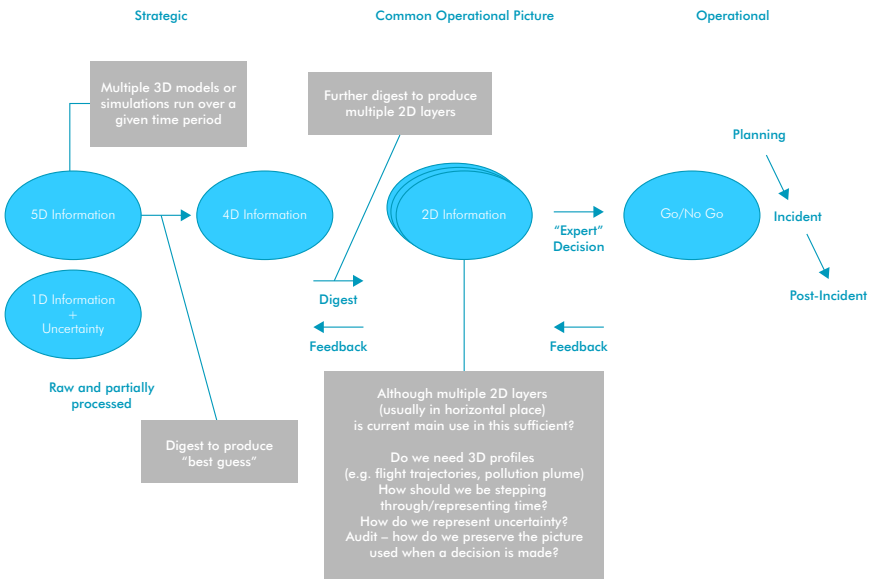

Figure 1 – Information flow in support of decision making

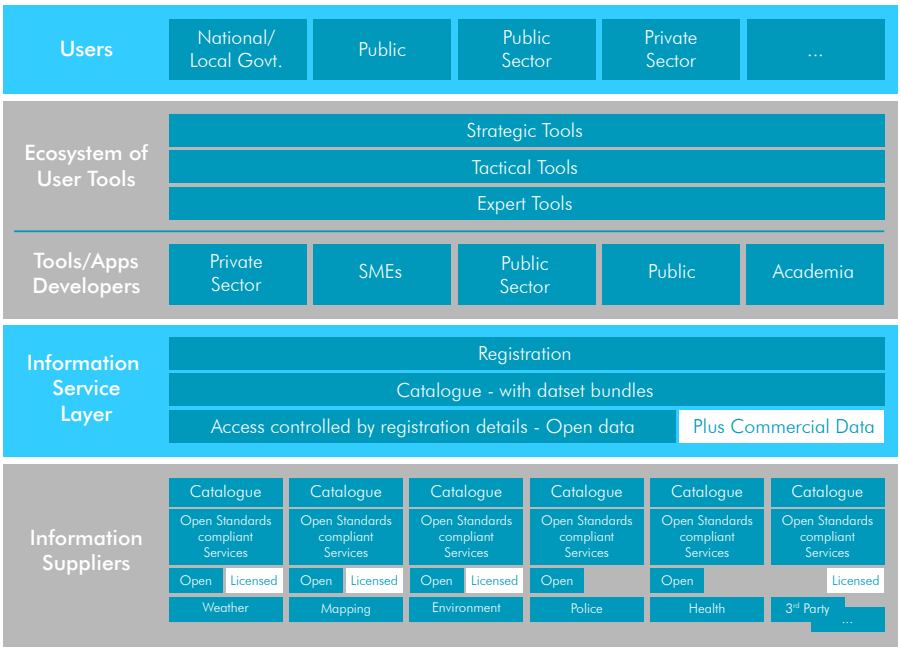

Figure 2 – Emergency and Disaster Management Information Services

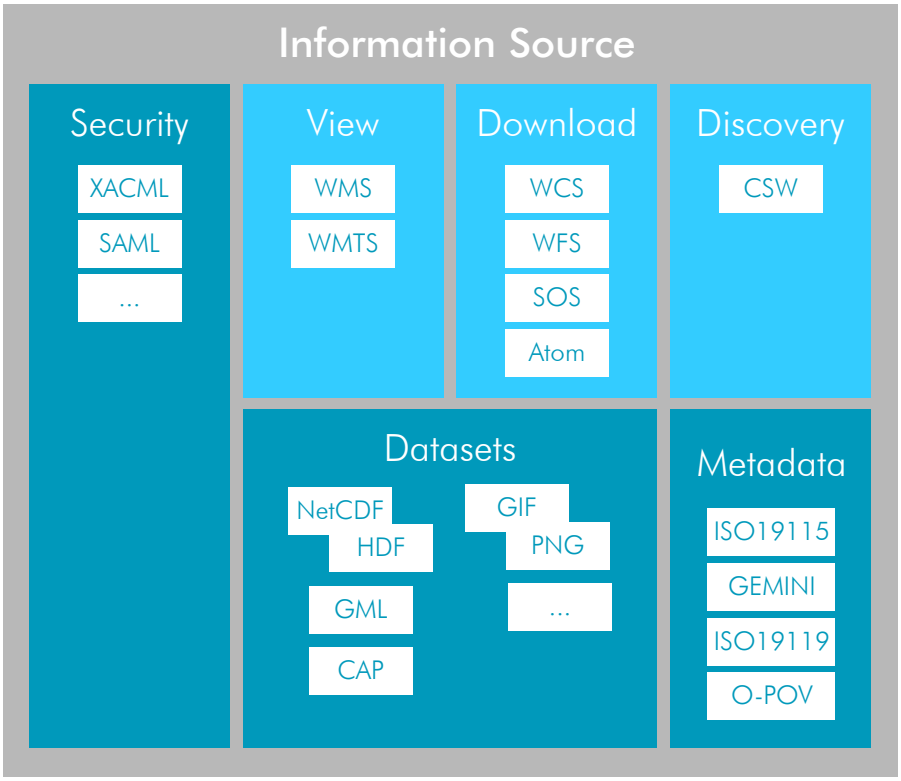

Figure 3 – Generic Information Source

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Big Data: Opening up a Smart New World for the Geomatics Industry

Martin Penney | Technics Geospatial Surveyors

"The Internet of Things (IoT) remains largely an amorphous construct with many different meanings to many different constituents. One thing that is clear, however, is that it represents a next generation set of technologies, systems, networks, platforms, devices, solutions and services that will transform virtually every industry vertical…Big Data and Analytics will increase in importance as IoT evolves to become more commonplace. Data generated through sensors embedded in various things/objects will generate massive amounts of unstructured (big) data on real-time basis that holds the promise for intelligence and insights for dramatically improved decision processes…We see great synergy coming in public and commercial IoT initiatives, but it will take up to twenty years fully develop. Major IoT initiatives will begin to be impactful starting in 2020 as critical adoption points are reached and major issues, such as interoperability and security, are solved initially through preliminary solutions."

"Key Areas of Focus for the Internet of Things".

Telecom Engine, September 2015.

Big Data is the latest buzzword amongst industry analysts. Collecting data, storing it and using it to advantage are top of every boardroom agenda. Research on big data in 2001 by global analysts Gartner termed the challenges and opportunities of data growth as being "volume, velocity and variety", to which has been added veracity[1]. Aptly the definition was enhanced in 2012 to include *"requires new forms of processing to enable enhanced decision making, insight discovery and process optimization"*[2].

While aimed towards market data information the essence of the definition has never been more relevant for the Geomatics industry. Today organisations are moving away from viewing data integration as a standalone discipline when necessary, to a mind-set where data interoperability, data quality, speed of transfer, metadata management and data governance are designed and used together. The challenge for Geomatics will be how we define our emerging role and all that entails.

The State of the Nation

There is no escaping that technology dominates our lives. From our everyday work with email and industry software applications to social use for shopping, reading, downloading films, sharing photos and keeping in touch with family and friends, we rely on our phones, IT and internet.

At the heart of today's world is the data that this generates, from operational and transactional systems, scanning and facilities management systems, inbound and outbound customer contact points, mobile media and the Web.

The Geomatics industry, as part of the wider geospatial community, is just one area which is on the edge of change, and for which we must prepare for. How data is gathered, manipulated and shared, is now one of the most discussed issues in this and other sectors. New applications, software and hardware, sensor equipment and measuring tools are being developed that will make the collection and analysis faster and more accurate and easier to share. These issues affect all companies and partners who rely on it, whether in construction, transport, utilities, engineering planning and development teams. Joined up data provides a pivotal basis on which to collaborate and make informed decisions. The Scottish Government for example created a deliberate long term strategy for linking data and information to allow better decision making[3].

The UK Government is driving the need for technology driven collaboration. The recently realigned Construction Leadership Council launched six new work streams this month to drive construction productivity; with Crossrail Chairman Andrew Wolstenholme leading on "smart innovation"[4]. Other Big data initiatives such as BIM level 2[5] and the Digital Built Britain Vision[6] especially in the construction sector have been introduced to encourage the advancement of 'smart city projects', whereby social data is collated and interlinked on transport, energy, buildings and infrastructure to provide a holistic picture. With a comprehensive view, developmental issues and plans can be assessed and outlined in a detailed, joined up and transparent way.

On a global scale there is ongoing research into FutureCities[7]; processes and standards to allow the effective interaction of spatial and temporal data between infrastructure, human and environmental systems which transcend traditional data boundaries. Building Smart International (bSI) building on its expertise in BIM standards is now also focused on driving positive transformation of the built environment[8] through collaborative open standards in conjunction with other agencies such as the Open Geospatial Consortium (OGC)[9] and the UK Ordnance Survey (OS)[10] to enhance the social and civic quality of our cities, through geo-enabling the Web and geospatial standards and allowing straightforward decision making. The OS open source geospatial data base for the Kingdom of Bahrain, producing a city-wide 3D national mapping program provides a suitable international case-study[11].

How did we get here?

Our industry has experienced significant technology step changes and upgrades before. Every few decade we have seen changes including:

- In the 1960s, the introduction of the electromagnetic distance measurement (EDM) to replace survey chains and intersecting theodolite angles
- 1980's, the draught board and ink pen giving way to CAD and today, in 2010+, the proliferation of 3D/ smart modelling and visualisation
- The analogue theodolite angle measurement surpassed by the electronic total station (1980's) and laser scanner (2000's)
- 1980's and the GPS unit for survey co-ordinate control replaces astronomical observations
- 2010's with airborne scanners and sensors replacing terrestrial equipment, mobile applications and multi sensors, indoor positioning[12] and mini drones and scanners[13]

But these advances have largely been industry specific instrument evolution events, not the vast society advancement in information and data sharing worldwide that we see today.

So the data explosion is not new, with dispersed data collection having started as early as the 1970s, epitomised by the perhaps extravagant NASA Voyager program and coinciding with the huge advances in solid-state physics with the introduction of the integrated circuit; it set to propel the survey instrument industry forward[14]. What has changed however is the speed of growth and information exchange along with the diversity of the data and the need to make better use of information for decision making. With the Internet of Things (IOT), this speed and connectivity of data and technology is set to increase even more[15].

Challenges for the Industry

For the Geomatics industry, while there are many benefits for this new world in terms of faster working and joined up thinking across disciplines, this Nirvana comes at a price; increasing client expectations, meeting new industry standards and training and development of employees to address changing roles and skill sets.

Changing Client expectations

Client expectations along the food chain have changed with the new world. There is an assumption that data can be provided instantly, on demand, and that it is the very latest available. Data mining, whereby relevant data can be extracted and manipulated to meet a particular request, is no longer considered 'innovative' but the norm.

New Industry standards

With new data and information collection, collation, modelling and management comes the need to regulate and standardise. Currently the Geo-industry in the UK is assessing current best practice within BIM and wider geospatial community both at home, in the US and around the world; with consortia such as the Open Geospatial Consortium and BuildingSmart (UK) to provide guidance in the UK and to set out the way forward.

Training and development

Traditional job roles within Geomatics will start to blur, as new technologies speed up routine measurement and data collation and more time is spent on visualisation, evaluation and sharing of big data. While the internet and technology savvy younger generation embrace this fluid way of working as the norm, there will also be a need to structure new resourcing, learning and development in order to accommodate this shift in emphasis.

The opportunity

A catalyst for change

The Geospatial Industry has the opportunity to morph into a new role in this information rich world, but it must take charge of technology and not be its slave and raise its head to view the wider geospatial picture in context. If successful we will be ideally placed to support society and community initiatives. However, failure will see the industry wither within the confines of historic tradition and methods.

There are four key areas that we must address if we are to meet the challenges going forward:

- There must be a role change - the former Guardians of data collection must now act as new arbiters of data standards, accuracy and interpretation
- The Standards and guidance need to reach out to a wider Geospatial community, both National and International such as advocated by OGC and bSI- Start local think global
- Industry leadership – we need leaders to champion the cause, help spread the word and show the way
- Resourcing – the current status quo will last a while. However, the role of the future surveyor will be very different; as well will be their "type", aspirations along with the needs of the industry

The next steps

As an industry we can start the process now to tackle the challenges ahead:

- Rally the professional bodies and their membership; combine thoughts and ideas and information cross-party; work out how this fits nationally and internationally
- Engage with the up and coming generations on their level as future custodians of the geospatial industry
- Collaborate with the wider industry to support richer discussion and exchange between colleagues and professionals locally, nationally and internationally around open standards and guidance

About Technics Group

Technics Group is a leading utilities and land survey company. We aim to make information transparent. Adopting innovative technologies, we use the latest data mining and modelling software to respond to client requests for land and utilities data. We work for clients and government in large and small construction projects for planning, transport, energy, utilities and buildings.

We'd love to hear your views.

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Creating Economic and Socio-Economic Value from Marine Geospatial Data

John Pepper | OceanWise

Where are we now?

Unlike the terrestrial geospatial sector, the marine sector in the UK lags some years behind in its thinking, attitude and ability to the **sharing and re-use of data**. Wider access to marine data outside of the traditional scientific and navigational purposes remains a slow and often painful process. Whilst a fast changing business environment means that demands placed on organisations for information continues to grow, the marine geospatial providers have been slow to respond with access being somewhat restricted which is stifling re-use and innovation.

The **value** of geospatial data is falling making it a commodity rather than a specialist requirement. This has had the effect of restricting the income necessary to undertake the re-engineering and re-purposing of existing marine datasets which are historically almost all product based. The UK agencies responsible do not have the remit (knowledge and funds) to do this work, which to date has been undertaken by the private sector. Commoditising geospatial data – without central resourcing – is stifling progress and is not sustainable.

There is a **lack of data centricity** in the way information is captured and managed. Products are often the only place where specific themed content is provided. These products are often not fit for purpose other than for their intended use (e.g. charts for safe navigation do not have to be accurate, they have to be safe therefore rendering the information sub-optimal for say site selection for an offshore wind farm).

Source data is not always treated as a valuable resource (e.g. the "crown jewels") as historically charts use approx. 5% of such information in compilation.

At the same time UK Government pursues its "Transparency" and "Open Data by Default" initiatives, there remains a **lack of awareness, understanding and coherent strategy for Spatial Data Infrastructure (SDI)** principles and the wider uses of marine data. Legacy datasets and work practices do not always support SDI because of inefficiencies, a lack of awareness of who the customer is and data security (often used an excuse rather than a reason not to release). The marine sector is not considered important enough and struggles to get its voice heard, exacerbated by the lack of strong leadership and fragmentation.

Multiple datasets in a wide variety of (new) formats - the different types of data that conform to make up a marine environment make them difficult to harmonize in a single combined usable way (i.e. via a common platform).

There is a **lack of awareness and understanding of emerging technologies** and better formats to represent dynamic (x,y,z,t) marine data (e.g. NetCDF for multi-dimensional data).

There is **no authoritative source for many key marine datasets in the UK**. The hydrographic and oceanographic communities remain fragmented with a lack of cohesion, replication of effort, wasted resources and provision of mixed messages (internal and external) in terms of what data might be authoritative. Management of such information is spread across many Government departments and agencies and even commercial companies (e.g. Global Marine for cables data).

A lack of support from decision makers: the marine sector decision makers often do not have the technical background necessary to **make the "business case" for GI investment**.

There is a **need to connect the scientific and technical motivations** to create a sense of purpose to support economic and social incentives and how the general public will realise the benefit.

"Not invented here" syndrome. UK Government players (e.g. Defra, UKHO, JNCC) develop their own necessary products instead of enabling access to information that would allow re-use licensees and users to create the value-added products and applications. This is counter-productive to UK Govt. stated aim for SME's to deliver the added economic value which politicians see as critical to the health of UK economy.

Globally Electronic Navigational Chart (ENC) data could form the basis of a marine base map, where source data is not available, but **the current business model to distribute such data does easily facilitate its wider use** by the non-navigational market. ENC data is only distributed through the Regional ENC Centres and VARs focussing on navigational outputs. This business model is not efficient for the majority of non-navigational users that may want this type of data. Because of high pricing levels and the S-63 data protection scheme, one of the most valuable assets cannot reach a broad audience beyond the traditional mariner in many countries.

UK Government needs to generate **more urgency across its own marine geospatial data providers to become better at making data available** and bring about change. Knowledgeable leadership and better coordination at a strategic level is essential and is likely to result in substantial cost savings. This has yet to be achieved despite the presence of the Marine Science Strategy and Coordination Committee.

Scientists collecting and analysing data need to allow more openness to "their" data. The need to retain "cited or published" data in reports ad infinitum for fear of losing control of that data can no longer be justified. Journals are giving way to databases as the means for access to this precious resource.

UK data collection programmes remain insufficient to meet the growing needs for information about our sea space. Collection remains fragmented because the only UK funded programme delivered by the MCGA, supports, as its priority, safety of life (SOLAS) needs. Whist some cross-agency work is now happening, it is a small percentage of the £7-8M per annum programme. Another government committee has been formed to look at all UK seabed survey data needs for the future which will finally identify the need for a more comprehensive and far-reaching programme.

The Marine Environmental Data and Information Network (MEDIN) http://www.oceannet.org/ continues to provide a focal point for discovery of and access to marine data in the UK. Its primary role is to provide, through its Data Archive Centres (DAC's), access to specific datasets which are freely available for re-use. INSPIRE themed data are those which are being made available through this portal. However, it does not provide direct access to the actual data but points to where and how such data can be accessed. It does provide a valuable if under-used resource but will not progress until it has direct access to data themes so becoming a one-stop shop.

UK Government Business Models - The Shakespeare review in 2013 made several recommendations of which the Government accepted with the exception of the one regarding Trading Funds. With the solution now to migrate Trading Funds to Gov. Co's, the threat of publically funded data providers becoming, or remaining as "competitors" to the private sector is a real worry as already witnessed with stated OSGB and NERC intentions. This will further undermine the ability of UK SME's to effectively deliver value-added products, services and solutions and with it, economic and social benefit in a cost effective manner. Even non-trading fund departments and agencies within government currently exercise the right to undertake commercial work (e.g. Cefas, JNCC, EA).

Summary

With the real value of data falling, the ability to compete fairly with data providers undermined and the growth in free, open (and linked) data in the UK and Europe; the market for GI services will inevitably decline.

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Integrated Digitally- Enabled Environment: the Internet of Places

Jim Plume | Building SMART, University of New South Wales, Australia Building SMART

This paper has emerged from discussions within an international Working Group established by buildingSMART International to consider the interface between information exchange standards in the spatial and design/construction sectors. The Working Group is co-chaired by Jim Plume and Anne Kemp, and the ideas expressed here are contributing to that discussion. The author is indebted to Anne Kemp for her contribution to this work, which must be seen as exploratory and speculative: we welcome challenge and other thinking that might inform these discussions.

In this short essay, we propose an information framework to support the digital enablement of the built and natural environments. In doing that, we envision an inevitable shift towards a world in which our interaction with the physical world is increasingly facilitated through digital technologies that rely on data and information, either to inform the decisions that we take, or, where appropriate, form the basis for the autonomous response of entities acting for our benefit in the physical world.

We can, of course, already cite examples of this trend, not the least being the fledgling exploration of the concept of a Smart City as the embodiment of this vision, the commonplace availability of location-based mobile apps, and the emerging realization of autonomous transportation systems that promise to address much of the vehicular congestion that arises from the growing number of people who need to get around in our cities. These developments, though only in their infancy, represent the beginning of a revolution in the way we operate as human beings within the physical world.

When we talk about our interaction with the physical world, we are not just referring to our position as end users, however, but must include the many professionals with responsibility to monitor and nurture the physical world, as well as those who plan, design, build, adapt, manage and operate the assets that make up the built environment.

At their core, all these activities rely on us finding better ways to manage the increasing quantity of information that is required to fuel these innovations. That information is derived from the growing store of on-line data available through the Internet, using digital technologies to collect, search, organize and structure it in ways that open up unexpected opportunities for innovation and entrepreneurial enterprise.

Broadly-speaking, there are two technologies that form the foundation of these ideas: the digital models that are used to represent aspects of the physical world; and the Internet technologies that collectively capture, hold, find, interpret and deliver the information. In this section, we expand on both these sets of technologies.

For some time now, we have developed digital models (along with the processes that rely on those) to inform our understanding of natural phenomena and to facilitate the design, management and operation of the built environment. These broadly fall into either the spatial domain (using approaches such as Geographic Information Systems, or GIS, city and infrastructure modelling – CityGML and InfraGML – predictive simulation or systems engineering) or the design and construction domain (using tools generally associated with Building Information Modelling, or BIM). Collectively, these technologies provide us with all the information and analysis that we need to guide the enjoyment, stewardship and management of our world, and to address many of the environmental and social challenges that we face.

These models rely, quite rightly, on the use of proprietary software tools that deliver innovative solutions to specific aspects of the challenges that we face when managing our world. However, those challenges generally demand integrated approaches that rely on more than one proprietary tool, leading to the need to move information and data freely between those different modelling approaches.

For that, we continue to develop standards across both the spatial and construction domains, not only defining how such information should be structured, but also the processes associated with its creation and delivery.

In this paper, we refer to this combination of proprietary tools and open standards as the Integrated Digitally-Enabled Environment (IDEE), affording us a comprehensive way of holding information about the natural and built environments.

For the IDEE to be of value to us, we need a way of accessing that information when we need it. That leads to the second set of facilitating technologies described above: the Internet to transport the information; the semantic Web to enable smart ways to find and retrieve information; geolocation technologies to enable searching based on geographic context; and RFID's with sensors to facilitate the Internet of Things to realise a sensate environment.

With those technologies in place, we can create direct links between the real-world objects that are represented in the IDEE models and relevant information about those entities that is available from the growing set of open data sources available through the Internet. That becomes a very valuable resource for those charged with managing the built and natural environment since, as they work with their planning and design models, they are able to take advantage of the vast amount of available contextual information. Furthermore, if the IDEE as-built models are archived and made available, then the data links can work the other way: the information held within those models becomes an invaluable resource for end users when they are interacting with the physical world, providing insights into the nature, performance and designed intent of the built environment.

That scenario is achievable today with the technologies available, as long as we continue to develop the open standards needed to link these technologies. That work is proceeding strongly, particularly with the increasing degree of collaboration between buildingSMART (responsible for BIM standards) and the Open Geospatial Consortium (OGC, responsible for spatial standards).

The question arises, however, is there a need for a conceptual framework that helps to tie all these technologies and standards together? Here we propose a set of ideas that might just provide such a framework.

In order to understand how we can harness those technologies, let us consider the way in which we experience the natural and built environment. All our interactions with the world occur in what we call *places*.

At all times in our lives we engage in activities that are entirely dependent on the place where that activity is focused. Our success in that activity is determined by how we understand, configure, adapt or manipulate that place. Places form the point of interaction between human beings and the physical environment that we occupy. On the one hand, places are given substance by the physical environment, so are therefore inherently linked to the physical world. At the same time, our individual perception of a place gives it value, meaning, significance and purpose.

This leads to the idea of the Internet of Places. Though not an entirely new concept, if understood in its entirety, it provides the key to managing the way we interact with a digitally-enabled environment.

It follows that a place is more than just location. It has a physical reality that is generally captured through some kind of digital modelling technology, which can be archived and made available through the Internet, and it can be linked to all sorts of other data through semantic Web techniques. It also has value and significance, either in a collective sense (the value that society puts on a place, generally already available through the Internet) or in a personal sense, the value that individuals associate with a place at some point in time.

Notice that places come in all shapes and sizes, ranging from a specific activity space (an office desk and workstation, seat in a bus, family living room, etc.) to a monument or destination, even a transport network as a whole can be considered as a place (providing a mode of access to other places), or it can refer to an entire city or country. Whatever its size and shape, places do change over time, so their temporal attributes become an important aspect of how they are understood and defined. Even the location of a place can change over time!

Our role with respect to a place at a given point in time can also vary, giving us a different perspective on each occasion. In general, we can identify three broad roles. We may have a stewardship responsibility toward a place, or we may be required to design or plan a place, and of course, in our everyday life, we are users of places.

The proposition in this paper is that the concept of place may provide the third pillar upon which we can build a comprehensive information model of our environment. What if we were to collect, store and make available in an explicit fashion all that we know about how places are valued, both collectively and personally?

At the most basic level, we are able to use the IDEE technologies to inform our understanding and management of the physical world, the Internet-related technologies to give us in-situ access to information at the time when we are engaging with the world, while all the time having that information filtered or tempered by the knowledge that is held about the value of that place. Those three planks would then provide a comprehensive understanding of our interactions with the physical world.

Our perceptions of place are very personal, they vary over time and they inform or direct the quality of our experience of the world. If we are able to find a way to collect and capture our understanding of place in a structured way, would that provide a useful conceptual framework for an integrated digitally-enabled environment?

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Geospatial Industry: Challenges

Alex Ramage | Transport Scotland

The challenges that are facing the Geospatial industry come from the introduction of various standards which are appearing from outside the normal channels that the industry monitor. These standards are not coming from the Open Geospatial Consortium (OGC) in the main although the OGC are trying to pick up the new ways of working and trying to put real standards in place. These "new" technologies (Linked Data et al) are acting as disruptors to the Industry as the way forward is not always clear and competing standards exist (GeoJson, GeoSparql).

At the same time as this is happening the Engineering World has brought the concept of Building Information Modelling (BIM) to prominence. Compliance with BIM is now being mandated both in projects that create buildings, (where the BIM concept first appeared) and also linear infrastructure projects (building Roads and Railways). The BIM world is being led by the big names in Engineering (AutoCad, Bentley) where additional functionality is being added to the standard packages to meet the additional requirements of BIM. The classical geospatial world has been slower to add the additional components to their systems to support BIM.

Finally, within governments, there is a very strong call for the data of government to become open. Government hold huge numbers of dataset, a significant number of these geospatial in character. How to make this information available to the general public in a way that it can be easily used?

Disruptors

Standards

The Geospatial industry supports a wide range of standards mainly originating from the Geospatial Standards Body: the Open Geospatial Consortium (OGC). This body creates standards collaborating with the members to identify, manage and maintain appropriate standards. As new technologies emerge, the membership of the OGC decide which technologies require to have standards.

This process of course takes time, so there is a lag between when a technology emerges and when a standard is put in place, there is a further lag before software suppliers support that standard, although the Open Source community sometimes does better than the traditional Commercial Off the Shelf organisations.

So emergent technologies such as Linked Data are not very well supported with standards as yet. This will change with time, but there will always be a time lag before the appropriate standards bodies catch up.

Building Information Modelling (BIM)

Bim is a set of processes that interact in one way or another with geography. BIM comes in a number of levels of compliance which go beyond 3D geography but to 5D (the 3 dimension, time and cost). The classic geospatial community has been slow to implement additional tools to support the use of BIM in their core products. The engineering software suppliers have been at the forefront of the BIM development and have made significant investment into their product sets. The main component provided by these tools over the normal engineering tools is a collaborative environment with appropriate security. This allows for appropriate workflows to be built that release designs to a wider group as time progresses.

It is important to realise that BIM is not just a set of tools that once in place provides compliance at one or more of the BIM levels . In the UK, BIM level 2 is being mandated for Government projects that are to complete after, depending on the part of the UK, 2015 to 2017.

Open Data

Although Geospatial data is a small(ish) subset of the Open Data community, there are a number of significant advantages that are enjoyed by our community. The existence of INSPIRE, has given the entire community the leg up to the use of "Open Standards". The technology required for INSPIRE can also be re-used for Open Data delivery mechanisms.

INSPIRE sets out, as minimum, to establish the ability to Discover data. Using a profile of ISO 19115 a minimum set of information is held about each data set and provided to the world as Metadata regarding the dataset of data series. This Metadata is held in a metadata catalogue, which is searchable. The next part is to allow a user to View the data, so INSPIRE requires the use of Web Mapping Services (and appropriate Metadata for the Service), to ensure that the dataset of series is what they were looking for. Finally the user can Download the data, so INSPIRE requires the use of various download Services (and appropriate Metadata for the Service). This technology stack, that is often in place already to support INSPIRE, can be used to provide the same facilities with geographical Open Data.

Resources

[1] http://bimtalk.co.uk/bim_glossary:level_of_maturity

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Linking location to sustainability: The UK context

Steven Ramage | Ramage Consulting Ltd

There are a series of global activities underway that are bringing together government and industry leaders to share ideas and concerns around sustainability, such as the Eye on Earth Summit and the United Nations initiative on Global Geospatial Information Management (UN-GGIM). Both these activities and many other initiatives involving international bodies have been addressing sustainability and the sustainable development goals (SDGs).

This is a universal set of goals, targets and indicators that UN member states (including the UK) will be expected to use to frame their agendas and political policies over the next 15 years. Many people will see this agenda applying mainly to other countries, however as we have seen recently with extreme flooding across the UK, considerations around welcoming refugees into the UK and a growing number of people on the poverty line in the UK, sustainability is a major topic for everyone.

One of the key goals for geospatial professionals should be to demonstrate the role of geospatial information i.e. location in the new era of sustainable development. However, one of the key challenges is communicating the value of geospatial information to support these initiatives when technologists and policy makers speak different languages. There's an opportunity to communicate the value of location and use it to support our long-term sustainability.

Fast moving change

In the days of big data, open data, Internet of Things, sensors, augmented reality and with details around events, such as disasters being shared almost instantaneously on social media, there's a mismatch between the rate of change of technology and the ability for policy makers to keep up and possibly even understand the implications for geospatial technology.

Across many sectors there is a *technology translation gap* where technologists (including geospatial practitioners) are unable to succinctly explain the usefulness or value of their data, tools or services. Some of the reasons for the existence of the gap include the use of jargon or industry specific terminology, a lack of clearly articulated business case or return on investment (which may not necessarily be limited to a financial return) and a lack of education or knowledge on the part of the governing body. This gap can also exist inside organisations between product management and the finance department or across organisations working in the same fields, it's not limited to just technologists and policy makers, but for the purpose of this paper it is limited to the broadest description.

Only a few organisations in the UK are poised to take a leadership role to tackle this communications issue and the AGI is one of them.

Background

It's important that there is a collective ability for geospatial technologists and British policymakers to address the ever-increasing social and environmental challenges facing everyone in the UK. Both groups are also important to develop the economic case for working with geospatial information technology and the competitiveness of the UK on the global stage.

Pockets of the global geospatial community are reviewing legal and regulatory problems, but how many organisations in the UK believe that these issues will sort themselves or are waiting for others to tackle them?

Policy makers and politicians cannot afford to not understand new technologies or fall behind the curve while society continues to accept new and innovative products and services.

In the geospatial realm these include developments around open data, open source, open standards, 3D, addressing, artificial intelligence, augmented reality (AR), building information modeling (BIM), cartography, cyber security, data visualisation, global navigation satellite systems (GNSS), indoor positioning, Internet of Things, the Sensor Web, future/green/resilient/safe/smart cities, virtual reality and many other areas.

There is a risk of policymakers not understanding the application or impact of these application areas and existing or emerging geospatial technologies. If we fail to successfully communicate or even bring these developments to the attention of policymakers, there's a possibility that regulations or guidance put in place by political, legal or regulatory authorities are out of touch with reality. Such regulations could be misguided, counterproductive, limit innovation and possibly even dangerous. See here for more information and examples where a lack of understanding causes problems.

Current situation

There has been extensive discussion and debate over Spatial Data Infrastructures (SDIs), which has been important to drive the understanding and awareness of spatial data, tools and technology. The INSPIRE Directive is a great example of such collaboration. However, the time taken to deliver such policy is extraordinarily long and technology is moving in cycles several times faster.

A major element of INSPIRE has been sharing data across borders and part of the activity to support INSPIRE goals has been underpinned by open standards from the Open Geospatial Consortium (OGC) and the International Organization for Standardization (ISO) Technical Committee 211 for Geographic Information and Geomatics. Both of these organisations are committed to interoperability, but what does that mean for geospatial practitioners and others, such as policymakers? How do we translate what such terms offer?

From the paper entitled 'National Mapping Authority Perspective: International Geospatial Standards, July 2014' there is a description that is also applicable to organisations working in the geospatial domain that are not national mapping organisations:

"International standards enable what is often described as interoperability, which can be defined as breaking down institutional barriers, as well as addressing differences between nations, languages and cultures. Interoperability also covers diverse disciplines, professions and industries, as well as different levels of industry, government, academia and the public working together by using common formats and Information Technology protocols. At a fundamental level this means teams, departments and organisations interacting seamlessly using different technologies and software vendor products."

Even the simple term interoperability has different meanings to different people and organisations; as does sustainability.

For policymakers interoperability has to align with government or organisational goals to reduce long-term risk in IT investments, link to open access and sharing of data, as well as meet general procurement requirements (which need to be compiled using the correct language).

Translating capabilities and requirements

Explaining interoperability is just one example of a much wider communications challenge. AGI members can play a role in the communication of the value of location to support the Sustainable Development Goals (SDGs) by aligning a number of activities with existing benefits of AGI:

- **Provides a focus for the GI community** – bring together a range of domain experts, as well as data providers, software and service providers and consultancies to provide input to the challenges outlined in the SDGs, i.e. align them with geographic information
- **Promotes the value and benefit of GI** – provide specific examples of the value and benefit of GI in terms of long-term sustainability
- **Represents the GI community to policy makers** – explain the legal and policy ramifications of technological advances in GI technology
- **Keeps an eye on emerging markets** – share good practice from the UK around technology innovation and policy developments to help low and middle income countries respond to the Sustainable Development Goals. Bring together different members of the AGI to discuss topics

Call to Action

The proposal is that a taskforce of AGI members take a few hours to read through the Sustainable Development Goals and consider how their work is relevant and applicable to this global initiative.

How can their work be translated into value for lawyers or policymakers and help to bridge the technology translation gap?

1. AGI to provide a series of industry definitions or glossary of terms (which may already exist), for terms such as interoperability, sustainability and open data (aligned with UK government policy).
2. AGI members to review the Sustainable Development Goals to assess which goals are linked to location and can benefit most from geospatial information technology.
3. AGI to share findings with other bodies to assist other countries and the wider goals of the United Nations, also to possibly open up new business opportunities for AGI members at home and overseas.

About your Company

Ramage Consulting Ltd provides technology and vendor independent advice around the business topics relating to the geospatial industry.

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Key Challenges and Opportunities Facing the Geospatial Information Industry: A view from the British Geological Survey

Kate Royse | British Geological Survey

'The move to monitoring geological processes in real time will mean that we will need to be able to ingest, process and visualise massive amounts of data. Significant changes in how the geoscience community handles geospatial data will have to change in the next five years'

The British Geological Survey has a bold new strategy to instrument the earth. What does that mean in terms of data and specifically geospatial information? In essence the survey is going to be moving from concentrating on the solid subsurface to monitoring processes below the ground in real time. This will necessitate not just the instrumentation of subsurface boreholes but also the use of satellite measurements and real-time monitoring of natural hazards.

The drive for this monitoring is to enable us to model, predict and mitigate the impacts of environmental change. To do this effectively will mean that we will need to look at novel ways to visualise and communicate our data to non-specialist users and combine our geological data with data from other sectors. Making use of mobile platforms and open data will provide us with many opportunities as well as some significant challenges over the next five years. These can be grouped into 3 areas discussed on the following pages.

Smart Data

Big data as a concept is defined around four aspects: volume, velocity, veracity and value. Although within BGS there are significant challenges going forward with volume and velocity in terms of data generation process and how to capture and store data. There are bigger challenges with the quality and usefulness of data. By 2020 big data will be the norm, the key to not being drowned in a big data deluge when the geoscience community opens the flood gates, will be the development of new technologies and architectures designed to extract value from large volumes of disparate data by enabling high velocity capture, discovery and or analysis. Currently the vast majority of data being generated is unstructured which means that more often than not we know little about the data unless it is somehow characterized or tagged. Metadata is not a new concept within the data information community but it is something that will need to become more prevalent if we are to make data 'smart' i.e. make data useful.

I believe that in the next five years we will need to move from a data management organisation culture to a learning organisation culture leveraging all the value behind the data that we collect and manage. Having lots of data isn't going to provide a solution to the 'big' science questions that we are faced with solving today. We will need to become better at filtering out the noise and holding onto the valuable data. Essentially the focus should not just be on collecting a vast amount of all the possible data out there but to contextualise each bit of data with its own specific context. Data needs to be understood and interpreted in a specific context for example what is the value of some information about a website visitor clicking on a link if the context that precedes and follows the clicking is not known? The capacity of big data to change how we do research will be down to our ability to make data smart.

Open Data

In the last five years we have seen an explosion in open data particularly in the public sector with the publication in 2012 of the government's white paper 'unleashing the potential'. The Open Government Data (OGD) initiative has emerged as a major movement in knowledge and data sharing. Although interoperability and accessibility are key challenges i.e. the governments linked data initiative, holding data in machine readable formats will no doubt become the norm in 5 years; there is a growing need to integrated social-economic and environmental data together.

Crowd-sourcing of data, through mobile devices, offers huge potential for fast acquisition of valuable datasets. The importance of crowd-sourced data in disaster resilience and response will continue to develop, given the rapid spread of mobile technologies and infrastructure across the globe. The role of new technologies and social media in the acquisition and sharing of data was highlighted by the 2010 Haiti earthquake. Communities affected by the disaster asked for help using social media. The result was that thousands of citizens were organised to collect, translate, and plot these pleas on maps so facilitating better-organised technical responses to the disaster situation. Data generated by apps (social media such as Facebook and twitter) and other background services leave huge trails of information that document every action a user makes, the full potential of this data is yet to be fully realised not only to improve and personalise web-services but also to improve communication and decision making at a national and local level.

'Cloud' technologies and services are challenging conventional models of data acquisition, management and processing. Despite widespread concerns over data security and caution over the role of private sector companies in managing public sector data, the rate of implementation of cloud services is growing rapidly. Several governments and state agencies are using cloud-based storage and processing services, e.g. the US National Institutes of Health uses Amazon Web Services to store its 200 terabyte human genome dataset from the '1,000 Genomes Project' (National Institutes of Health press release, March 29th 2012). The business model behind this initiative is one in which digital storage is provided free of charge but high performance computer processing is charged for. One consequence of this model is to make the data and the processing services accessible at low cost to all-comers radically reducing the barriers to entry.

Visualisation

Data visualisation unleashes geospatial data true impact and this is where we will see some of the biggest opportunities in the next five years, through improvements in data interoperability resulting in improvements in the visualisation of time series, point clouds and satellite data. The ability to do 4D visualisations in real time will allow us to harness the potential of geospatial data to become much more predictive, improving our forecasting and scenario planning. Data based policy making has necessitated the need for decision makers to be able to argue their case to a much more data orientated public. This necessitates improvements in not just how we communicate but also how we visualise data.

Visualisation of geospatial data has so far been flat; in two dimensions there is a significant push to start to integrate the subsurface with the surface. We are already seeing a growing interest to include subsurface data within BIM systems and integrating subsurface and surface infrastructure within smart cities. In the next five years the ability of technology to visualise seamlessly the flow of geospatial data and information from the surface to the subsurface will open up possibilities for managing the life cycle of buildings and infrastructure as well as monitoring and responding to the effects of environmental change and natural hazards within a virtual environment which will enable scientists to engage more effectively with policy makers, responders and the general public to provide effective and intelligent solutions to a wide range of problems and challenges.

Key Points

- How do we maximize the value of the data we collect and manage?
- How will new visualization technologies improve the value of big data?
- Crowd-sourcing of data, through mobile devices, offers huge potential for fast acquisition of valuable datasets but there are also limitations
- The 'Cloud' is changing how we acquire, manage and process data what new markets will this open up in 5 years time?

Conclusions

Within the Geo-Environmental sector there are significant challenges and opportunities around the development of smarter data, the use of Open data and cloud services and improvements in visualising the sub-surface and time-series data. There is no doubt that new approaches and technologies such as crowd-sourcing of data, mobile platforms and cloud services are radically changing the norms of data acquisition, management, processing and delivery. The biggest challenge is to be able to filter out the useless data and keep what's valuable. Data needs to be contextualised to be of use and there needs to be a shift in focus from collecting and managing to contextualising data and adding value. Finally the application of cloud based services and processing will significantly increase the efficacy of data sharing and processing which will encourage new and innovative ideas and technologies as the barrios to entry are lowered.

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Data Quality for a Connected World: Shared Learning to Increase our Ability to Reduce the Risk of making the Wrong Decisions

Mike Sanderson | 1Spatial

> "Geospatial data is increasingly being used to support effective governance, improve productivity and drive innovation. In the near future, knowing how to manage and make authoritative data interoperable and accessible to enhance decision-making on issues of national or global importance will be the hallmark of successful governments."
>
> Dr. Brian T. Gray, Assistant Deputy Minister, Earth Sciences Sector, Natural Resources Canada.

Data quality underpins some of the key topics covered in the 2010 Foresight report, namely: open data; lots of data from sensors (including human beings); the growth of the global enterprise and the failure to establish the basis for climate change. Data quality barely received a mention in the 2010 report except in the context of the last topic in the list above. Similarly the first McKinsey[1] report on Big Data barely mentioned data quality and only treated data quality as a by-product of the open data movement[2]. It is a surprise that since the last Foresight report the ISO[3] standard on the quality of geographic information has been updated. Certain people must have worked out this is kind of important!

Much of our work to 2010 was centered on analysing static data and a GI focus on building Spatial Data Infrastructures. If we are to make cities smarter then we have to recognise patterns as they emerge, not after the event. This means that location (just as time) will need to be a component in the solutions that develop to 2020. This means becoming a part of a parallel processing data driven architecture. The noughties concept of geospatial, with its monolithic approach from capture to visualisation, going mainstream will cease to exist as a concern for the GI profession. By then we will be part of the solution if not then part of the problem.

Developing location as the component in Smart City architectures

Let's move on to the contributors to the big contributors to engineering Big Data: sensors and BIM. At the recent ICE lecture on BIM for Infrastructure (Sep 2013) Ann Kemp posed the question what is the point of the data avalanche? What is it supposed to deliver? Collecting data for design and build using BIM is expensive. It requires far more data and greater accuracy than previously. We are undoubtedly getting better at defining standards (BIM4, CityGML, ISO19157). This is of little value if we do not improve data handoff. At the handover point it is not only the asset that needs to maintained, during its life, but so too does the data. The expense means that the data cannot be regarded as proprietary but needs to be passed on as accessible and trusted. Going forward it will not help cities to become smart if the data are not treated as such.

Sensors are pretty dumb. They are really on/off switches (read any Beer[4] treatise on cybernetics). Sensors generate lots of Big Data. This doesn't make a city smart; it's the treatment of the alarms in holistic fashion based on the overall knowledge of how the infrastructure should interoperate in relation to the current pattern in real time that is the basic currency of knowledge and therefore measure of smartness. This requires rules based approaches which can conflate data, remove bad data and drive out augmented understanding. Consider data handoff as a lifecycle component like any asset. Would you handover an asset without an operating manual? In the data sense this means handing over the semantics and metadata ideally mapped to an ontology. This is no different to any data time series. A city cannot be smart if it can't let the maintenance contracts to keep it smart.

So it does not help the highway maintenance activity in the UK if the records in the database suggest that the A1 is in Kent. I suspect this is brought about because it's better to squeeze another yard of tarmac out of the contract than get the handover data to a given level of accuracy. We might argue that in this simplistic case that the human operator would spot this error and correct it. Not in the big data world. There is too much data to scan and so automation using rules is required to establish patterns and correct inaccuracies. Unless you can automate this function to identify and correct such inaccuracies how can you know how many miles of carriageway you are really responsible for? More importantly as you do more of this the risk of making errors is reduced.

If I take the work one of my colleagues has been involved in 3d topology. So the handover from the BIM world to the real world of maintenance requires accurate geo-referencing as Ann Kemp stated in the Sep 2013 ICE lecture. Oh and there is more of it than in the topographic world. Opposite is fairly typical example handover where the building representation still fails the accuracy test (See **figure1**).

Beyond this simple example there are issues with the building interior volumes to be tackled based on the use case (for more on this see Evans (2008) CAD-GIS convergence: Beyond Visualisation[5]). If the data handover is poor then in an 'inside' emergency situation (think Towering Inferno), the social networks are going to be pretty unimpressed when the response is fumbled and the citizen realises it is better informed about emerging pattern of the incident. This social network sensor aspect of engineering the location element needs trust to be established on both sides to make for a better operational experience.

Most of the McKinsey use cases in the big open data world focus on doing things more efficiently. There are a number of examples of trusted data exchange. Retail has long exchanged data in this way. The cola industry and automotive manufacturers already collaborate through a third party intermediary. In this case the intermediary is in effect providing a private portal. Technology is now at the point where a consumer organisation could create citizen portals if consumers chose to collaborate. Portals provide the opportunity share knowledge and drive out efficiency for the citizen. An example: one smart meter customer talking to other similarly connected customers in a region where the ambient climatic conditions are similar can maximise their competitive advantage in negotiating prices.

In any event, Big Data collaborations are emerging. The Human Genome project (based on the Bermuda Agreement, 2000) is an example of collaboration and trust in a similar critical risk area to engineering projects. There are examples in other fields, such as astronomy where non-experts are invited to classify galaxies from telescopic sky surveys (http://www.galaxyzoo.org/). In addition there are many open source software collaborations. These are dependent on people with spare intellectual capacity electing to collaborate. The data.gov movement is hoping to harness this capacity.

One of the biggest areas where we should be collaborating globally is in the arena of climate change. Nowhere is there a more evident need to have accurate, accessible and authoritative data.

The biggest opportunity is for shared learning through a convergence of ideas. As can be seen from the picture above, this is about more than the visualisation. So the games industry could use real world geo-location data to simulate real world events, particularly if the data were free (see http://www.ordnancesurvey.co.uk/about/news/2013/minecraft-map-of-great-britain.html). This must be cheaper than creating a make believe environment and the free data is likely to contain enough inconsistencies for the cheats to work. The gamers are using their intellectual surplus to play (collaborate) in a make believe world where real world accuracy does not require the precision that engineers need. Why can't engineers exploit this spare intellectual capacity – after all these people live in and work around the built environment? Their *cheats*[6] could provide extra knowledge for the real world practioners who ordinarily might not perceive these options in their response set.

Conclusion

A truly smarter generation will only really emerge when its citizens can share trusted knowledge for their gain. Location is one element of that vision and needs to be delivered as a component to identify real time patterns.

Key Points

- Automation
- Ontologies & Rules
- Trusted Data Exchange (Portal)
- Data Lifecycles
- Location as a component within Smart City architectures

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Strategy Director
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5. Geo Connexion (Nov 2008)
6. By this I mean the exits where characters can evade pursuit/attack before re-emerging into the game landscape.

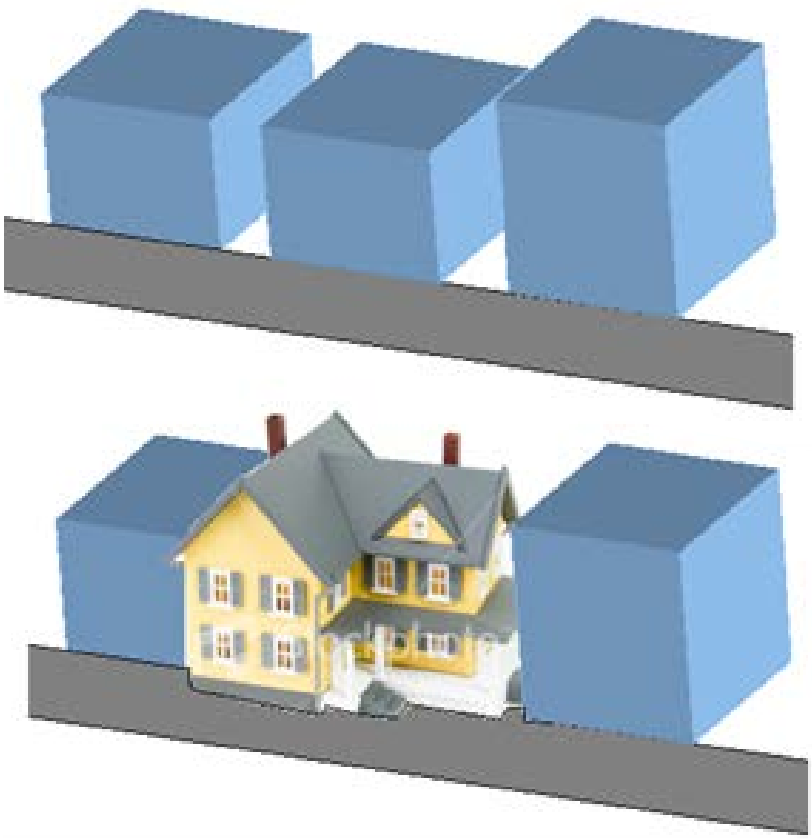

Figure 1 - typical example handover where the building representation still fails the accuracy test

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Smarter Local Places

Gesche Schmid | Local Government Association

"Places should be more ambitious about how they approach information sharing, make better use of data and use digital technology to enable better outcomes."

Bolder, Braver, Better: Service Transformation Challenge Panel Report, November 2014

"Open Data has the power to transform productivity and outcomes in public services, as well as drive enterprise value in the broader economy."

Open Data Institute Business Plan 2012-2017

Over the coming five years local government and the public sector will be challenged to transform their services to increase efficiencies and productivity. The transition from public sector centred to distributed and commissioned services; increased self-service; and broader engagement with the community will continue. The drivers for this change are:

- further cuts to public sector spending combined with an increasing demand for services especially due to an aging population
- an increasingly open society with expectations of an open government
- digital technology that drives smarter ways of living and working and smart cities and places

In order to meet some of these challenges local authorities have shown some innovative ways to transform services and increase efficiencies and productivity by collaborating with other organisations and the community, sharing services, using digital technology and harnessing customer insight[1].

The use of geospatial information services and technology have contributed to those efficiencies. The LGA commissioned a value study in 2010 which demonstrated that geospatial services and technology added £230 million in productivity gains over the previous five years with further increases of £370 million expected by 2015[2]. The McKinsey report on "Innovation in Local Government" argues that geospatial technology and analytics will further contribute to changing city services, reducing cost and creating a better community for citizens[3].

Recent case studies published by the Ordnance Survey and GeoPlace demonstrate the value of the Public Sector Mapping Agreement (PSMA) - which has provided free mapping and address data to the public sector at the point of use since 2010. Over 80 case studies[4] give detailed accounts of savings in local government through the use of geospatial information and technology in fraud detection and prevention, health and social care integration, emergency planning, transport, planning and other civic services. The future will see further innovation and change born out of the necessity to continue to transform services and improve productivity.

Current Trends

What changes have we seen since 2010 and will we see over the next five years up to 2020?

General trends

A big driver for change is the opening up of data including geospatial data with an explosive use in apps and big data. As indicated in the 2010 AGI Foresight report "by 2015 spatial is not special". In 2015, spatial has become mainstream and geographic coordinates underpin much of open data as the "Where" is a key component in location services and data analytics. For example, location will play an increasing role in where public funding is spent to meet local needs and demands which will be used in procurement and commissioning, health and social care integration, housing, managing the public estate locally. Examples of this are emerging in local open data case studies[5].

Smart Cities is the other big trend where geospatial data will play an important role in the future. Smart places will harness the power of big data and digital technology to manage cities and communities smarter and in more sustainable ways. Geocoded sensors will feed real time data into the *Internet of Things* which will be used in Big Data analytics to self-manage and self-operate infrastructures and services. Glasgow[6] and Milton Keynes[7] are leaders in the UK to explore ways to transform the City into a better place to live, work and play.

Policy

The INSPIRE regulation, the Transparency Code and other open data policies have shaped the release of data in local government over the last five years. This trend will continue into the future. By August 2015 local authorities have published almost 6000 datasets and over 3200 location datasets on data.gov.uk alone, driven by the INSPIRE requirements and government funding to support authorities in publishing geospatial data.

Authorities are starting to combine the Transparency and INSPIRE agenda which provides new opportunities for better managing and making better use of data in the future. But some incompatibilities about standards - especially around land assets - still act as a barrier to full interoperability.

Local authorities have long been hampered by tight Ordnance Survey licencing rules to release their derived geospatial data. Thankfully, some of the restrictions have been lifted. Overall we should see a wider release of open data with a geospatial component in time, which should lead to new and innovative ways of using and analysing data.

Technology and science

Technology has been driven over the last few years by hosting data and platforms in the Cloud and making use of an increasing marketplace for open source applications. This has led to some substantial cost savings as demonstrated by Barrow Borough Council which used open source software to publish its geospatial data in line with INSPIRE[8].

Currently, however, much of the software, platforms and applications in local government are still fragmented, creating a siloed approach and preventing the integration of data and applications. Open source and Cloud computing has opened up and enabled the joining up of applications and have reduced IT costs.

However, the barrier to building more integrated and open platform approaches remains more organisational; financial; and contractual than technical.

The digital government agenda with its move to "government as a platform"[9] will impact on future geospatial service provision as web services and information from across government and increasingly from the public sector will be brought together to serve the user from one platform. Government as a platform has been a game changer for central government and will most likely find some interest in local government streamlining transactional services. Together with open source, these are the most likely technical changes that will occur.

The move toward government as a platform will require data from across government departments and local authorities to be standardised. The INSPIRE regulation is showing the way for standardised data and services across Europe to enable greater interoperability. Where it can make an impact locally, the benefits from standardising data and web services beyond good data management, needs to be better understood by decision makers before it will be more widely adopted. But more needs to be done to support national initiatives to coordinate, develop standards

There are some notable standards initiatives which promote a local government led approach to standards in local government including the smart city concept model, local government standards, schemes for the Transparency Code[10] and the recent local open data incentive scheme[11] which encouraged local authorities to publish data to common standards. Over ninety local authorities took part in the incentive scheme and published over 200 datasets to given standards - mostly with a geographic reference - covering public toilets, planning applications and licensed premises.

The public toilet data are now used by the Great British Toilet Map app to show people where the nearest loo is[12]. To make such initiatives more sustainable more needs to be done to invest into the national coordination of local standards and reference data and to work with the vendor community to support authorities to make the publishing of standardised data more effortless.

The *Internet of Things* is still in its infancy in local government use but will increasingly link data and information for use in big data analytics which will feed the decision making and the operation of services of smart cities and places. The Unique Property Reference Number (UPRN) - allocated by local authorities to every property and land in the country - is heralded to play a key role as golden threat to link local services[13]. Local authorities have long used the UPRN to link services through the same property and location reference with savings of £24 million. With the open release of the UPRN, local services will be much more widely linkable with unimaginable opportunities.

Organisations

Instead of publishing data through regional and national data hubs as predicted in the 2010 foresight report, local authorities increasingly share, outsource or commission their services to meet efficiencies (see shared service map, LGA[14]). Political and organisational obstacles and the sheer number of local authorities in England make it difficult and complex to develop a national hub approach. Scotland and Northern Ireland have been more successful in developing respectively a joint e-planning hub and INSPIRE hub for local data. But shared services are not without a challenge and require a willingness to organisational and cultural changes to agree what data and tools to join up and how.

In the future there will most likely be more regional hubs as a result of devolution deals and decentralisation. The Interactive Infrastructure map developed by the New Economy for Greater Manchester is an example for developing a regional approach for combining data from local authority supporting local enterprise partnerships in their decision making to promote overarching infrastructure projects[15]. The move towards a more collaborative style across local places, cities and regions will mean that leadership will be crucial to provide shared and collaborative data models in the future.

People

There have been winners and losers of the public service transformation over the last five years. Due to budgets cuts, the number of GI specialists has been reduced in many local authorities leading to a drain of skilled resources. On the other hand, GI specialist have been well equipped to meet the skill set of data scientists and have extended their responsibility in local councils to include management and delivery of data services within local authorities. They have embraced the open data/open source agenda and drive a range of innovations in local authorities (see open data projects[16]).

In the future, fewer job opportunities for GI specialist will exist in local authorities simply because spatial is no longer special. However, there will be opportunities for the wider skill set of data scientist to manage a wider data portfolio within local authorities in local authorities.

Overall future trends in local places

Geospatial will no longer be special but will form part of a main-stream local data infrastructure and service:

- INSPIRE and Open Data will merge to increasingly offer standardised quality data that underpin digital platforms, and big data analytics
- The value and recognition of data use will increase as a driver for transforming and innovating services to meet efficiency and productivity gains
- There will be an increasing move towards smart cities concepts and sensor use. Any public asset on the highway, buildings and properties will have a geographic location and feed data automatically into a wider smart city model
- The development and use of open standards will be a prerequisite for linking data and increasing its value. But standards do not come for free. Thereneeds to be a wider recognition for the need to invest into this area of the information infrastructure
- The major challenge of linking data and services will not be so much technical but organisational and cultural to provide digital leadership to foster collaboration across local and regional partnerships. Local authorities will need the support and capability to provide and manage high quality linked data services.

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

BIM4Infrastructure: Rather than answers, do we know the right questions yet?

Liz Schofield | ThinkBIM, Leeds Beckett University

BIM is more and more being understood to be "Better Information Management", and as such employs a number of different technologies. While the building element of the built environment is better served by current tools and processes than infrastructure. At last week's BuildingSmart International Summit and BIM Prospects, there was discussion around the use of Geo-BIM, and closer collaboration with the Open Geospatial Consortium, to develop an OpenBIM solution for infrastructure.

But first of all do we even know the right questions we need to be asking? What are the problems with developing digital solutions for infrastructure?

- Do we need an integrated solution across the infrastructure space, and across the whole life cycle?
- Do we anticipate using more and more different apps, or convergence to one or a limited few platforms?
- How important, then, are open information standards – regardless of their heritage in CAD, BIM, GIS
- What is the problem statement?
- Who should be involved in developing these open standards?

Key Points from the Session

- Buildings are much better served than the infrastructure side at present in terms of BIM implementation. This is mirrored by thinkBIM's experience of delivering training on behalf of the CITB where highways/civils training is at point zero compared with building
- Infrastructure is more challenging - more ambiguous, no set boundaries and consistently moving and changing – how do current BIM technologies tackle that?
- Key observation is that our infrastructure is poor, we can't get around the country well enough. There has been too much focus on glory projects rather than on individuals/businesses (SMEs in particular do more work locally) to move around and therefore increase efficiencies. Examples included the York to Leeds and Leeds to Manchester railway lines, dramatically underinvested and still operating like they were in the 1980s. We need to be looking to BIM and digital technologies to find efficient solutions to our infrastructure problem
- BIM 4 Collaboration – how do we integrate what we are doing with buildings with infrastructure which is what we will need to do (and beyond) at Level 3
- With infrastructure, the data that is being pushed out is changing month by month. How do you make data available in a way which makes people understand the rationale behind the decision making? Need to find a way of sharing the data in a way that informs people, isn't manipulative and doesn't mislead
- Following on from this however, there was also a discussion around the fact that the way we get data has shifted. The expectation is that data is served to us rather than us having to go out and look for the information we need. Therefore concerns over what data to share may become irrelevant as the models will be in the public domain whether we want them to or not. In the session I sat in on, this discussion was mainly driven by a point raised by the Environment Agency in that they looking to get some open source outputs but needed to decide what information should remain confidential from a security point of view. The response from the assembled was that technological advancements have meant that decision wouldn't necessarily be theirs anymore – everything IS already open
- With this advancement has come a shift in expectations, there is an expectation that things are done for us, due to technology. Younger generation want intelligent buildings and infrastructure which can respond and those that can provide that will get ahead
- There was also a discussion about trust, how can you ensure you trust the data and where it comes from. Solved in some degree by the PAS 9111 standards but doesn't go far enough as they don't tell us how to use the data
- Doesn't matter what the data is, the challenge is pulling it all together. Example of Hong Kong – a lot of key parts of infrastructure are owned and surveyed regularly by government. Data is kept by government – starting to integrate it with the emergency services so they can plan road/rail networks for accessibility. Correlation with Smart Cities and the Open Geospatial Consortium
- There was a discussion around whether the two technologies need to be kept apart? i.e. Geospatial approach is really good for conceptual design and visualisation. Once you go into detailed design and construction that is really the domain of BIM. How important is 3D - are we making 3D & specialised technology too much of a priority? The group felt having two technologies was too clunky, the opportunity is there to link "BIM4Potholes" right through to how we strategically manage our network
- Viewpoint of one attendee - Not interested in the data, I want the service! What do you need to share in order to provide an efficient service should be the starting point
- We need case studies in practice – Airforce bases could be good examples as they are mini villages, integration of buildings and utilities
- In the session I sat in on, there was also a useful (if slightly off topic) discussion around gaming technologies and how these have helped to foster collaboration - great example of one of the group's two children who only talk to each other when they are playing Minecraft together. Should infrastructure be using gaming technologies? Possibly but we have to be driven by our needs rather than technology itself. When the focus is on the technology rather than the end result that can hinder progress – someone in the group gave the example of email. We all started communicating in emails rather than phone/in person in the belief that it was faster and more efficient when actually it has less immediacy than traditional communication or even social media. Get much better responses to tweets than emails!
- Social consequences of digitisation - we need to be wary of creating an artificial world for the next generation which makes it harder and harder to live in the real world. Again slightly off topic but a very important point – the digital world has to be reflective of the real world.

DR. ANNE KEMP

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

GIS: The Next 5 years in the Oil & Gas Industry

Gareth Smith | Exprodat

The oil & gas industry is facing mounting challenges: increasing costs, harder-to-find hydrocarbons, changing workforce demographics, increasing geopolitical instability and falling oil prices. Can the GIS industry help address these issues?

The amount of information generated by the oil & gas industry is rising at an exponential rate. This is often held in poorly integrated departmental silos, suffering from duplication and inconsistency and with no standard way to access and share it. These problems have created barriers to functional integration and operational efficiency which often lead to poor project execution and soaring costs. As the 2010 Deepwater Horizon disaster in the Gulf of Mexico illustrated, the impact and cost when things go wrong can be enormous.

Just about every piece of information in the E&P industry is or can be linked to something spatial and the potential for leveraging GIS to improve efficiency and reduce risk is enormous.

Over the past 20 years, we have seen GIS progress from a niche tool used for simple map making in the mid-nineties to something that now has the potential to impact the entire oil & gas value chain. Yet this hasn't really happened over the course of the last two decades. So what's changing?

The next phase in the evolution of GIS is upon us, triggered by the broader commercialisation of GIS in the noughties and beyond. Google Earth, SatNav, smartphone GPS integration; 'spatial' is now an integral part of our day-to-day lives which has raised general awareness about its potential. Many of the new spatial services we consume are cloud-based and delivered in real-time. Are we now entering the age of 'GIS as a Platform'?

That's certainly what Esri, the market leading provider of GIS technology in the oil & gas industry believes is happening. Esri proposes that GIS should be ubiquitous, simple to use and accessible through all channels: desktop, Web and mobile and by everyone, not just the geo-specialist. Everyone should have an identity, allowing people to access their apps and data regardless of location or device, and for everyone else to understand the provenance of shared spatial data and maps. Esri have also adopted the Apple-style 'App' paradigm, pushing GIS functionality and data in targeted, bite size pieces to everyone that needs it, on whatever device they want to use. The GIS platform can also integrate spatial with all other key business data, providing the integration that's been missing for so long, breaking down the silos between applications and departments.

This is allied to a change in demographics in the oil & gas industry: the baby boomers are moving on, and are being replaced by 'generation Z' graduates who are comfortable with working with spatial tools and data. The Cloud is a totally natural concept for this generation, and they expect simplicity. They are also able to customise and automate repetitive tasks, an important goal for many companies to improve efficiency and reduce overheads. The latest generation of GIS technology fits perfectly with these requirements.

Is the Oil & Gas industry buying in to this vision? There are signs that they are, but barriers remain. In the latest edition of our annual oil & gas GIS benchmarking study we found that most participants were struggling to move beyond the basics. Many of the issues relate to the view that GIS is somehow 'special' and only has specific uses. GIS often propagates from a single department, usually in the upstream oil & gas exploration side of the business. This has stopped GIS expanding into other departments and hindered the technology being adopted as a corporate business tool or horizontal technology platform.

GIS is often funded from the department in which it originated. Whilst the potential is obvious to the new intake in the oil & gas industry, there is little understanding of the potential at more senior management levels. It might be argued that the GIS community is partly responsible for this, unwittingly propagating the view that somehow GIS is a technical speciality and 'hard' for others to use without their support.

It has taken time for decision makers to see how 'GIS as a Platform' can impact their business in a broader sense and to put it on the same footing as, say, integrated finance management or business management systems such as SAP.

There is also an innate suspicion of all things 'Cloud' that will take time to overcome in what can be a very conservative industry. However, oil & gas companies have started to revise their IT strategies in light of the cost pressures they face and Cloud will certainly become increasingly important over the next 5 years.

We discovered other issues: skills (50% of the companies we surveyed have no geodetic awareness training), support (over 80% lack a career development path for their GIS support staff), systems integration and data management.

The GIS Platform vision doesn't necessarily fix these fundamental problems. Not only are we managing data in-house, we're now throwing it out on to potentially poorly managed Cloud systems. The ability for everyone to make a map allied to a systemic lack of geodetic understanding could lead to potentially catastrophic errors.

Despite all of the challenges we face, we are beginning to see real signs of progress. The number of presentations at industry events such as the Esri Petroleum GIS Conference that focus on deployment of the GIS Platform is increasing, and we're starting to see the spread of GIS right across organisations.

Our clients are starting to explore the role of the platform in areas such as emergency response, engineering design, integrated operations management and environmental management. GIS is becoming part of the conversation right across the E&P industry, and we strongly believe it will become a core technology over the next 5 years.

And compared to technology spend elsewhere in the E&P industry, GIS is relatively cheap! According to our review, the average spend per head on GIS users (including technology, data, support, and training) was just $14,000 pa, and the majority of that was on spatial data. That's a tiny fraction of the total IT spend in most companies. In times of low oil price, that may be a big driver for growth in the use of GIS.

We are just scratching the surface with GIS in the Oil & Gas industry. There are still many challenges, but we are potentially at the tipping point where GIS moves from the side-lines to being an integral part of industry's DNA. As an industry, we need to support the move from providing GIS support to geocentric experts, to providing everyone in an organisation with access to GI resources.

The five key trends for the next 5 years of GIS in Oil & Gas:

- Technology will become simpler and more pervasive, moving out of the 'geocentric' expert domain
- Everyone will be able to access GIS resources, when and where they need them, delivered through the Cloud and Web map services
- Everyone will have an identity, allowing them to access their resources regardless of location or device
- GIS will drive greater integration across the value chain, reducing technical risk and uncertainty
- The next generation of industry recruits will drive greater adoption and geospatial innovation, and improve efficiency through increased process automation

About Exprodat

Exprodat transforms oil and gas company performance by implementing and supporting ArcGIS, Esri's industry leading location platform, for use within petroleum workflows. Our highly trained and experienced staff deploy location-based visualisation and analysis across a wide range of departments including exploration, operations, production, unconventionals and crisis management.

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

The Future of GI in the 3rd Sector

Doug Specht | University of Westminster, Communication and Media Research Institute and Director of Voz

"We should now talk of people making not their own history but their own geography"[1]
John Urry (n.d.)

The use of spatial data in the third sector has exploded in the last five years, driven by drastically reduced costs and a proliferation of open source mapping tools and data collection applications. The release of Google's Forest Watch via their outreach project, Map Action's work on tracking the Ebola epidemic, hacked maps such as Harass Map in Egypt, and emerging platforms such as Voz, which maps human and environmental rights, have all helped to highlight the potential of maps and geospatial representations to codify local knowledge, presenting it in quickly accessible and useable formats. Using a combination of rich data sources, often collected through mobile devices, coupled with advancements in processing capabilities we are able to turn ever larger, imperfect, complex and often unstructured data into actionable information with increased speed and efficiency[2 3].

This presents exciting opportunities for NGOs and the GI industry as a whole. By 2020, more than 70 percent of mobile phones are expected to have GPS capability, up from 20 percent in 2010[4], leading to a massive increase in spatially located data. The dominant line of thought suggests that the more data we have, the better our predictive modelling and analytics will be, and the better we can understand our environment and support those in need. Caution, however, must be taken in our rush to exploit these new vast pools of data and information for predictive analysis.

It was back in 2006 that Sarah Elwood of the University of Washington asked why if so much has changed in terms of how GIS works, and how it is used, are we still being asked questions about access, representation, expertise and power?[5] Now a further nine years down the line, her question remains as present as always. Much of the work of the NGO sector in using geospatial technologies relies on a degree of local participation, either actively or through VGI, yet when most people are asked if they can make a map, they say no. Does this really matter? The GI and NGO sectors are full of highly skilled map makers, cartographers and GIS experts, producing excellent and much needed work which often includes volunteered geographic information. Do we need to involve everyone else? Isn't it better to keep things professional?

The potential issue here is summed in the statement 'you don't know what you don't know', while advancements in technology have made our lives easier, cheaper and faster, the NGO sector still faces a significant challenge in included occluded knowledges in its work, and particularly when using GI and Big Data. Now is an exciting opportunity to overturn the classical mode of map production that supports knowledge building that were, or are, colonial and oppressive in nature, and to usher in a true age of Neogeography helping local knowledges break into the main. And it is the 3rd sector is best placed to take on this task and the lead the way for the GI industry as a whole.

Including local voices in map making and decision taking

There has been much research into the modes of knowledge construction through geographical and cartographic artefacts, and much of this points to classical liner constructions of knowledge by experts that is then imposed upon the other. Supporting the dominant Eurocentric and Western discourse and Western knowledge systems that have been used as *'an instrument of cultural violence on the Third World'* and which through their production, accumulation, circulation and functioning permeate rigid power structures[6]. In recent years however the field of cartography has moved in directions unimaginable just 10 years ago. In the *'last few years cartography has been slipping from the control of the powerful elites that have exercised dominance over it for several hundred years'* bringing about the creation of *'neogeography'* and the democratisation of participation[7]. Maps are no longer being solely produced and reproduced by a trained elite, but along with most other information we create them when we need them ourselves[8].

The release of free and open source, yet highly powerful and adaptable applications has led to a proliferation of map hacking. This has taken us beyond merely increasing the ease with which spatial data can be digitised, but as the neogreographical age progresses, it is allowing for the repurposing of such spatial data, opening up the concept of geography and cartography and allowing for its 'repackaging' via digital media and the internet[9]. Yet, while it is *'rarely contested that digital media have an impact on civic and political involvement'*[10] the connections between these elements and political engagement and Development is still an emerging field, and one that changes quickly.

The 3rd Sector has long talked of using more participatory methods in both implementing and evaluating programmes and projects, and while much has moved forwards the route out of underdevelopment often remains a series of hoop jumping exercises prescribed by the West and performed by the Rest. For all the good intentions, and proclamations about the democratic nature of digital technology thus far little appears to have changed. As we fully enter the age of neogreography we may have the opportunity to evolve a model of working that does not perpetuate the neo-colonial dependency theory-based arguments for development. Local people and particularly indigenous peoples have important knowledge based on intimate and prolonged interaction with a given set of biophysical conditions and that, as a result, local people are often best placed to understand and regulate those conditions in most of cases. It is essential to include these knowledges in our work and our maps in order to foster a true post-development era.

All maps have an inherent power and objectives, just as all knowledges have inherent power and objectives. Indeed maps are often seen a visual representation of knowledge. The power held within maps is not necessarily negative, nor does it necessarily need to be removed, indeed *'if power had repressive effects it also produced subjects who act freely'* and many problems of politics and power require spatial knowledge[11]. New information technologies are allowing for the challenging of elites, a challenge that should be embraced by NGOs rather than feared. Maps may now be viewed as being the production of space and place combined with the political identities of the people who inhabit the spaces represented by the map[12], they have moved beyond being a purely communicative tool[13] rather expanding there emphasis from the delivery of information to also encompass its exploration. This change in power over maps has significant implications for NGOs and SMOs operating within the terms of geographical change[14].

Through deeper levels of participatory GIS (PGIS) and community mapping it is possible for NGO's to foster a harmony between the scientific maps of old and newly 'hacked' maps, allowing for a variety of knowledges in co-existence. *'By simultaneously allowing the expression of a variety of knowledges… …PGIS creates a level playing field for comparing knowledge consensus and division. In so doing it allows a wider exploration of cultural and political conditions'*[15]. These maps should not however be created by a cartographer, but produced by the users themselves on the spot[16]. These 'counter-maps' which express local knowledges in cartographic form can be a powerful tool in promoting the rights of communities[17]. These kinds of mapping exercises have been known to development workers for a long time, and this kind of 'bottomup' mapping has long been lorded as very successful in promoting the inclusion of marginalised communities[18]. Digital technologies now perhaps offer an opportunity to case this net wider, and to remove the 'expert' from the centre of the exercise, leading to a greater understanding of local needs.

Furthermore going beyond including marginalised knowledges, GIS can also be used to interrogate knowledge itself; exploring links between production and information, politics and ideas. Historically maps and GIS have been used to eliminate ideas and codify knowledge into set rigours[19], however with the fast change landscape and increase of PGIS, there is a potential that GIS will be at the forefront of breaking down these barriers and opening up new ideas on the production of knowledge itself, *'eliciting competing localities and ground truths, and so [to] enunciate and draw conflict to the centre of attention'*[20]. Much will depend on how GIS technologies are made available to the world, and how much 'conventional' NGO practice is willing to view the importance of these new maps[21]. Yet with the speed of technological advancement, effectively putting PGIS in the hands of billions of people, the role of the Development worker as a facilitator is become less and less important, and thus the real power of PGIS, the people, is taking centre stage allowing for a true shift in the way GIS is used, the way knowledge is created, and shared.

Implementing Mapping in Projects

The potential and power laden within maps has been made clear, however engaging with marginalised and oppressed communities and fostering new maps that begin to redress the power balance is a more complex task all together. For starters *'most local people, asked if they can make a map, say no'*[22]. Yet in reality the ability to make a map, even a stunning interactive 3D map, is now available to anyone with a home computer or smart mobile and an internet connection[23]. Even without online resources the most reluctant of participants are still able to produce maps with only limited support, but with enough time to work it out for themselves[24]. The wealth of resources available via the internet makes this process even more personal, and further removes the need for consultation with an expert. These new resources are not so much new mapping software but rather are a mixture of "open source" collaborative tools, mobile mapping applications, and geotagging programmes[25].

The role of creating maps has already become diffused, and thus the power in them has begun to spread. There remains the issue of learning how to and where to produce the map, or even why to. And although the internet's many resources address this to the converted, to gain the full wealth of knowledge to produce a map of substantive use requires involving as many people in the process as possible. Here participatory GIS plays out its role, being *'geared towards community empowerment through measured, demand driven, user friendly and integrated applications of geo-spatial technologies'*[26]. In order for these mapping projects to work though effective participation is required. This does not mean that a facilitator is required to be on site with the respondents, but means ensuring that mapping software and apps are built in such a way as to allow for high levels of participation. E.g. simple to use, correct language in the user interface, correct software for all devises and the necessary precautions undertaken to protect users and information. GIS tools developed and used by NGOs should have an emphasis on the product rather than the outcome of a map. This will allow for the emergence of information that may not have been previously examined, the beginning of understanding the unknowns.

Cautions

The rise of digital technology presents some exciting new opportunities for international Development, and NGOs, however, it is not a 'silver bullet' or even a straightforward solution for universal inclusion of these alternative and local knowledges[27]. It is easy to view maps and digital mapping platforms as just neutral tools that can be used both to promote good and bad causes[28]. In doing so however we would fail to address the conscious and subconscious agendas that run through the creation of such tools. Every technology and digital interface is built based upon the ideologies of the creator, whether they are aware of them or not, and it is thus impossible to suggest true neutrality[29]. Digital technologies are inherently a conservative force that can lull people into thinking that they are creating change, all the while pacifying them from making any real changes, they *'make it easier for [people] to express themselves, but harder for that expression to have any impact'*[30]. Indeed information collected online and through GIS and big data might be louder and quicker than ever before, but nothing guarantees that those voices will be acted upon once they are heard; success is not automatic[31]. Questions around access also still persist, and while the digital divide is narrowing in terms of access to technology it is essential to remember that society's most vulnerable people are likely to be significantly underrepresented when collecting data through digital technology. Caution too should be taken not to open a new digital divide around the power of analytics, it must be remembered that *"computers will talk to anyone, but only the wealthy teach them to speak"*[32].

Conclusions

Advancements in technology and GI analytics are creating exciting and powerful opportunities for NGOs to better engage with communities and local knowledge. Locally produced maps are helping us to better understand the needs and requirements of populations. However, these maps must be viewed in the context of their inherent power, their relationship to the public and private sectors, their seeking or representation of knowledges and their levels of human interaction. A map is not objectively 'above' or 'beyond' that which is represented; nor can one track back from the representation to some ultimate object, knowledge or mind.

There is in motion a significant shift in the power of maps and the sources of the information they represent. While still a long way from fully changing global power dynamics, the marriage between digital media and PGIS is opening space for new and exciting conversations, and more importantly a lot more people are inviting themselves to the conversation. By listening carefully to these cartographic conversations we can move the 3rd sector away from asking 'if we are doing things right' and towards 'are we doing the right thing'.

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

A Major Challenge for the Surveying Industry

Rory Stanbridge | The Survey Association

Life is full of challenges and the type and intensity of the challenge will depend largely on where you were born and the environment that you live in. You only have to look at the current worldwide migrant crisis to see the validity of this statement.

I have now been a part of the surveying industry for just over fifty years and can honestly say that I have loved almost every minute of it. I was very fortunate. At my school, our Maths teacher decided that he would like to demonstrate Mathematics in action and introduced Elementary Surveying as a lesson which then became a GCE "O" level subject. It ceased to exist in the 1970's. I was immediately struck by the somewhat romantic idea of a working life outside in the sun, travelling and seeing other parts of the world as well as the UK. In the end, I chose Photogrammetry, an almost totally indoor based job, but I have still travelled around the globe in my chosen career path. I was even offered a job before I left College, a pretty rare occurrence if it were to happen now.

So where is this article going you may ask? It is intended to clarify what I perceive to be a major challenge facing the UK Surveying fraternity today. This is, put simply, a serious lack of appropriate existing skills combined with a lack of new entrants to the profession. Very few children at school today will know what the role of a modern day geomatics surveyor is and this is a problem that TSA has been attempting to address in a number of ways. I am talking about people that collect data, usually in 3 dimensions whilst measuring things, not merely checking numbers as in Quantity Surveying.

The recession in 2009 hit the members of The Survey Association (TSA) very hard and a serious number of redundancies were imposed. Many of the people that were both well trained and versed in surveying were made redundant and subsequently left the industry never to return. The UK industry has now returned to pre-recession levels and despite major advances in technology, much of this requiring less manpower than previously, there is still a serious shortage of both qualified and trainee surveyors.

TSA has over the last few years introduced a number of initiatives to address this serious lack of surveyors. The first of these was to develop a website aimed primarily at schoolchildren and people looking for a change of career. The "Become A Surveyor" website was launched a number of years ago and was completely revamped in 2014. It can be found at: www.becomeasurveyor.com. Visitors to the site can view what the life and work of a surveyor entails and can see the various routes into the profession. To date, the main views have been from people that wish to change their careers but we do need to push the schools to look at it much closer.

In 2009, TSA introduced a new service to members of FREE job adverts on our website. At the current time there are in excess of eighty positions available to be filled in a variety of roles. Not all of these require experience so a new entrant to surveying should still find something to suit them. The number of openings bears witness to the expansion of the industry and the opportunities on offer for anyone wishing to join in.

The problem of structured survey training is one that TSA first addressed about 13 years ago. At that time, there were very few universities offering a course that was dedicated to surveying although some included the topic in other courses, and it should not be forgotten that not everyone wants to go to University. As a result TSA wrote a Survey Technician Training syllabus consisting of six blocks of two weeks learning, practical and theoretical, spread over a two year period and delivered at The Survey School in Worcester. At the time, the course was run by a commercial company on behalf of TSA but in May 2014 TSA took over responsibility for the running of The Survey School. Since its inception, over 400 students have gone through all or part of the TSA course with over 320 graduating through the full programme.

Since taking over The School, TSA has also introduced a number of short courses on Setting Out, Utility Surveying, Levelling, using a Total Station and Practical Photogrammetry. All of this will help to ensure that the modern day surveyor is both knowledgeable and equipped for the challenges ahead. However, it does not really address the issue of getting more young people into the industry. The Become A Surveyor website mentioned above goes some way to addressing this problem, but there is another scheme out there that may well help.

Class Of Your Own was set up by Alison Watson a number of years ago with the intention of getting surveying and engineering to become part of the standard school syllabus. The scheme has been extended and now a number of major consultancies have taken on the role of adopting a school and working with them. The website can be found at: http://designengineerconstruct.com/ In recognition of the work undertaken by Alison, she was awarded the TSA President's prize in 2014 for her efforts. As more and more schools get involved in the scheme, we will hopefully see an increase in the number of younger surveyors working in the industry and it is good to report that the number of girls showing an interest in becoming a surveyor has grown enormously.

All of these initiatives together will hopefully help to develop and expand the surveying industry and avert what could become a crisis rather than a challenge. We still have much to do so "get involved."

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

GIS and Big Data Analytics: Two Sides of the Same Coin?

Trevor Steenson | Digital Transformation Service - Department of Finance & Personnel NI

A key moment in the development of modern GIS can be traced back to a chance conversation between Roger Tomlinson, a geographer who at the time was working for a Canadian aerial survey company and Lee Pratt, the then recently appointed head of the Canadian Land Inventory. The conversation between the two men took place in 1962 on a flight between Ottawa and Toronto during which they discussed the challenge of compiling and representing data held on the thousands of maps of the Canadian landscape. The result of this chance meeting was the development of one of the first Geographic Information Systems.

Since those early days, GIS has become recognised as the most effective tool for collecting, compiling, analysing and displaying geographic data, from simple location maps to highly complex 4D predictive models.

Used across the public, private and voluntary sectors, GIS is credited with significant cost savings, improved operational efficiency, improved decision making, improved communication, better record keeping and information management and the saving of lives. Arguably the greatest strength of GIS is its predictive analysis capability which can help in decisions as diverse as where would be the best place to locate a new department store, helping emergency responders model the effects of natural or manmade disasters such as flooding or a major chemical spill, predicting potential crime hotspots, or identifying the optimum place to locate ambulances based on patterns of past accidents, expected road conditions or the location of large civic events etc.

The increased use of GIS across all sectors has also seen a corresponding growth in the GI marketplace, which in Europe is expected to reach three billion euro by 2016, driven largely by the Public Sector and the non-manufacturing industry. This growth has also resulted in increased opportunities in the GI profession and the related fields of IT and data analysis.

However, GIS in not the only analysis tool that is available to business and increasingly organisations are turning to other data analytics technologies to help meet their business challenges.

The birth and subsequent growth of data analytics[1] in many ways parallels the growth of GIS and whilst it may be harder to trace the origins of data analytics to a single event, such as the meeting between Tomlinson and Pritt, the early development of data analytics tools in the mid 1950's was similar to the development of the early GI systems with small specialised in-house teams working on decision support using largely well-structured historical data. This early data analytics work eventually led, in the 1970's, to the development of desktop statistical software tools such as spreadsheets and more sophisticated tools that only a few specialists could use.

Recently the increasing interest in data analytics, particularly in respect of big data analytics and the development of new big data analytics tools has been driven, in part, by the need to derive useable information from the vast amounts of new data that is being created on a daily basis. The 2012 Digital Universe Study by IDC projects that the amount of new data generated throughout the world will reach 40 ZetaBytes by 2020 with a prediction that data production will increase 50-fold from the beginning of 2010 to end of 2020[2].

This large volume of data provides one of the 'Four V's' - Volume, Velocity, Variety and Veracity[3] by which big data is differentiated. Of the other V's Velocity is the term used to describe streamed real-time data, Variety refers to the different forms that big data can be presented in and Veracity refers to the quality issues commonly encountered with big datasets.

Just as there are different types of GIS applications, there are different types of data analytics tools that are aimed at addressing a range of particular business problems. *Descriptive Analytics* applications are used to query, report and visualise historic data in order to determine the cause of something that has already happened. More advanced *Predictive Analytics* applications are used to highlight patterns within historic data in order to help determine future trends and *Prescriptive Modelling* can help businesses in areas such as reducing customer turnover, improving marketing effectiveness and avoiding equipment malfunctions. These analytics tools can accept a wide range of data types from multiple sources ranging from well-structured data held in relational databases through semi-structured data such as the data created in e-Commerce transactions to unstructured data such as that found in text documents, emails and social media posts.

Other common issues that GIS and early data analytics projects shared were problems associated with the processing and storage of large quantities of data and the reliance on good quality data and as with GIS much of the effort in using the early tools was in the preparation and cleansing of the data before it could be effectively analysed. However, these barriers are now disappearing with the growth of cloud-based rapidly scalable clusters of servers and distributed storage, big data platforms such as Hadoop and software specifically designed to deal with the challenges of poor or inconsistent quality data.

As with GIS software the use of data analytics tools has moved out of the domain of the specialist teams of data scientists and the same tools are now employed by business analysts and business managers supported by IT developers. The types of organisations using data analytics are also changing with uptake spreading from the early adopters such as Google and Facebook into mainstream business and into the public sector. This uptake has been helped by reduced entry costs, the increasing availability of Open Data and the real-time data feeds from social media platforms.

As much of the big data being created today contains some type of location information such as the location of the millions of photographs published on social media every day; places across the world that tweets originate from; or the real time position of mobile phones transmitted to a crowd sourcing site, it is not surprising that GIS software vendors are starting to include the capability to process big data within their products. Indeed, many of the challenges associated with managing Volume, Velocity, Variety and Veracity of data will be very familiar to many GIS users. Tomlinson and Pratt's conversation which led to the development of that early GIS was prompted by the difficulties of dealing with the masses of data collected by the Canadian Land Inventory, the tools for manipulating Remote Sensed data, which have now become a standard feature of many GIS packages are now able to deal with near real time data feeds and the ability of GIS to deal with a variety of data types, while still considerably behind data analytics tools, continues to grow. The remaining V - Veracity - data quality is something that the GIS community has been faced with ever since those early days.

Some published articles suggest that GIS is losing ground to the rapid developments in big data analytics however the similarities in the business problems and data issues - the four V's, that the two technologies are addressing suggest that rather than being rivals GIS and Big Data Analytics are complementary and will benefit from each others advances. The biggest challenges will be the cross-skilling of users and bringing both technologies into the mainstream of other business tools.

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

BIM and Spatial Data: Working Together for Effective Infrastructure Development

Marek Suchocki | Autodesk

BIM and geospatial data are opening new opportunities for civil engineers and specialists to address global demands for infrastructure investment delivering projects at lower total costs, quicker and with fewer available resources. To maximize the impact, the approach to project delivery requires a review of the entire process taking into account available data, selection of appropriate technologies, options exploration with stakeholders and ensuring buildability, usability and suitability are considered throughout the project lifecycle.

Problem/ Opportunity Statement

In its Strategic Transport Infrastructure Needs to 2030 report in 2012, OECD forecast a required infrastructure investment of around $53 trillion over the next 15 years. This is impacting at a time of professional and trade resource challenge:

- the Engineering UK 2015 State of Engineering report indicates a potential doubling of the number of engineering graduates is required to meet demand by 2022 and
- the KPMG 2015 Global Construction survey identified resource issues as a key source of project delay with around 45% of contractors struggling to attract qualified trade workers and project professionals

Meeting the investment challenge with fewer resources requires innovation. In the Construction 2025 industrial strategy report BIM was identified as a key enabler to achieving a 33% reduction in the cost of construction and over an asset's whole life, as well as a 50% reduction in the overall time to deliver from inception to completion.

History

The need to adopt process change and technical innovation in the construction industry to achieve improvements is however not a recent revelation. Reports over the years have highlighted deficiencies and potential remedies:

- Banwell in 1964 identified construction as 'an industry with people full of ideas and not afraid to change practice and procedure, but others who do not move forward… and existing contractual and professional conventions lacking the flexibility needed for a process of modernisation'
- The Latham Report in 1994 suggested that 'the use of co-ordinated project information should be a contractual requirement… and that government should commit to being a best practice client'
- Then in 1998 Egan repeated messages in the Latham study asking that the whole team work together to deliver specific customer projects, where possible using computer modelling, standardised components and pre-assembly, and encouraging the supply chain to drive innovation and performance improvement, with opportunity to share in the rewards

When in 2009, Wolstenholme's Never Waste a Good Crisis report asked 'What will make the industry change when it has failed to do so before?' it was clear that the time to change was upon us driven by difficult economic conditions and acceptance that enough was enough.

This and further reports pointed to technological innovation as a catalyst for change, eventually with the 2011 BIS Strategy paper for the Government Construction Client Group calling for BIM adoption from 2016 to achieve desired 20% lifecycle cost benefits for central government projects.

The Solution

Although correctly adopted BIM can catalyze change providing many of the required benefits and improvements, within the infrastructure sector BIM remains something of an enigma with poor understanding of the technology as well as the processes to be used in its application.

The ICE Information Systems panel and BIM Action Group identify BIM 'as the purposeful management of information through the whole life cycle of an infrastructure asset, necessitating a managed approach to collecting and using information across the life-cycle of a built asset, using technology throughout for the preparation of graphical models and associated information'.

It is the 'managed approach' that is perhaps the most important concept as it introduces the greatest process change into design, construction and operation of a built asset. Simply using the latest '3D' technology does not provide BIM, it is instead down to controlling who prepares information, how it is prepared, determining what gets prepared and at what phase; that is what provides the foundation for effective BIM.

To achieve substantial benefits, BIM adoption and process changes have to be applied throughout the lifecycle; in design, construction and into asset operation and also apply robust information management practices such as the Common Data Environment described in BS1192: 2007 and PAS1192-2:2015. If not, only incremental gains will be achieved as the majority of work is delivered using traditional approaches with no opportunity for improvement; you can't keep doing the same thing and anticipate a different result.

BIM and Geospatial; an approach for infrastructure

Where do you start?

For infrastructure projects BIM cannot be applied in isolation; long linear schemes have a geographic component that necessitates adoption of an integrated approach, which leverages both spatial and 3D model data.

An infrastructure project can in fact uniquely create a contextual understanding of an area under inspection by leveraging readily available raster and vector 'map' data. The data can be used immediately, searched, filtered and displayed within GIS and engineering software to gain an understanding of a region. This data can be supplemented with further data such as land ownership, proposal corridors, flood extents, sites of special scientific interest, and aerial photography. For full understanding detailed local surveys can be undertaken using traditional techniques such as field surveying or increasingly point cloud data acquisition using laser scanners or photogrammetry either at ground level or with aerial views from aircraft or UAVs (unmanned aerial vehicles).

A number of technologies can now transform this comprehensive mix of base data to create three-dimensional representations of a region, some even apply realistic styles to buildings or convert single vectors into realistic roads, rail lines or utility pipe networks. Designers and engineers can then plan new infrastructure or modifications to the existing built environment against a full context without necessitating local detailed surveys until early options have been confirmed or eliminated against known constraints.

Early concept design options can even be prepared with immediate engineering rules applied constraining proposals to those that are technically viable. For example such early optimisation for highway vertical alignments, junctions, bridges, surface water drainage and culverts can be carried out within Autodesk's InfraWorks® technology. This approach immediately reduces downstream effort by focusing on appropriate design options from early phases as well as carrying out preliminary analysis.

Preferred option concept models can effectively be used within design review meetings, planning consultation activities, shared with stakeholders for viewing on the Internet or on mobile devices. This can confirm the appropriateness of proposals and significantly accelerate the planning approval process.

Developing the scheme

Once preferred options have been approved, projects move into one or more design phases. For infrastructure, design has historically been dominated by two dimensional views in plan, elevation or cross-section of a scheme. A three-dimensional model of a proposal would typically have been developed for a highway or rail alignment, however this may not have been directly linked to the cross-sections that would have been developed using calculation at specified intervals and requiring complete rework should the profile change.

Infrastructure BIM solutions now provide the ability to create rail profiles, engineering structures, highway alignments and go beyond simple 3D geometry to integrate to other required model views as well as holding or calculating further attributes for sections or point locations. Such models can be created from simple alignments, such as those developed during conceptual designs, and enhanced to apply all engineering constraints needed for a viable scheme including; horizontal profile, vertical profile, junctions, super-elevation, cross-section changes, drainage and structures. These fully developed designs can then be exported for re-integration into a fully aggregated view with the geospatial and local survey data used during initial option selection.

Where structures and buildings are defined within an infrastructure scheme, similar technologies used within vertical building projects can be applied. These BIM technologies are generally more mature with a number of vendor solutions available for architectural modelling, structural design and analysis, building services design and analysis, data aggregation and visualisation.

Into Construction and Operation

BIM technology is fully applicable within the Construction and Operational phases of built assets with design and geospatial technologies as well as all prepared data able to be utilized. Solutions for asset data capture and management and increasingly mobile field based solutions can also be leveraged to ensure project data is available and can be directly updated at the work site.

Leveraging design models during construction execution permits significant improvements in productivity and accuracy include using model coordinates for setting-out and machine automation typically using GPS rather than ground based positioning. This can eliminate a significant amount of manual setting-out effort and associated risk of error. Following construction, verification of as-built vs. designed can be executed using capture of specific points or using laser scans.

Progress reporting using mobile field based reporting, laser scanning or photo/video captured by UAVs is increasingly being adopted, particularly for large projects such as infrastructure schemes. Actual project progress can also be compared against four-dimensional sequence simulations prepared from models linked to project plans.

Field based data capture is significantly accelerating the time for snagging and commissioning activities. Use of flexible forms allows any required information to be checked or recorded on mobile devices, supplemented with photographs and linked to specific locations or objects within a model.

Facilities and asset managers can leverage BIM technologies to rapidly update their asset management systems with accurate information. They can leverage the enhanced BIM data in the field when carrying out inspections as well as planned or reactive maintenance.

Asset managers can also identify data omissions or errors that need correcting to have a complete overview of managed assets. This working approach is no longer limited to models associated to single large assets e.g. buildings or structures, but can now work across long infrastructures enabling civil owner operators to leverage the same benefits.

Call to Action

BIM for Infrastructure is not an aspiration; it is a managed process for leveraging available technology to understand the context of a project, explore and assess options, fully design preferred proposals and efficiently execute the construction, providing a comprehensive accurate set of data to the owner and operator of the delivered assets. It increases certainty, better meets client expectations, allows for more rapid execution and, because of process benefits such as elimination of errors, proves cost effective.

To obtain the benefits, practitioners need to avoid the temptation to immediately start engineering solutions in familiar technologies; project teams should instead apply best practices such as the guidance prepared for the UK Government BIM initiative to firstly plan a project by identifying what information is needed, when and by which party. The clarified requirement will then aid selection of the specific technologies and data sources to be adopted.

The rapid innovation occurring in the technologies for construction should be considered as an enabler and driver of change. Using traditional tools and processes eliminates the opportunity for any improvement because only known workflows and outcomes can be achieved.

Adoption of new ways of working does introduce risk due to lack of familiarity and confidence in the approach; however these risks are outweighed by the inherent contingencies for managing accepted risk of traditional processes. Provided the process of BIM adoption is managed and monitored, risks can be controlled and benefits realised.

About your Company

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

GIS and Agriculture: The Next Five Years

Julian Swindell | The Royal Agricultural College Cirencester

GIS has always been about visualisation of spatial data. The problems with it have always been the data. Getting up to date, high resolution data with clear geo-location has been problematic. Firstly, getting it at all was hard and expensive, but once you had it, users always said it was a shame it wasn't even more up to date and even higher resolution. People were never content with what they could do, they always want to do a bit more. "It's interesting, but last month's data isn't as useful as yesterday's data would have been. Or how about today's?" "Looking at treetops is all well and good, but what's going on underneath them?" This dissatisfaction and frustration can best be seen by the disappointment of precision farming.

Precision farming

After the event data

In the 1980s and 90s agricultural technologists were excited by the potential of targeted, variable input farming; so called precision farming. Many of the problems farmers face are spatial. Crops don't thrive in certain areas, some land retains water whilst other is always dry. If you could map the problems "exactly" and then target remedial measures "precisely" at the location of the problem, you would be able to solve everything, cut down the use of agrichemicals and save the planet. It didn't work out like that for a number of reasons.

Firstly, the whole concept was driven by engineers, who were hugely, and rightly, excited by the technology, but weren't really looking at agriculture as a whole. There is a lot more to it than just poorly performing crops in particular locations. The technical problems, conceptually, were very simple, and the advent of accurate and precise GPS coupled with GIS managed digital mapping, provided all of the software needs and engineers just had to make the machines to use it. The best outcome from all of this that could be measured was a possible 5% increase in value of the crop yielded by a field.

This might seem a good improvement, until farmers pointed out that one week's cold weather in the spring could have a 20% impact on yield, and a bumper harvest in Canada could lead to a 50% reduction in grain prices. A possible 5% improvement was just noise in the data.

Secondly, farmers are human, and don't do what technologists expect them to. When weeds were precisely mapped in a growing field, the engineers anticipated that farmers would target just the infected areas with precision applications of herbicide, saving an enormous amount of chemical application. In reality, the farmers still spread herbicides as widely as before ("don't want to risk weeds getting established") and then applied even more on the mapped weed patches. Herbicide use went up.

But most importantly, the real limitation with the first wave of precision agriculture was that it was largely based on after-the-event data. Yields maps, which formed the basis of many systems, were created by tracking the combine harvester as it worked, and measuring the yield of grain in real time. This gave you a map of yield variation for a crop which was now harvested and finished. Far too late to do anything about it, and of very limited value in planning the next year's work because of the myriad other variables that come into play every growing season. After the initial enthusiasm, many farmers simply abandoned the technology, although GPS has become ubiquitous, just as it has in cars. But this could change in the next five years, for a range of reasons, which may lead us to a new, technical farming driven by near real time data and advances in data capture that couldn't be believed just 10 years ago. For the sake of differentiation, this can be called "Focussed farming" (See **figure 1**).

Focussed farming

Before the event management

Not all precision agriculture was based on post-harvest data. It has always been possible to collect current data and what might be called low temporal variability data. A clear example of this would be soil data. The old saw, the "the answer lies in the soil" is largely true, and that answer can be measured, analysed and mapped with considerable certainty, as the soil doesn't change that quickly. The properties of interest are multitudinous: permeability, texture, depth, pH, organic content, micro-nutrient concentration. Even earth worm and invertebrate concentrations. Collecting the data is slow and labour intensive, but it has gone on for decades, well before digital computers were conceived. You dig holes and record the attributes of the soil in that hole. If the locations of those holes are accurately recorded, they can be mapped, interpolated and combined with other hole records, decades or even centuries after the data was collected. Whilst this gives opportunity for long term change analysis, it also provides pre-harvest data which is of value in farm management. If you know where the essential micro-nutrients are in short supply, you can target those areas with pre-planting fertilisers. GPS guided tractors can do this just as a matter of course. (See **figure 2**)

The idea of focussed farming is to collect, and use, far more pre-harvest data, which can be used in the management of the current crop. Yieldmapping still has a use, but largely to check the effectiveness of the focussed farming. Soil mapping has shown the way, but an upsurge in new spatial technologies shows that this is just the start.

Developing Technologies

There have been too many technological developments in the last five to ten years to cover them all. Possibly the most important has been mobile technology and remote internet accessibility, but here the concentration will be on specifically spatial technologies. Much of what can now be done has been thought about for many years, but we never believed it would become practical quite so quickly.

Remote sensing

Remote sensing, and satellite remote sending in particular, has had a profound effect on agriculture and rural land management, but up until recently this was mainly in monitoring and mapping. The ability to be able to look at anywhere in the world, without restriction (clouds permitting) has profound implications. It seemed that old fashioned aerial photography was just that, old fashioned. But that has changed. The advent of high quality digital cameras has both improved both the spatial and the spectral resolution immensely and the data can be fed directly into a GIS database. You can "photograph" in the morning and work with the images in the afternoon. That seemed revolutionary enough, until people started flying very sophisticated model aeroplanes. (See **figure 3**)

UAV reconnaissance

The drone, the unmanned aerial vehicle, the UAV, whatever you want to call it, is now common and slightly unnerving. A recent demonstration of an autonomous UAV over Harnhill Manor Farm at the Royal Agricultural University showed how a 10ha field could be imaged in under 20 minutes. The software plots the ideal flight plan over the targeted area, the UAV follows the plan on autopilot, to the extent of switching off the motor as each image is taken to cut down vibration, and the data is downloaded on return into a GIS. This data consists of so many overlapping images that a 3-D map of the land can be constructed from it, in full multi-spectral detail. No need for satellites or expensive data processors to work your images up into something understandable. You can have the images on the day they were collected. The farmer can deal with any identified problems tomorrow, not next year.

LiDAR

Large aeroplanes still have a vital role, although miniaturisation is bound to catch up here eventually. This is in the realm of LiDAR surveying, pummelling the Earth below with millions of laser pulses and measuring the height of the land. This equipment is still too heavy for UAVs and too power hungry for satellites, but both those will change. The exquisitely detailed topographic measurements it gives is invaluable for managing drainage, planning water harvesting and predicting flood risk. (See **figure 4**)

LiDAR has also transformed archaeological exploration by its ability to penetrate tree canopies and model the hidden ground underneath. It is almost magical in its ability and is only just opening our eyes to the extent of human historical culture in the densely forested areas of Central America, South East Asia, Amazonia and Savernake Forest, just south of Swindon. (See **figure 5**)

Laser scanning

Lasers don't have to be mounted on aerial vehicles. They can be mounted on terrestrial ones. Even two legged ones, walking the fields. Mobile laser scanning can now pick up full, horizontal 3-D imagery on the move. This can be combined with the slightly lower resolution imagery from the UAVs to create a full 3-D virtual model of a farm, showing buildings, trees, ground form, even overhead cables (a vital piece of information for farmers if you think about it.) You can view it from above or go down onto the ground and even walk into the buildings. Once a full model is built, it can be queried at any time without any additional surveying being needed. Will the new combine harvester fit into the shed? Measure the door height on the model. What volume of timber is there in the plantation down in the valley? Measure the trees on the model and standard formulae can tell you. Will the new, self-driving, self-steering, self-anything tractor fit under the high tension cables over field 23? Measure it in the model, but make sure you go and have a good look before you let that tractor off by itself.

3-D printing

But even a virtual 3-D model needs a computer to be turned on and booted up. Why wait? Print a 3-D physical model and leave it on the kitchen table to be looked at whenever you want. This can be printed in realistic colours, but tomorrow? It can be translucent and laid over an LCD screen which projects any data you want up onto it. Soil, drainage, crop yields. Whatever you have got. As they say "The future is now" but it will be multi-coloured, three dimensional and it is coming up on us very fast indeed.

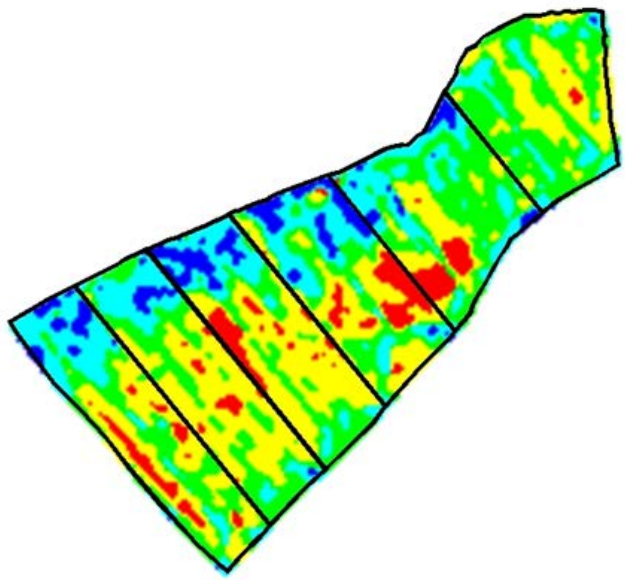

Figure 1 - Post-harvest yieldmap from Harnhill farm, 1993. Blue lowest yield, red highest

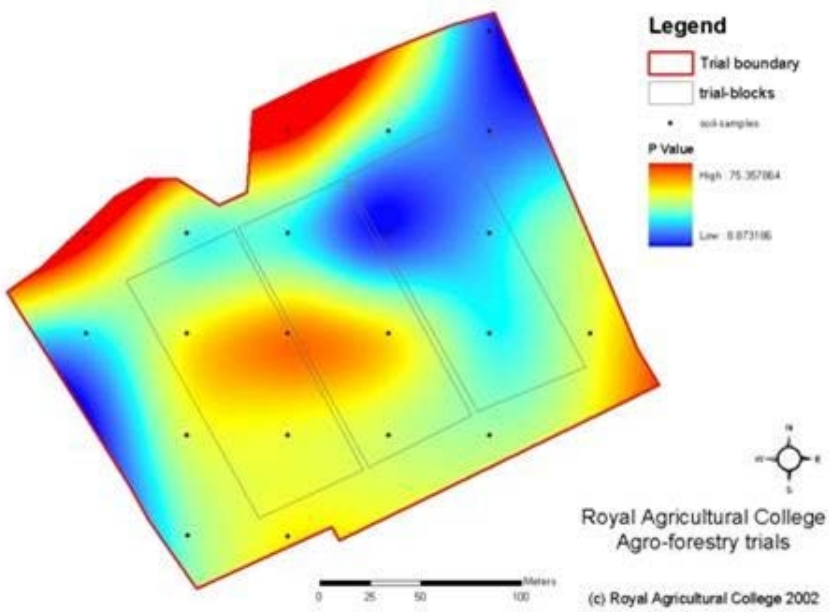

Figure 2 - Soil micro-nutrient mapping, 2002, based on chemical analysis of a grid of soil samples. This shows variations in phosphourus concentration

Figure 3 - High resolution aerial digital photograph, 2011, Harnhill Manor Farm

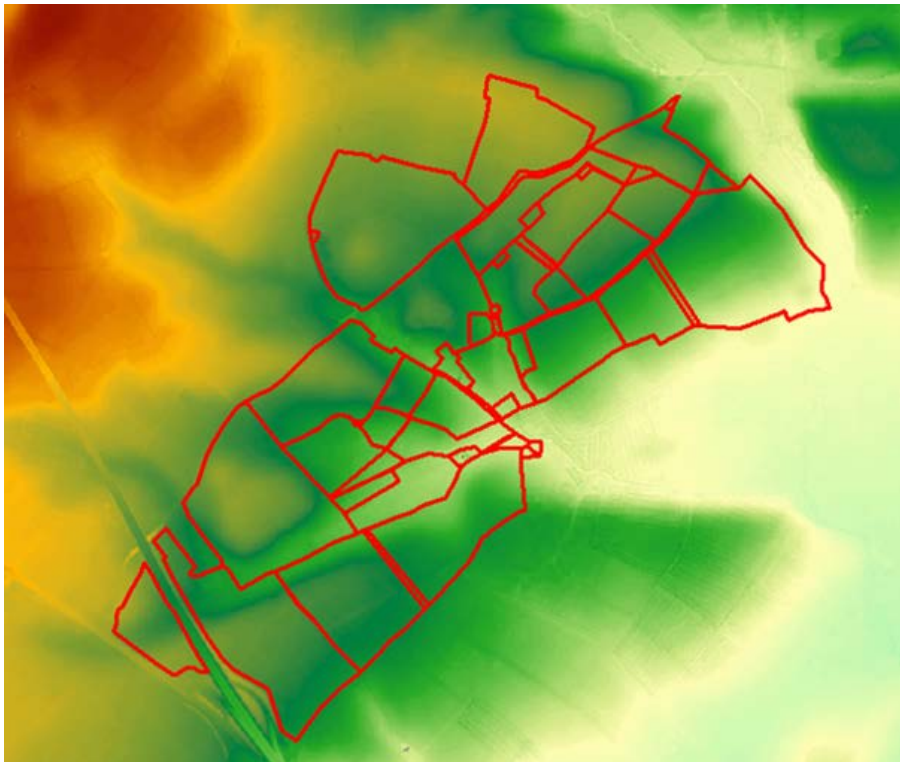

Figure 4 - 4 LiDAR aerial survey 2011, Harnhill Manor Farm. This has a horizontal resolution of 1m and a vertical resolution of 0.001m. In this image, the trees have been removed through the magic of LiDAR canopy penetration, the archaeologist's dream come true.

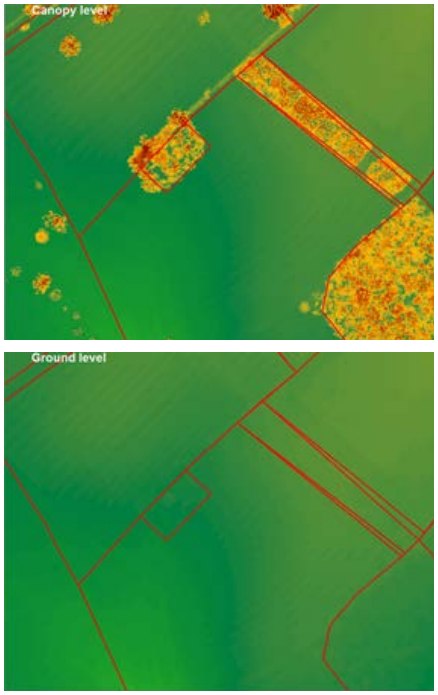

Figure 5 - 5 LiDAR survey with tree cover (top) and without tree cover (bottom). The medieval ridge and furrow ploughing system can be measured directly from these images.

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Challenges for Geography: The Environment Domain

Liz Tucker | Head of Geographic Evidence, Defra **Gary Kass** | Deputy Chief Scientist, Natural England
Neil Kaye, Adrian Hines and Alberto Arribas | Met Office Hadley Centre

The overall objectives for Defra[1], are to achieve a

- a cleaner, healthier environment which benefits people and the economy,
- a world-leading food and farming industry,
- a thriving rural economy, contributing to national prosperity and wellbeing
- a nation protected against natural threats and hazards, with strong response and recovery capabilities[2]

These objectives span the marine and terrestrial environment, animal and plant health, and farming policy. It also covers atmosphere and air quality, the natural environment, noise and waste policy. This leads to a diverse and complicated range of information needs as well as the requirement to work across disciplines and sectors.

We need to be able to monitor ecological systems, understand farming practices and how people engage with the natural environment, respond to environmental changes, regulate industry, and deal with emergencies such as animal disease or flooding.

We also need to horizon scan for emerging trends and technologies and assess risk from future threats, whether from a changing climate or from changing disease and pest pressures. We also need to be able to identify opportunities which emerge from changes, whether that is changes in food production and or new technologies to allow improved monitoring and assessment.

What bridges all these demands together is the need to understand dynamic complex systems which underpin the environmental, social and economic relationships from local to global scales from the near-term to the long-term. This understanding informs national policy and local delivery and 'Geography' provides the framework to integrate information and knowledge to allow us to do this. Geographic Information (GI) can be used to present information and is increasingly being used to engage with a range of stakeholders. We need access to the right technology, the right data, and most importantly the right skills & knowledge from across a range of specialists.

This paper is not examining technology challenges, other than to say that access to the right tool for the right user is essential to realise the business benefits. The tools need to be flexible, scalable and user-centric. Instead this paper suggests some of the areas where skills and knowledge need developing.

Accessibility of data has changed beyond recognition in the last few years and we will continue to see more publicly funded data sources become available for use. Defra has committed to make 8,000 data sets freely available, including flagship data such as LiDAR from the Environment Agency. Defra views data as both a public asset but also that it enables citizens and businesses to make better decisions and promotes growth. The EU Earth Observation Programme, Copernicus, is already making vast amounts of data from satellites freely available to users.

To illustrate the challenges we are presenting two perspectives from across the range of Defra interests; one from Natural England, governments' statutory adviser on the natural environment. The other is from the Met Office Hadley Centre, a research centre to monitor global and national climate variability and change; the Climate Programme is co-funded by DECC & Defra.

Geography and GI – challenges for the next five years.

A perspective from Natural England Gary Kass, Deputy Chief Scientist

The key challenge we face over the next five years and beyond is safeguarding the natural environment for its intrinsic value and the benefits it provides to society and the economy. Geography and GI are at the heart of this. Geography as a discipline helps us to better understand the relationships between human beings and the natural world and get a slippery handle on the complex spatial and temporal dimensions of the dynamic and adaptive human and social systems in which we live and work.

So, as the statutory advisor on the natural environment in England, our starting point is that we need to have the best evidence available to inform the decisions we make and the advice we give. The breadth of our remit means we need evidence across a huge range of subjects, from soil science to sociology; from ecology to economics and from historic environment to futures analysis. These boil down to two key themes: understanding the state and trends of our natural and cultural environments and the pressures upon them; and understanding the impacts of our advice and interventions, and improving their effectiveness.

Both have a strong geographical thread running right through them. For Natural England, succeeding in fulfilling our statutory purpose means that geography matters! The environment is 'somewhere' and 'everywhere'. What happens on the ground in specific social, economic and biophysical contexts, in specific locations, across different boundaries and scales and between different communities is crucial to us. Geographical thinking helps us to work systemically and make the most of the synergies arising.

But a key challenge is gathering and applying the most relevant evidence of the right quality, in the right way at the right time, ensuring that it meets the needs of those using it. The complexities within which we operate mean that we will never have all the information we'd like so our decisions and advice must be robust in the real world of incomplete, uncertain, ambiguous and sometimes contentious knowledge where flexibility and adaptation are critical.

But challenges can present opportunities too and environmental information, much of it geo-coded, is growing all the time, with terabytes of data every day from satellites, drones, autonomous vehicles, sensor networks and social media. Big Data challenges of volume, velocity, variety and veracity are upon us. While advances in data analytics, spatial analysis, GI modelling and visualisations offer huge potential, they also present huge challenges around how we can avoid getting bogged down or left behind and make the most of this bounty of information and ingenuity. We need to work with our partners, locally and nationally to find new ways of working in the fast-moving Big Data world.

Met Office Hadley Centre

Climate Science & Geographic Challenges

In recent years, there has been a huge increase in the supercomputing facilities available to climate scientists. This has resulted in a rapid improvement in the detail, the complexity, and the size of climate model experiments. These improvements each provide specific challenges for GI:

- Detail: enhanced model resolution will mean that local details and events are better represented, for example, small scale convective storms that may result in flash flooding. These will need to be reconciled with local information from other sources, such as infrastructure and flood defence location.
- Complexity: an increasing number of interacting data fields will need to be manipulated and explored together, such as the link between projected physical climate impacts and possible future socio-economic conditions.
- Experiment size: projections of future climate are produced from multiple model runs (often numbering in the hundreds) which provide a plausible range of future outcomes. The size of these model 'ensembles' are increasing, providing improved information on this future range, but also presenting a challenge about how to interpret and communicate this information appropriately.

Improvements in climate modelling come with a correspondingly large increase in the volume of data produced. The next assessment of the Intergovernmental Panel on Climate Change (IPCC) has not yet begun, but early estimates suggest it may be based on over 50 petabytes (50,000 terabyte hard drives) of climate model data, which would be about 50 times more information than was produced for the previous report in 2014. The increased size and complexity of these datasets mean that new tools are required in order to usefully analyse and interpret this vast quantity of information.

There is an increasing shift in the focus of climate science towards understanding both the impacts of climate change and how society can adapt to those impacts. As a consequence, there is a growing need to combine climate datasets with other, multi-disciplinary sources of information such as population datasets, asset locations and damage datasets.

This will require bringing together datasets with very different characteristics and based on different assumptions about the underlying physical environment. In particular, climate model datasets are produced at a much more coarse resolution than most GI datasets. The use of GI to provide coherent interpretation of such diverse datasets is necessary to deliver full value from the on-going investment in climate modelling capability.

Furthermore, methodologies need to be developed to synthesize and visualise the various range of outcomes that are associated with climate modelling and impacts. This is best served by the ever more powerful open source web based GI solutions. It is expected that web based analysis will develop in the next 5 years which means that relationships between climate, environmental ,and socio-economic data could be explored in online tools, which will be particularly useful for climate impacts studies.

Discussion

Collectively these case studies highlight a number of issues about the skills and capabilities which geo-professionals, inside and outside of government, need and a challenge in engaging a wider audience. To make the most of the potential we need to be able to access the right data and information from a wider range of sources and we need to work across analytical and policy professionals to equip those colleagues to unlock the value of both spatial data and geographical thinking.

It goes without saying that a challenge in the next 5 – 10 years will be an increasing pressure on public sector budgets. As well as needing to update internal management of data and systems, so they are modern, flexible, and cost effective, we also have the opportunity to look at how we collect data. The well documented increase of mobile technology and crowd sourced data for our personal decision making, such as best visitor attractions or a place to grab a coffee, can be pulled through into the professional decision making tools. Citizen Science, or the involvement of volunteers in science or monitoring, has increasingly been seen to have a clear relevance to government policy. This can be a one-off event, such as public engagement when the Ash Die Back (Chalara) disease hit the UK in 2013, or a long term, sustained interest by a few highly skilled & dedicated people such as the records collected by the Biological Records Centres. The UK Environmental Observation Framework, UKEOF[3], has been at the forefront of the use of citizen science in government, including publishing a 'Guide to Citizen Science'[4]. For the geographic community we need to be able to provide simple and engaging tools to enable high quality geo-referenced data collection. But we also need to understand the scientific and data challenges to allow decision makers to access, make sense of and use the results from citizen science.

This includes understanding uncertainty & error in observations and geo-coding but also quality issues, such as a lack of spatial stratification of samples and the challenges for users following the OS Positional Accuracy Improvements.

The range and scope of data available to decision makers has changed beyond recognition. As the MOHC perspective outlines the volume of data is now at a level which needs specialist management and handling to ensure that the decision making value of the data isn't lost. Specialist data management skills, access to powerful computer processing are also required. The challenge for government agencies, and others, is to be able to access the right data for the right purpose and to be able to access scalable, on demand processing capacity and the right tools.

As the perspective from Natural England highlights, there is a demand to make the right decisions but its rare we ever have all the information to do this. To do this on a systematic basis, from local to global decisions, means increasing our capabilities for modelling, risk based decision making, citizen participation and adaptive management. This requires not only modelling skills but also skills from the policy or operational customer to be able to articulate the issue and understand the short term requirement but also to define how the issue can be monitored and adapted over time.

Conclusion

In all the challenges identified above there are two skill sets which need developing. The first is that of the geo-specialist. As a generality the geo-professional in government is also a scientist, modeller, statistician, data manager or some other specialist; geography is the essential tool they use to provide high quality evidence and advice. These specialists need to be open to new ideas, new ways of solving problems, and new ways of asking questions. We need to embrace tools and technologies which allow us to make the most of the flow of data and continue to integrate our skills with those in other disciplines such as economics, social research and operational delivery. There is work ongoing to develop a network of government geographers, this will help share skills and knowledge across policy themes, but also embed geographical thinking as an essential skill.

The second community is less defined and far larger. The industry has talked about making GI a must-have tool, and in many ways we've achieved this through Google Maps, web-mapping portals and through other integration of business tools. People now look at maps on a daily basis without considering them. However the challenge remains for the decision making community to use maps more analytically and have the skills to access and use data independently or through pre-determined models.

But, it is our view, that this isn't just about using tools but making sure that managers and policy makers are asking their questions in a geographically literate way and truly putting 'place' at the centre of their decisions. Together as a professional industry, we need to work with organisations like the AGI and the Royal Geographic Society to embed geography as a core knowledge skill in education and within our organisations to support the ongoing education to really make geography the go-to profession.

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References

1 Defra includes its executive bodies and agencies. A full list of Defra and its bodies can be found here: https://www.gov.uk/government/organisations#department-for-environment-food-rural-affairs

2 https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs/about

3 http://www.ukeof.org.uk/

4 http://www.ukeof.org.uk/our-work/citizen-science

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Future of GI in Food and Farming

Dr Toby Waine & Tim Brewer | Cranfield University

"To hear analysts at the Agriculture Department talk, geospatial information systems are moving from being merely useful tools to becoming game changers."

Patrick Marshall, GCN, 2013

The UK Government Foresight Report into the Future of Food and Farming (2010) highlighted some of the key challenges we must meet to address food requirements for a world population predicted to reach more than 9 billion by 2050. With natural resources such as land, water and energy under increasing pressure from population, urbanisation and uncertainty of changing climate patterns, improvements in the productivity of global agricultural systems are required to meet this challenge.

The agriculture industry is rapidly embracing technologies to attempt to optimize agronomic decisions. The volume of agricultural data collected by growers, both spatially and temporally is rapidly increasing, along with the diversity of sources, e.g. crop canopy measurements from drones, proximal soil sensors, geo-tagged photographs of disease.

New methods of analysing and interpreting these 'big-data' are required, so we can address both micro-perspectives to support farmers livelihoods and big-picture monitoring for planning and managing farms to provide the right kinds of incentives and disincentives to balance farmers needs with long-term sustainability.

Problem/ Opportunity Statement

Agri-informatics and big data analytics

Optimised food production increasingly requires a mechanistic understanding of the processes involved within a geospatial context. There are limitations in the implementation of recommended application rates, and when crop management decisions are made at a much higher spatial resolution. Improved models for variable rate application of inputs and integration and interactions within agricultural supply chains are needed to enable farmers and agribusiness to adapt to increasing resource pressure and adaptation to changing climatic conditions.

History

Current Precision Farming practices

Precision agriculture service providers and growers are routinely collecting remote sensing (earth observation and aerial surveys) of farmers crops to monitor canopy development, and meteorological, soil, water and yield data from within individual fields at much higher spatial and temporal resolution than ever before. GI technology, such as precision navigation is at the heart of these systems. There is an assumption that the methods for determining the optimum application rates of irrigation water, nutrients, and pesticides requirements and their environment fate are fully understood in a spatial context. However, this is not the case. The problem is that the existing guidelines, such as RB209, are designed to recommend fertiliser application uniformly at the field scale, and to comply with environmental legislation, for example, loss of nitrogen (N) into water courses.

The current precision farming approach is to take a large field and subdivide it into smaller management units (zones), often based on underlying soil properties or in response to crop canopy development. Then the application rates of inputs within each unit are adjusted up or down depending on the management strategy employed. The problem is the recommendations used in the management units are generalised and do not account for local within-field conditions, or as in the case of N-application based on canopy reflectance, are over-simplistic, or risk averse - making only small changes around the average application rate, with little significant impact on production.

Another problem is the variables used to determine the boundaries of management units are often continuous, therefore are not accurately described by step changes. New approaches are needed to address these issues.

Currently the UK does not have an annual cropping map. This has been implemented in the US where data is made available via web based applications to provide land managers with access to data to allow informed decisions on farming practice. Weather conditions across the UK has made this a difficult proposition in the past but with increased revisit times of satellite based sensors this could become a reality with appropriate investment.

The Solution

New services will require the development, integration and application of technologies such as real-time remote and proximal sensing, data fusion and predictive modelling. Techniques for manipulating different types of data (including legacy data) at different spatial and temporal scales, and developing algorithms that underpin decision making will be critical for the success of new services. These will include informatics techniques such as machine learning, pattern recognition and geo-statistics. These techniques will be used to de-risk food production using integrated soil, water, land and nutrient models to protect and improve soil and water quality to ensure sustainable crop production under variable environmental and agronomic conditions.

However, the success of these solutions will be dependent upon data availability i.e. collection of that data but also the freedom to access that data in a cost effective manner.

The Benefits

By improving geo-spatial models through data fusion and agri-informatics, robust and reliable agronomic recommendations can be made that are truly optimised to every part of the field, to meet a combination of economic and environmental requirements. As historic field data is accumulated the models will be improved and incorporate real-time inputs coupled with probabilistic forecasting to adapt to current and changing climatic conditions. Then this data could be used at a wider scale to consider other farm, business or regional requirements to address more fundamental questions such as where is the best location to grow different crops for water, disease or nutrient requirements, what are the trade-offs, is it sustainable?

Call to Action

There has been significant investment in sensor technology, developed both in the space sector and in-situ industrial sensor technology. However, new ways of integrating and modelling these data needs investment in research and education, to produce the next generation of data scientists who can make a significant difference in the agriculture sector, if we are to fully realise the potential of agri-informatics for precision agriculture services.

About your Company

Cranfield University is a business-focused, exclusively postgraduate University with a world class reputation for applied science, technology and management. The vast majority of our research, training and consultancy are industrially funded. As a result, our staff work in multidisciplinary, sector-focused groups. Cranfield has eight thematic areas with the capability to draw on specialist expertise in the following areas:

- Aerospace
- **Agrifood**
- Transport Systems
- Defence and Security
- Energy
- **Environmental Technology**
- Leadership & Management
- Manufacturing

Agrifood has been a key strategic theme at Cranfield University for over 40 years. We possess internationally recognised expertise across both domestic and international food supply chains from primary food production, inputs - soil, plants and water, through to point of sale, waste reduction and applied informatics. Our staff have expertise in water, soils and geospatial mapping, environmental risks & futures.

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

GI in the Health & Social Care Sector

Dr Edward Wallington | EsriUK **Matt Bull** | Public Health England (PHE) **Iain Goodwin** | Ordnance Survey
Matthew MacDonald | NEL Commissioning Support Unit

"One of the greatest opportunities of the 21st century is the potential to safely harness the power of the technology revolution, which has transformed our society, to meet the challenges of improving health and providing better, safer, sustainable care for all."

Personalised Health and Care 2020, National Information Board, 2014.

The Health and Social Care (H&SC) Sector in the UK has a significant challenge to satisfy its 'customer' base, some **60.6 million individuals** (ONS, 2014). This is a challenge at the best of times, but the world we live in has changed, and the NHS hasn't adapted fast enough, hence the resulting struggle to meet increasing demand, long term conditions, and an increasingly elderly population (NHS England, 2014), coupled with the increasing diversity of the population, funding challenges (mismatch between resources and patient needs of nearly **£30 billion** a year by 2020/21; NHS England 2014), and the desire and need to maintain and improve patient outcomes.

The ability of H&SC to meet demand and delivery pressure is underpinned by a number of recent strategies to make better use of data and technology. The Personalised Health and Care 2020 report states better use of data and technology has the power to improve health, transforming the quality and reducing the cost of health and care services (NIB, 2014). The authors' view is that geographic information (GI) with H&SC needs to be intrinsically linked to this agenda.

To date, the health and care system has only begun to exploit the potential of using data and technology at a national or local level (Personalised Health and Care 2020, NIB, 2014), and this is even more pronounced when looking at use of GIS and geographic information.

Further, the NHS needs to change how it approaches health care, as outlined in the NHS England Five Year Forward View (NHS England, 2014) which calls for integration and re-alignment of services, linked to population's needs. This transformation is inherently spatial, as analysis and assessment of options needs to take place based on where the population and current services are, and how these will change in coming years.

The use of geographic data and GIS technology should not be overlooked during this digital transformation as our health and our interaction with health and social care is intrinsically linked to where we live. GIS have the ability to transform how decision making is undertaken, by providing the data management, analysis, presentation and sharing capabilities that are required. The authors recommend that the H&SC community should engage the use of GI as part of their daily workflows, and the GI community need to support and work in collaboration to make best use of the technologies available to drive increasing patient outcomes, through informed decision making founded on a robust evidence base.

We envisage a future where the H&SC community use GI as part of their daily workflows – it is not explicitly seen as GI, it is just 'what we do'. We need a form of geographic enlightenment within H&SC where geography becomes part of our daily business and we become 'spatial by default' as well as 'digital by default'.

Problem/Opportunity Statement

The H&SC sector has the challenge to provide and deliver services to 60.6 million individuals in the UK (ONS, 2014), with care tailored to their needs. The population is increasing, as is the diversity of the population, the number of elderly, increasing long term conditions and a challenging funding landscape.

Some examples of the challenges being faced include (NHS England, 2014):

- Monitor, NHS England and independent analysts have calculated that a combination of growing demand, if met by no further annual efficiencies and flat real terms funding, would produce a mismatch between resources and patient needs of nearly **£30 billion** a year by 2020/21
- Long term health conditions, rather than illnesses susceptible to a one-off cure, now take **70% of the health service budget**. And as the 'stock' of population health risk gets worse, the 'flow' of costly NHS treatments increases as a consequence
- Diabetes UK estimate that the NHS is already spending about **£10 billion a year on diabetes**. Almost three million people in England are already living with diabetes and another seven million people are at risk of becoming diabetic. Put bluntly, as the nation's waistline keeps piling on the pounds, we're piling on billions of pounds in future taxes just to pay for preventable illnesses
- There are now over **3,000 alcohol-related admissions to A&E every day**
- Our young people have the highest consumption of sugary soft drinks in Europe
- About **700,000 people in England are estimated to have dementia, many undiagnosed**. Perhaps one in three people aged over 65 will develop dementia before they die. Almost 500,000 unpaid carers look after people living with dementia

The application of GI and use of GIS allows mapping and analysis of conditions to provide an insight into incidence, thus forming the basis for healthcare provision. This can also importantly be applied to health education and population awareness as the sector moves towards focusing on prevention rather than cure.

H&SC delivery structures have been in place for decades, and there is a need to change to be able to cater for changing requirements now and in the future - recent strategies provide this incentive and direction. There is a need to have a better understanding of demand and service provision so as to inform decision making, and this needs to be based on a robust evidence base. As indicated, GI/GIS can help with modelling options and solutions. The H&SC sector has a wealth of data; for example, the Hospital Episode Statistics (HES) data alone contains over 125 million admitted patient, outpatient and accident and emergency records each year, and this is just one source of data. This data needs to be utilised effectively to derive information and insight to provide decision makers with the understanding to enable them to establish requirements, to assess options and to plan the shape of future service provision.

Designing a better integrated healthcare system means gaining a better understanding of the community, in operational terms so as to assess options and instigate interventions now, and strategic analysis and option assessment to plan for future services. Processes and outputs need to be transparent, collaborative and informative. This influences and effects commissioning and service delivery. The way in which H&SC services are provided is inherently geographic and GIS have the ability to transform how decision making is undertaken, by providing the data management, analysis, presentation and sharing capabilities that are required.

This GI focus aligns with the Personalised Health and Care 2020 report (NIB, 2014) where the proposals include the ability to:

- Give care professionals and carers access to the data, information and knowledge they need… and comprehensive data on the outcomes and value of services to support improvement and sustainability
- Make the quality of care transparent – publish comparative information on all publicly funded health and care services
- Make England a leading digital health economy in the world and develop new resources to support research and maximise the benefits of new medicines and treatments
- Support care professionals to make the best use of data and technology – in future all members of the health, care and social care workforce must have the knowledge and skills to analyse, interpret and present information effectively
- Ensure that current and future investments in technology reduce the cost and improve the value of health services and support delivery of better health and care regardless of setting

> **Geographic information plays a key role in all our public health analysis, whether it is to accurately plot vaccination uptake for children or to understand where to target public health programmes. People understand reams of complex information much more easily and they can visualise the data if it is presented on a map.**
>
> **Colin Seward**, Public Health Intelligence Specialist, NHS North Essex - https://www.ordnancesurvey.co.uk/docs/case-studies/north-essex-os-maps-improve-health-care.pdf

History

The arrival of the Health & Social Care Act in 2012 has seen a dramatic shift in the application of geographic information (GI) away from Primary Care Trusts (PCTs) and Strategic Health Authorities (SHAs) and into Clinical Commissioning Groups (CCGs) and NHS Trusts. There is growing recognition of the power of GI to visualise and analyse the wealth of complex health data in new ways, providing decision makers and stakeholders with new insights into the needs of their communities. One of the largest determinants of your health is where you live and work – understanding location is therefore key to understanding the health of communities and target services and interventions effectively. And increasingly the NHS is looking to make innovative uses of health data, through web tools and mobile apps. The interoperability and reuse of health data is therefore a key focus for the NHS and understanding is growing within key Arms-Length Bodies (ALBs) within the NHS of the benefits of embedding geography to support decision making, effective data sharing and innovation across health and social care.

The application and benefit of GI

With such a broad range of organisations and responsibilities and constant changes to structure and staff within the NHS it is not straightforward to summarise how the NHS benefits from using GI; and the sheer size and fragmentation of the NHS makes identifying best practice of GI adoption challenging. Examples of GI applications tend to be for specific purposes and part of a wider programme of work making it difficult to find an explicit link between using GI and a citizen benefit of improved health outcome.

But where you do find GI delivering benefits, understanding return on investment is absolutely key to developing and sharing best practice to grow the market. The following attempts to summarise the market by segmenting:

Ambulance Trusts

GI is critical to emergency response and is embedded within 999 Computer Aided Dispatch (CAD), Patient Transport and navigation systems. Up to date and accurate mapping, addressing and road network data is essential in deploying ambulances efficiently and supporting their 8 minutes response time targets.

Clinical Commissioning Groups (and Support Units)

Since their creation in 2012 the uptake has been slow but steady with PSMA membership now at 74 of 211 (34%). Some CCGs have chosen to develop in house GI capability; others access GI intelligence via their Commissioning Support Units (CSUs). Many commissioners want the intelligence to be gained from GI, without the overhead of managing data, and increasingly spatial analytics is forming part of Business Intelligence tools.

The key value of GI to commissioners is its power to visualise complex information and provide an easy to understand evidence base to support decision making across a wider group of stakeholders. Typically it is being used to understand the relationship between the service location and the needs of the population to ensure equal access to services and targeted interventions. It is also used to model demand for services, support contract negotiations with providers and improve interactions with the public.

For example, in the South West, travel time and demographic analysis has been used to ensure a stroke service remained open by demonstrating a significant adverse impact on patient and emergency travel.

> Hull spends £800 000 a year on the programme but saves more than £8 million by reducing teenage pregnancies and preventing children from going into care, both of which have huge cost implications. Mapping is critical to the process, not only to ensure that contraception services are located in the right place but also to help communicate complex data to different audiences and to provide evidence that the strategy is effective. The visual format means that commissioners, councillors and other partners can see at a glance where services are having an impact and providing value for money. We plan to use the same methods in other local health campaigns to reduce smoking and obesity levels.
>
> **Gail Teasdale**, Integrated Services Manager, Children and Young People's Services, Hull City Council - https://www.ordnancesurvey.co.uk/docs/case-studies/hull-reducing-teen-pregnancies.pdf

NHS Trusts (Mental Health, Acute, Community)

Since the arrival of the PSMA the numbers of Trusts benefiting from GI through PSMA membership has rocketed from 5 to over 130. Typically GI is used within Business Intelligence (BI) and marketing teams to understand patient needs and inform strategic planning. But it has potential to break out of the BI silo to do much more for a trust, with examples of GI used to support estate management, asset rationalisation, marketing and patient transport services. For example, in South Devon, they have invested in a system using accurate addressing and travel time to help them better understand service offerings to meet the growing demand of an ageing population with increasingly complex health needs.

Public Health

Mapping and geographic analyses are used across Public Health England's (PHE) functions to better understand health information, including: the risk from and spread of disease; the ecology of vector borne disease; radiation, chemical and environmental hazards; emergency response; accessibility of health services; and identifying, understanding and finding solutions to reduce health inequalities. More widely in the public health community GI is essential in responding to public health challenges and making targeted and effective interventions; from ensuring sexual health services are in the right place for teenagers in Hull, to modelling correlation between fast food outlets and childhood obesity in Birmingham. Understating where public health challenges exist, and sharing this analysis with commissioners, is key to ensuring NHS services are in the right location to improve patient outcomes. GI also underpins a myriad of free web based public health atlases, on anything from cancer to nutrition, to help public health professionals understand the challenges in their communities.

Arms-length bodies

Most people think of the NHS as hospitals, ambulances and GPs, but there are also a range of national ALBs that benefit from GI. The breadth of application is huge, from underpinning emergency planning, to defining CCG boundaries at NHS England or supporting the management of the old PCT estate at NHS Property Services. But **key to the growth of the NHS GI market will be the capture and integration of geography within health data**, to enable the type of reuse by local bodies described above.

The Solution

We envisage a future where the H&SC community use GI as part of their daily workflows – it is not explicitly seen as GI, it is just 'what we do'. We need a form of geographic enlightenment within H&SC where geography becomes part of our daily business and we become 'spatial by default' as well as 'digital by default'.

In order to realise the benefits of a geographic approach the H&SC sector must work hard to spatially enable its H&SC data. At present H&SC data is not always collected with suitable geographic identifiers and that needs to change. PH&C2020 (NIB, 2014) provides a significant opportunity for that change and one that we must get right. It has been agreed that NHS number (with you from birth) will be universally adopted as the key to link and share clinical data – in other words that gives us the 'who/what'. What we need to do is ensure that a geographic locator (e.g. a person's address/UPRN) is linked to NHS number to give us the 'where'. From this, all our health based data from the individual level to the aggregate level can be enriched with location. When we know the locations of patients as well as the locations of H&SC services we can geographically interrogate how the population is accessing the H&SC system and use that information to inform better, more efficient and responsive design. It should be also be noted that although NHS number will be used to link data within H&SC it is not widely used outside of that domain. Linking NHS number and UPRN will provide the opportunity, governance permitting, to link H&SC data with data held in other government databases that store information at the address level. It's a fairly simple idea that could have a radical impact on our ability to use geography within health and social care.

We have the 'who/what', via NHS number, we just need the 'where', via a geographic locator, such as the UPRN for addresses. This then enables "sharing and management of information at a citizen level, scaled up to a population level to effectively understand the holistic nature of integrated care and the many confounding factors that affect health and social care outcomes and a person's resilience to improved wellbeing" (NIB, 2014).

There's no doubt that more health and care data will become digitally available as part ofPH&C2020 agenda and standards are recognised as an important part of that. We need to make sure that geography is part of that standards discussion. Having geographically referenced health data readily available via standards based API's is going to enable the H&SC community to not only get that information faster but also be more responsive.

As well as improvements in data collection and interoperability we need to improve our use of GIS technology and suitably train our workforce to make use of geography. Again, this is in line with the PH&C 2020 report (NIB, 2014), that highlights that health and social care needs to learn from the application of technology in other sectors, and that this includes an up-skilled workforce that's not afraid to use technology. It is worth acknowledging that the ability to use GIS should no longer be seen as an exclusive domain for specialists as like many other technologies GIS is becoming more accessible and easier to use, largely through web and mobile access points.

Being able to make wider use of geographic data and technology will support a range of activity, including:

- **Operational insight** – what and where is demand currently?
- **Strategic planning insight** – what and where is demand likely to be?
- **Transformational change option assessment** – what can I do and what impacts?
- **Use of 'big data'** to create information and develop robust insight

For example, the need to change and focus on targeted prevention and treatment highlights a simple question – where to target? Where can quick wins be realised whilst initiating longer term benefits. A geographic approach can help. Other sectors (e.g. environmental, government, defence, commercial) have used a GI-focused approach, and the H&SC sector needs to learn from this. Learning and benefits from other sectors can be fast tracked – many of the approaches are the same, just a different context – e.g. optimising routing of delivery vehicles is very similar to routing of ambulances or H&SC field based staff.

Geography, GI and GIS can support the transparency and patient engagement agendas by taking a geographic centred approach to making information more readily available. An easy to access and understand format will allow a better public appreciation and understanding of health & social care activities and services. The ability to visualise on maps and through spatial search for health facilities and other resources that impact on health (e.g. access to green space, exercise facilities, healthy foods, support groups etc) will provide an invaluable and useful resource for practitioners and public alike.

The Benefits

The application of GI within the H&SC sector is diverse across the range of national, regional and local bodies planning and delivering health care. GI is an essential tool to understand the needs of communities and improving health outcomes, and awareness of the intelligence to be gained from GI is growing and becoming accessible to more areas of the NHS. Since the PSMA, we have seen a rapid uptake of GI by the NHS, particularly by providers and some commissioning areas, but understanding of the power of GI is still in its infancy, particularly at senior levels, and its application tends to be silo'd or used for specific purposes. In addition to the traditional use of GI for epidemiology and resource planning, we are starting to see the adoption of spatial data for more strategic uses. There is a huge drive to make innovative uses of health data through effective data sharing and reuse, particularly within mobile aps where understanding location is essential.

> **While the determinants of obesity are complex and interrelated, social and environmental factors clearly have an influence. The city has a large number of hot-food takeaways close to schools and local centres. The use of maps helps us to accurately describe where they are located and to tackle their spread.**
>
> **Dr Iris Fermin**, Head of Public Health Information and Intelligence, Birmingham Public Health - https://www.ordnancesurvey.co.uk/docs/case-studies/nhs-birmingham-mapping-the-way-to-good-health.pdf

Key to this will be 'geo-enabling' health data by embedding geographic references, like the Unique Property Reference Number (UPRN), centrally or at point of capture and sharing GI best practice and ROI. The URPN was recently made available on a royalty free and open basis and its use is advocated by the Office for National Statistics (ONS) and the Government Statistical Service (GSS) Geography Policy, which states that "when the data being referenced relates directly to a real world object (for example a building or section of street), they should be linked to these objects by its identifier. For addresses the identifier is the Unique Property Reference Number (UPRN), which uniquely identifies each address on the Great Britain's national address gazetteer, AddressBase" (ONS, 2015).

> **Data available to us through the PSMA and investment in MIS's C3 CAD system has enabled Patient Transport Services to improve our understanding of the efficient allocation of resources to help us meet growing demand for patient travel in South Devon.**
>
> **Andy Knowles**, Transport Services Manager, South Devon Healthcare NHS Foundation Trust - https://www.ordnancesurvey.co.uk/docs/case-studies/nhs-south-devon-healthcare-foundation-trust-deliver-pts.pdf

The future of the NHS is a more patient centred approach to service delivery and giving patients more control over their health care – the need to understand the relationship between patient and service locations will only grow.

The use of GI in H&SC workflows would help to better utilise data, increase understanding, inform decisions and drive improvement in patient outcomes and financial efficiencies. Using a geographic centred approach would allow end to end data capture, analysis, reporting, presentation, and sharing aligned to patient outcomes and enabling efficiency gains to be realised. The ability to understand patient flows and service delivery with geography, within a local authority setting, a CCG boundary or nationally, gives the ability to scale from the 'big picture' to individual pathways and a new perspective on 'the way we work'.

It could help us make decisions in near real time on where to allocate resources and it could allow us to detect and respond to outbreaks more quickly, as well as enabling us to identify those geographic areas of health disparity more effectively and to then tackle those disparities. GI could help us to better rationalise the NHS, taking into account geographic differences in population demands/needs for H&SC and target our investment and resources more effectively.

Some example pathways where GI can support include:

- Prevention - analyse, model and assess cohorts of population to identify 'at risk' groups, allow early intervention to prevent/reduce need for primary care.
- Medicines management – assess what types and brands of medicine are being prescribed by GPs, look at cost benefits of alternative drugs/therapies, target cohorts of medicine users that regularly attend hospital.
- Benchmarking – assessing and analysing performance across providers, taking into account number of referrals, patterns of attendance, and supporting resource allocation to enhance pathways.

> **Thanks to OS data, the social work teams have not only saved £74k in costs and staff efficiencies but now have more time to work directly with families. The mileage saved supports our green agenda, and we'll be rolling this out across other services in the county.**
>
> **Denis Payne**, GIS Manager – Cambridgeshire County Council - https://www.ordnancesurvey.co.uk/docs/case-studies/savings-to-cambridgeshire-social-services.pdf

The ability to analyse operational data (attendances, admittances, prescribing) by hospital, GP Surgery or CCG, combined with contextual data (demographic, deprivation, for example), allows a greater insight to support robust evidence-based decision making. A range of analysis and visualisation can be undertaken to inform decisions, and this analysis can include: hotspots of activity, illness or prescribing; drive time and service area analysis, real-time tracking, patient flow analysis, service redesign, and dashboards for performance monitoring and reporting.

With the £30bn funding gap needing to be resolved, along with an increasingly patient orientated approach and focus on prevention rather than cure, there is a need to:

- Focus resource on prevention and better lifestyle
- Align healthcare provision with where need exists
- Identify specific programmes where GI can add value – e.g. GI applied to Care pathways

Call to Action

The use of GI is wide spread in many sectors, and H&SC can learn from these to drive usage and benefit. Other sectors have many similar challenges that have been identified and tackled; for example, retailers (demand management / store portfolio management), customer care (end to end process workflows), and insurance (predictive analytics). This provides an opportunity to learn from these experiences and good practice, and apply these to H&SC.

H&SC has a commitment to continuous improvement, and what better way to progress this than by making incremental steps through use of GI to identify and prioritise activity. GI can be used to assess what activities and interventions have worked and what hasn't, and where, and then use this insight to correct and adjust and to apply to areas where gains can be made.

Aligned with the authors proposal for H&SC to utilise GI effectively, is the need to develop the GI skill base within H&SC. The use of GI and GIS can take many forms from deep analysis using desktop and server based tools, web based mapping and analysis, integration with business intelligence and enterprise tools, and presentation in dashboards and tailored apps. When considering use of GI there is a need to consider the end user workflows and appropriate application of GI, and the training needs associated with this.

> **OS data helps keep hospital open for stroke patients "This is the biggest project we have been involved with in the last few years, in terms of impact and influence GIS has making.**
>
> **Trevor Foster**, SWCS GIS Manager - https://www.ordnancesurvey.co.uk/docs/case-studies/nhs-sccg-keep-stroke-services.pdf

Upskilling should not be seen as a barrier, it should be seen as an opportunity to embrace your workforces, enhance their working, and ultimately allow more focus on patient outcomes.

About the Authors

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Iain Goodwin is the PSMA Relationship Manager for Health, Culture, Media and Sport at Ordnance Survey. Iain has been working for 7 years with all areas of the NHS to help them understand the importance of location intelligence in support of planning and delivery of effective healthcare. Iain understands the benefits of using GI to the NHS and works to identify and share examples of best practice.

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The opinions expressed in this article are the author's own and do not necessarily reflect those of Public Health England, Ordnance Survey, NEL Commissioning Support Unit or Esri UK Ltd.

- How do you decide where to focus efforts?
- Are you using data to best effect? Are your spreadsheets telling you what you need to know?
- Take a look at GI use in other sectors – how could this be applied to your work to fats track patient benefits and efficiencies?
- How can the AGI support awareness raising and skills increase in use of GI in the H&SC sector?

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

The Only Constant in Life is Change: A View on the Future of Remote Sensing of Satellite Imagery

Andy Wells | SterlingGeo

"If, by the time you have finished reading this paper you are not planning to consider the impact of remote sensing and satellite imagery on your organisation's primary purpose, I have failed."

"In 348 months of working with earth observation, I have never experienced the sense of opportunity associated with the industry as I have in the last 3"

It is fair to say that the use of satellite imagery for earth observation remains a growing and vibrant segment of the geospatial market. From defence to natural resources and environmental management, many government bodies, commercial organisations and academic institutions continue to exploit satellite imagery for a wide range of purposes. However, for most, the value is limited, the outcomes are inaccurate and the cost prohibitive. It is not operationally implemented by most and until recently, progress has been measured but slow.

Unless there is a specific requirement that can only be met by satellite imagery (poor existing mapping, the imagery can be manipulated to identify objects not visible to the naked eye or you are looking on a regional / global scale) you are unlikely to consider satellite imagery. Why? There issues are numerous and challenging:

1. Issues of cloud and overpass time limit availability within the time winder you require.
2. Imagery remains costly and the approach to purchase constraining. Eg having to buy the whole image / scene when only 20% is required.
3. Access is difficult with specialist formats still rife and catalogues difficult to understand for the non-specialist.
4. The need to purchase specialist software to maximize the value inherent within the data is compounded by the staff costs, training and support.
5. When you have surmounted all of these issues, you often find yourself with just more data, or at best, a partial answer to your problem requiring further manual intervention / editing before the true value is created.

How have we got here?

The history and development of remote sensing is well known and easily available (I can highly recommend the following for more information http://www.sciencedirect.com/science/article/pii/S0924271614000720). For this reason, I will not dwell on what has gone before. It is fair to say that there has been an ever increasing improvement in resolution (from 50m to 50cm), resolution (from 3 bands mimicking the human eye to 10's of bands including radar) and availability (from twice a month to almost daily). However, developments in data alone is not enough. Yes the software has improved out of all recognition with the average cost of the hardware required dropping by a factor of 30 within the last 20 years. Furthermore, compression routines such as ECW, MrSID and JPEG have reduced the "big data" issues of processing and management. And yet, the uses / typology of organisations exploiting the data (other than just visual interpretation) has remained relatively static (**figure 1**).

So what has and what will change

Data Availability - Where do I start? The statistics are staggering:

- Satellite failure dropped by a factor of 3
- Longevity of the average mission increase by a factor of 2
- Average number of satellite launches increased by a factor of 6
- As many satellites being launched by commercial companies as governments
- Cost of launch 100 times smaller than 10 years ago
- Planet Labs producing a complete image of the surface of our world, every day, at 3-5 meters/pixel in the near future
- Digital Globe's archive passing 70,000,000,000 Mb of imagery available on demand, including the first 50cm single image of Africa ever created from space"
- ESA launching the Sentinel series of satellites – this will make available free optical and radar imagery
- Airbus, Urthecast, Deimos, Earth-i, Blacksky, Landsat, Geofen, the list is just too long for this short summary (**figure 2**)

> If we combine every provider at every resolution then within five years it is likely to be feasible to image every square meter of the globe every hour of every day.

Data Access – Previously, users had to fight with the individual cataloging systems of each provider. Therefore, as an independent user just looking for an image of a specific area, you have to fight your way through multiple sites. In the next 5 years, this will change drastically. Already some of the core issues are being resolved as increased competition reaches the market. Vendors are reducing the rice of imagery as it commodities, amending the single image approach to more "price per sq km or even pixel".

Strategic partnerships are being formed between the data providers and those offering the processing software, minimising previously referenced issues (exemplified by Airbus' recent press release regarding a content sharing programme with Hexagon Geospatial).

Furthermore, whilst developments in seamless ingestion into the analytics software have improved, this remains far from the optimum solution. The aforementioned press release indicates a seamless approach whereby the software will search and consume data automatically with users only having to provide the area of interest. This proactive monitoring approach will evolve so that users no longer mind which satellite is used, they will merely pay for the appropriate price for the relevant service.

> The combination of the Satellite Applications Catapult's creation, the UK Space Agency's focus and the European Sentinel Missions has revolutionised UK government thinking on the application of earth observation to smart country management.

Business analytics – We all know the effect that the cloud is beginning to have on our approach to data access, storage and management. The next stage is coming. Rather than operate the software locally, the ability to create specific analytic engines, upload onto the web and seamlessly (technically, legally and commercially) connect to the data is coming. This removes a large component of capital investment for most users and generates a direct link between the cost and benefit from specific applications. Furthermore the industry is learning from way that technology is consumed across the wider commercial landscape, creating the first "app stores".

With the ability for end users to discover the app that suits their need, pay on demand and receive the results automatically, the opportunity for use across existing and emerging markets is vast. There are likely to be many vendors delivering this new approach in the coming years, however Hexagon's recent launch of Smart M.apps indicates the rapid direction of travel towards a seamless approach.

Knowledge visualisation – all of the above is immaterial if the outcome cannot be consumed by the end user in a form that is immediately understandable. So perhaps the biggest change that will emerge within the world of remote sensing is a sense of realism. As a technology it is only part of the solution and, if combined with other geospatial data, the real potential will be realised. Rather than the creation of just another image or map, what happens if the "system"

- Emails the desk officer to confirm a new image has been captured of the target area and nothing significant has changed
- Sends a message to a field operative confirming that a specific object has been found and provides a hotlink to a streamed / compressed image to allow immediate visualization of said change
- Provides a single update to a bar chart showing the change that has occurred in the last month
- Creates a series of graphics in a webview that interactively change as the user explores the new information
- Generates 100's of text messages notifying staff or even members of the public of an event in their area of interest

And so to the conclusion

We are at the beginnings of a perfect storm within the earth observation industry. The heady combination of more data that you will ever need; the ability to seamless access it based only on what you need as an organisation; the power to process it on the cloud and finally; the opportunity to access the outcomes in a form that are immediately understandable has never occurred in the history of the industry.

Powered by government and industry investment at levels never previously experienced, the pace of change is almost daily. Monitoring of environmentally sensitive areas, coastline mapping update, pipeline protection, illegal build analysis, insurance risk mitigation, border security, greenspace loss in the built environment – the list goes on of pilot programmes emerging from this combination of change referenced above. Yes, all of these applications have been previously undertaken using earth observation, but at a cost and pace that just does not suit the users. This has and will change irrevocably in the next 5 years.

SterlingGeo

SterlingGeo is a UK company focused on enhancing the ability of governments, commercial and academic organisations extract knowledge from geospatial data. As a strategic partner of Hexagon Geospatial and Gold Partner of SAFE software, we offer a wide range of solutions to client requirements, especially for the ingestion, management, analysis and presentation of imagery.

Figure 1 - A pair of Doves from the Planet Labs Constellation. Photo: NASA

Figure 2 - Berlin Air Show. Copyright: Airbus

Figure 3 - Showing flooding using Digital Globes hires capability. Copyright Digital Globe

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

The Future of Cartography

Christopher Wesson | Ordnance Survey

"The communication of geospatial information is always evolving and remains forever relevant. New technologies demand new methods and perfection will never be attained."

As Georg Gartner, President of the International Cartographic Association (ICACI), pointed out, 'We've become very good at the mechanical aspects of map-making. The data gathering and representing that data using colours and symbols.' But map-making is about communication, 'something you can always do better at'.

In the past decade we have witnessed a shift from standardised to personalised mapping. Whereas a map used to be printed to a set specification, it can now be something bespoke and highly flexible that you can carry around on your smartphone or tablet.

While I expect this area to continue to grow, there is still a need for more traditional mapping as well as significant growing interests in geospatial science from other markets and business sectors. If we try to predict cartographic work in 2020 we have to assume a significant proportion will be in the latter.

Discussion

Web cartography

Since the 1990s, in parallel with the evolution of the web, 'cybercartography' has grown to lead cartography in terms of audience numbers and by 2020 it is predicted that 50 billion devices will be connected to the internet. Paraphrasing from van der Maarel, 'Anyone with a web-connected device can access maps for the entire earth in an instant.' Better known today as 'web mapping' the field is dominated by Google Maps who, according to Australian company Builtwith, are responsible for 89% of websites that use mapping technologies. As advertised by MangoMap, 'Interactive web maps are now the method of choice when it comes to publishing and sharing geodata.'

In the consumer space we might expect to see Google continue to dominate web mapping. Crowley once said that social maps mean the end of scribbles on scraps of paper. Yet, as suggested by van der Maarel, these maps aren't as personalised as one might think. You are still conveying the message of whoever designed that map engine. So there is definitely scope for different engines for different audiences, such as *OS Maps* which couples web-based device maps with our proud tradition in exploring the great outdoors.

Also, within the geoinformation industry, solutions for geo-professionals such as ESRI's ArcGIS Online are definitely growing and at some pace. With map creation and even GIS software moving onto the web, then data products are likely to increasingly follow suit. Perhaps rather than ordering data and then loading data into a GIS, the starting point will be a styled view of data products from which you can 'grab' the data, a bit like OpenStreetMap but using newer techniques. This might not happen in five years, but foundations may well be put in place by 2020.

So while Google Maps and the like will continue to dominate the general-use marketplace, here at OS we are looking into more efficient ways to supply data and information and by 2020 a better way of serving this information to our customers over the web is highly probable. We are also likely to continue 'what we do best' and create cartographic products, increasingly digital offerings through web and mobile devices (including wearables), tailored to core audiences such as outdoor activities (as is the case with OS Maps). Our web map services will be offered in a range of more-tailored stylesheets with greater emphasis on user-centred design and interactive experiences. However with these releases we are likely to expand our geographical area of coverage, initially from Great Britain to the United Kingdom by working with our Irish and Northern Irish counterparts and then to Europe by working with EuroGeographics and other national mapping agencies across Europe, for example with the realisation of the European Location Framework. This is driven not by a desire to take on Google or Bing at their own game but more so the needs of our ever trans-international customers whether they be big industries (e.g. utilities), corporate enterprises, new markets or outdoor-activity consumers.

New data-centric markets

Geographic data (geodata) comes in many flavours. Whilst topographic products are ideal for cartographic display, many other datasets are more difficult to visualise. Our presentation at the 2015 International Cartographic Conference will be on the relevance of a cartographer in a data-centric marketplace.

In 2012, Lantmäteriet, the national mapping agency in Sweden, suggested that 'the market for geodata was growing by 10-30% per year'. Good understanding of geodata, successful marketing of geodata and engaging reporting via new-media all depend upon the presentation of the data. Well-presented geodata, just like good cartography, 'communicates its message clearly and provides a pleasing user experience'. The nature of geographic and geospatial data is such that its visualisation requires specialist skills. Someone that understands geodata file formats, GIS and the experience of a user; all in addition to general design and visualisation skills and knowledge. Someone who can understand, manipulate and interpret the data as well as style it masterfully to tell a clear story.

It is therefore our conclusion that as these fields continue to grow, visualising a company's assets, proving projects by geodesign or making location-based economical decisions will all involve a certain and arguably growing level of cartography. Businesses not only rely on geodata for the precise location and management of assets but the cartography to communicate intelligent information to decision makers.

Whilst this is firmly with us in the present, as more and more businesses acknowledge the value of geographic information in relation to their own data, I would expect this theme and in particular the use of cartography to understand geodata to continue to be an area of growth into 2020 and beyond.

Open and collaborative future

In the words of our Chief Executive Nigel Clifford, 'No company is bigger than the ecosystem', so OS has opened itself up to people with a clear focus on location to work alongside us to collaborate and innovate with the creation of the Geovation hub in London. Skills from across OS are available to users of the hub and hopefully by 2020 more users will be looking at applying cartography to their innovations. Cartography as a whole is increasingly shifting towards a need to work with other professions. As Gartner puts it, 'The successful development of modern cartography requires integrated, interdisciplinary approaches.' It is fitting that our expanded audience as mentioned earlier comprises a wide range of industries from utilities companies to insurance and finance sectors.

On a similar subject, I can imagine by 2020 an increased democratisation of map technology with more open tools for more open or web-based software to enhance the rate at which we can find solutions to our problems and remove access barriers.

Single-handed mapping

There is a growing consumer requirement to navigate around the urban environment with a less attention-consuming form of map.

The buzz around Augmented Reality (AR) seems to have faded away but HERE continue to push the geographic use of this field forward with the introduction of *LiveSight*, a 'heads-up' solution for finding places of interest using a device's camera display. AR remains a niche market, perhaps even a niche technology, but that is largely because to commercialise it the device specifications and mapping both need to be more accurate.

As mobile technology improves it will be down to data cartography to develop more accurate and up-to-date underlying mapping as well as cartography to aid the visual integration of third party datasets. This could well be a feature of 2020 cartography.

Spawned from the same era was the concept of indoor mapping. Intelligent maps of indoor spaces such as shopping centres or conference venues. In a similar vain to AR, indoor map requirements are increasingly focused on ease of use. At OS we produced a mobile application (app) for this year's Digital Shoreditch creative technology festival. As mobile and app use continues to grow, and technology advances then there is a good chance of another indoor map app by 2020. By 2020 indoor location accuracy is likely to be improved which will really open the door for greater development.

Point Clouds and 3D

With the increased adoption at OS of point cloud technologies, which are expected to be a significant data source by 2020, we are likely to want to influence the user access points of this with cartography guiding the appearance and communication of this information.

Geovisualisation

Rather than admire the work of developers and innovators in the world of data visualisation, we could well begin to produce more maps of both human and mechanical activity; human activity in the sense of how people interact with their environments and behavioural patterns (important information for retailing businesses for example), and mechanical activity in the sense of devices interacting with one another, with humans and with the Internet of Things.

Real-time mapping

Live and time-influenced route data could become increasingly expected on OS network products. Our road network has already started taking on board third party information such as routine time-based restrictions. One can only expect this to continue to become a requirement for some and probably an increasing number of customers. As our publication platforms continue to modernise live changes and live updates could become more realistic avenues to explore.

Machine learning: when is a map a map?

Visualisation is important to human decision-making whether it be deciding which way to turn in navigation or an economic decision like deciding where to base a business. Increasingly our cartographic skills are being used to create automated processes at OS for map creation in the form of generating multi-resolution database(s), influencing and implementing rules for automatic generalisation and production and publication of cartographic stylesheets to automatically apply a pre-defined style to our map data. With machines (computers, robots and other devices) there is a lot of work being done around machine-based decision making, and as cartographers we should try to influence the machine processing of geodata, essentially providing a map that the machine can read without ever being visualised in the human way.

Achieving what we already said we were going to do!

Last but not least, it is almost certain that the future in 2020 will see us all implementing some of the cartographic advances and improvements that we have already announced and showcased. Multi-resolution data projects, better source data, better content data, better product data and so on. We know the theories of generalisation and in principle how to put them into practice but the experience of OS, and as reported by many other mapping agencies, is the need to improve upon the source and content data feeding into our product development systems.

Issues

Issues we might face include keeping pace with the collection and handling of data. For example Big Data and the Internet of Things: the growth of sensors giving us new data every fraction of a second. As Gartner said, 'We need to make more and more efforts to deal with all that data in an efficient sense, mining the relevant information and linking and selecting the appropriate information for a particular scenario.' The world is an ever-changing place. As the volume of captured data continually grows, for example capturing detailed road furniture for autonomous vehicles, it becomes increasingly challenging to keep it up-to-date. I would add that the cartographic visualisation of this information becomes as complicated as its management.

3D cartography also has a number of issues around interpretation and representation. Our own 3D experts consider it almost impossible to visualise true 3D due to both displays and the nature of the third dimension. Cartographers have in the past mainly considered 2.5D when talking about 3D. Automatic text placement already represents a significant amount of challenges to the near future and in three dimensions the issues around text only increase. By 2020 the technologies will have matured but we will still be figuring out how to perfect 3D cartography both in terms of data and representation.

Algorithms for automated cartography are good and getting better but there are still things that the human brain is a lot better at (Miller 2015).

Summary

At a high-level, cartographic principles and common portrayals are understood but all aspects of method of communication can be improved and the advances in technology expected by 2020 alongside a greater understanding of new market requirements will underpin a new growth in cartography.

What we can expect from the near future is that the right information is available for the given context and presented in a suitable format with the utmost of efficiency.

What is important to stress is that in 2020 we will still need to have human input into our automated cartography whether that be visual and tangible such vector-based products, web maps or mobile apps; or something less transparent like device navigation or machine learning.

'With location you can pull together everything in one place and that helps us make sense of how the world works' (Shearman, 2013). I hope that by 2020 we will be able to make even better sense of how the world works and I am sure that cartography will be at the centre of a lot of that.

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THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Open for GeoSpatial

Simon Wheeler | AGI Northern Ireland

"Open does not necessarily mean free, it is the Freedom to use as we see fit without restriction"
Steve Feldman[1]

Back in the late 90's, when new to the GI arena, I was exposed to the silo'ed nature of government. Data was hard to find and people didn't really want to let go of it. These were the days of digitising tablets and cabinets of paper documents. However, there were some attempts at data sharing in Northern Ireland where data was shared under the radar – horse traded and swapped on floppy discs between different Government Departments.

Fast forward 15 years, and whilst we have moved on in many areas, there are still issues where we have much work to do. A key kick-start for many around the notion of data sharing and publicising it was the INSPIRE directive (though this does not necessarily fit into the category of true Open Data) – all of a sudden, excuses such as it was too costly, or the data was 'Ours' no longer carried weight. The legal framework now meant there were greater financial penalties from not complying.

However, despite the levers of INSPIRE and the Public Sector Data Initiative, data still exists in silo's and (from experience) can be hard to access, though inroads are being made. Are Open Standards as relevant now? With people's ever increasing desire to access more data easily and quickly, it is imperative that the architecture is in place to facilitate this. These are being put in place with http://Data.gov.uk, http://open.canada.ca/en, https://salforddataquay.uk and https://data.glasgow.gov.uk as good examples. We just need to encourage more to publish their data on these sites. Open does not need to be confined to data however, and Open Source is also seeing greater relevance as both public & private sectors look to cut budgets through what is seen as Free Software.

Before exploring these issues further it is useful to clarify what the term 'Open' actually means. The Open Data Institute cites Open Data as "that which is made available by organisations, businesses and individuals for anyone to access, use and share. It has to have a licence which says it's open (without it the data cannot be reused), and the licence must also credit whoever is publishing it, and people who mix the data with other data must also release the results as open data"[2]. The same principle would apply to Open Source Software.

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With 'Open' now a widely accepted concept amongst the geospatial community, the challenges facing us are how do we maximise the use of Open Geospatial? What are the barriers to this? What mechanisms do we use to create value around Open Geospatial? Where have we progressed and what lessons do we need to learn going forward?

GeoBig5 – Open for GeoSpatial

The idea of the AGI Big 5 event on Open GeoSpatial was to bring together key players to discuss the issues around Open Source, Open Data & Open Standards in Open Debate in Belfast in 2014. Chaired by Bill Roberts of Swirrl (Linked Data), he led a discussion with a panel of influential players (John Carpenter of OSGB, Denise McKenzie of OGC, Anne Kemp of Atkins & AGI, Eamonn Doyle of ESRI Ireland, Dr Tracey Lauriault of National University Maynooth, and Eoin McFadden from the Department of Enterprise, Trade & Investment NI) to discuss the issue.

The debate can be followed here (https://vimeo.com/95262229).

John Carpenter discussed the idea that one of the big drivers for opening up data is that it will lead to huge returns to the economy through greater use by the private sector. It was however suggested that the figures given by McKinsey of $3-$5 trillion[3] to the economy was just too big to be believed and this was probably more damaging to the argument through being unbelievable. However, many of these savings are wider societal savings, e.g. through passengers saving time due to better transport information being made available. There are however plenty of studies where the case for open data has been proven and these can be found in papers such as the Shakespeare Review (2013)[4], and The Open Data Economy (CapGemini)[5]. The Shakespeare review cited direct savings of £1.2 billion

Many of these savings are through incremental savings. Many of the numbers relate to efficiency within Government through Governments sharing data, and removing the data silos that existed a decade ago. Though there is the wider benefit of open release for the economy, the high value comes from greater sharing within Government.

Anne Kemp suggested it was perhaps easier to show the negatives where Open isn't happening. Within BIM (Building Information Modelling), there is a reliance on the sharing of data in the information lifecycle, but it isn't always happening as the open standards aren't always there. This has led to issues where two organisations have competing strategies at the same location. She cited an example of Network Rail and the Environment Agency with different flood strategies at Dawlish in Devon during the 2014 winter floods without an open strategy which effectively cancelled each other out.

A question was raised of Open versus Free. Does it have to be Free to be Open?

Eoin McFadden suggested all government data does not have to be Open, and not all Open data has to be free. We need to decide what is of greatest benefit to the region. However there may be data that isn't Open that is of significant value to improve public service if properly utilised. Maybe a different model should be used whereby if it is free and Open, then there should be no expectation of a service, and a separate contract for service is where the revenue stream comes in.

Anne raised the issue of 'trust' and that to be truly Open and transparent this was required. So looking at the metadata, how would we quantify trust? Could we have a '5 Star' rating on trust around the quality of Data? Denise McKenzie suggested that this process may already be there through feedback and peer review of networks. Trust is created simply by someone who is trusted giving a high degree of satisfaction with a dataset. She said that many of these buzz words around transparency, trust and Open-ness have been in-grained in organisations such as OGC for over 20 years.

There is also an analogy between the process and the data. Policy making is messy. Making data is messy. If we don't have vibrant debate, then we don't make good policy and likewise we need to get the data out so that it can be refined and better understood. However, we need a mature environment which understands that data is messy, and if this environment isn't there, then people will not want to expose their data.

Quite a lot of data could be seen as exhaust data (John Carpenter). Some organisations such as mapping organisations and the Met Office are in the business of creating data, whereas for many other organisations the data they produce is a by-product and as such, the data are synonymous to the exhaust fumes that are a by-product of a vehicle and therefore could be coined 'exhaust' data. It still has significant value, but it's different; it just flows out of the process. For example a Health Authority keeps people healthy and as a consequence it creates data which is just a by-product – it could well be very valuable (or maybe not), but it isn't the sole purpose of the exercise. Conversely, there is reference data which is the sole purpose of the data collection process. There is a cost associated with this, and the user may well expect a level of accuracy because of this. John Carpenter also hypothesised about a two tier infrastructure where the reference data and some of the important exhaust data might need to be cleaned as part of an Information Infrastructure, with the rest of the exhaust data just pushed out with a caveat.

So where do we go now?

Whilst large numbers of government data sets are being released, there is also a desire to get various key reference datasets released, with a Common Address File at the top of the wish list. The ability to link numerous data sets from public and private sector has numerous benefits by ensuring everyone is referring to the same property. The Open Data User Group (ODUG)[6] see address data as data for the public good and should therefore be made freely available. They have calculated that the maintenance costs of £10-17million outweigh the benefits to the economy of around £1.38 billion[7]. What will the release of Open data from the Copernicus satellite system bring? Will this be the catalyst which prompts an increased release good quality accurate open data? We have already seen DEFRA release a huge catalogue of environment data including LIDAR this year, and a similar initiative from the Crown Estate has seen marine data released. What will be next?

Then there is linked data[8], seen by many as the future where data is published directly to the web in open format rather than as products. How will this affect the way Open is adopted?

How will the traditional vendors deal with the threat of Open Source software, or is it an opportunity? In many ways the proliferation of free or cheap data and software removes the barriers of entry, at least on entry into spatial. Some users will continue with open source, whereas others may then move to propriety software. The Vendors which survive are those which take this into accountant, and we have already seen changes in business model amongst the big vendors to change the way their products are used.

And then there's one of the forgotten issues around Open which Steve Feldman raised at AGI Geo Community 2014, which posed the question 'Are you a good Open Citizen?' It is very easy to take data and software, but how are you giving back? Are you donating money, or assisting through posting code or feedback? Open Source or Community data still has a cost through developer's time, server hosting & conference/hackathon attendance as examples, so it's good to put something back.

So with the value of Open Data to the economy in mind, it may be useful to close by looking at the GPS market where data has been made freely available, to see if any parallels can be suggested. The US Government dropped selective availability on their GPS network (which downgraded the signal) in 2000, and made this freely available globally. This has led to a huge increase in a wide range of uses for GPS technology in the positioning and precision timing markets. The US Government has invested heavily for use by the US military, but at the same time made this data freely accessible. What is the value of this reckoned to be, as it might give an interesting comparison for the Open Data Economy? In 2015, Congress provided around $1 billion to fund the Core GPS Programme building on their previous investments in the network (with a further $13-$25 billion to be invested between now and 2030). Whilst it is difficult to exactly quantify the economic benefits, a 2015 report[9] from the EU suggested global core revenues in 2014 of approximately €62 billion and enabled revenue at €227 billion. Back in the year 2000 would the number of applications for GPS and the associated global revenues have been predicted?

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Thanks also to Andy Wells (Sterling Geo) for suggestions on the benefits from GPS

THE ASSOCIATION FOR **GEOGRAPHIC INFORMATION**

Satellite Services Future Landscape

Catapult Satellite Application

The Satellite Catapult has recently completed a foresight report for the satellite industry similar to the AGI.

We are most grateful to them for their agreement for us to include the summary report in this report. For this reason, the Satellite Catapult study does not follow the AGI branding applied to the other White Papers.

Satellite Application Catapult

Satellite Services Future Landscape

CATAPULT
Satellite Applications

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Background and Methodology

This brief provides an insight into the current, state of the art, technologies within the satellite service industry, whilst focusing on the technology capability landscape to 2020, and onto 2035. This work centres around those innovations and developments which will have the greatest impacts on the downstream sector, as well as considering the industry as a whole.

Satellite services are becoming increasingly capable and therefore relevant to both government and commercial enterprise as a means of acquiring data and of deriving and disseminating information. The increasing rate of technology transfer between terrestrial and satellite based systems facilitates a convergence between the two, leading to a future where satellite and terrestrial services form a seamless panorama of capability over the next 10 years.

Historically the rate of development and commercialisation of terrestrial technologies has outpaced that of spaceborne technologies. The next 20 years will see a closing of this development gap. The emergence of small satellites, through the advances in miniaturisation and the use of non-space off-the-shelf products, creates an industry more agile and responsive to market and user demands. This new component, to the satellite service landscape, has the ability to influence all the major satellite services.

This brief considers all three major satellite services, Communication, PNT (Position Navigation and Timing), and Earth Observation, in addition to the emerging new space component. Each major section identifies the current state of the art, and then looks at each satellite service's future capability and landscape. These services are underpinned by technology in current satellite roadmaps.

The evolution of individual technologies represents the enablers underpinning the creation of services addressing market needs. Because the services provided by satellites can address multiple markets, with dependency on infrastructure that employs a vast range of technologies, it is appropriate to orientate the analysis methodology around the service concepts. These are pivotal for the future commercial exploitation.

The work undertaken references and builds upon existing work, including:

i) Market scoping studies that were undertaken in the Space Innovation and Growth Strategy (Space-IGS), and aims to inform the future Space Growth Action Plan.

ii) Technology roadmaps created within NASA Integrated Technology Programme, ESA, and the UK-space National Space Technology Steering Group (NSTSG).

Figure I is a visualisation of the key components that make up the satellites service industry from its underlying technology, outlined within roadmaps, to its ever evolving and emerging markets and applications. Parallel to this activity is the continual development of both user and data centric technologies. Through the identification, integration and assimilation of all of these components it is possible to create a picture of new potential satellite services and capabilities.

For the purpose of the Catapult's work, the timeline is split into two sections: Now→2020; and 2020→2035. Figure II below shows an illustration of the simplified logic that is used to determine how the various inputs and activities have been used to derive a view of the evolving landscape out to each of these horizons.

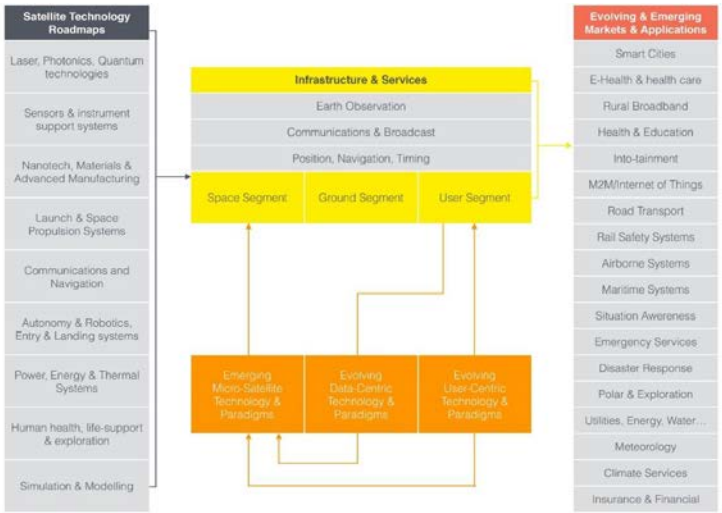

Figure I the different components which influence and shape the future satellite service industry

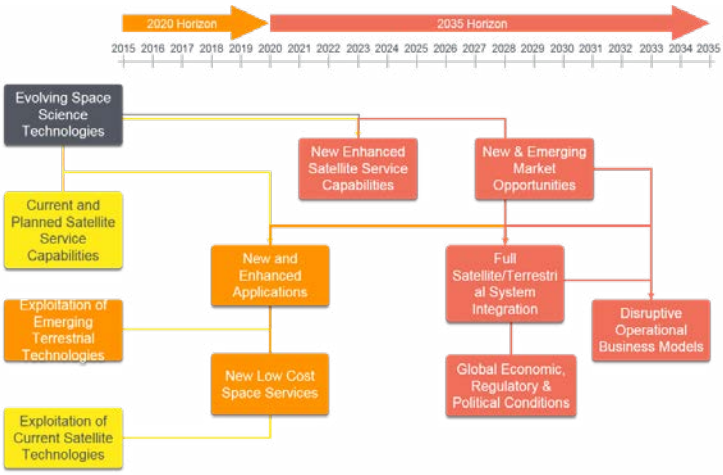

Figure II Simplified logic used to determine how inputs will used to derive a view of the satellite landscape within the two time horizons, now to 2020 and then onto 2035

2020 Horizon: Rapidly advancing terrestrial technologies, previously external to the satellite services, will have the largest impact in the 2020 horizon. Example technologies include seamless terrestrial communication, in the form of 4&5G, as well as greater intelligent data analytics and increased computing power. Furthermore this timeframe will see the rapid exploitation and deployment of current COTS technology in small satellite missions.

2035 Horizon: New emerging technologies, which are currently in their infancy (low TRLs), such as those captures within the different technology roadmaps, will come to fruition within the 2020 to 2035 horizon. This will facilitate enhanced satellite service capabilities. Market drivers and external PESTLE activities will inevitably have large implications on the long term landscape. These are however not explored within this work.

Communication Technologies

Satellite Communications technologies have achieved remarkable breakthrough efficiencies and performance increases in just under 50 years. These developments, have occurred in parallel with large gains in performance by other IT and telecommunications systems. Moore's law predicted a doubling of performance every 18 months, this has generally come true for all fields involving digital processing whether it be computing or communications. Those developments up to the current day are likely to just be the prologue to the industry. It is reasonable to anticipate continuing gains in terms of overall processing power, digital communications, and "intelligent" space communication systems.

Global and seamless communication will become increasingly important and relied upon as it continues to be intrinsically used within national critical infrastructure as well as the individual. The 2020 horizon will see the trend to build larger and higher capacity communication satellites, mirroring that of the previous decade, to keep up with the rapidly growing demand.

Early forays into the use of optical communication technology for ground to space communication proves a viable alternative to traditional Radio Frequency (RF) communications. Optical communication technology has many advantages over that of RF: wider bandwidths, larger capacity, lower power consumption, more compact equipment, greater security as well as increased immunity from interference. Satellite to ground optical up/down links of +200Gbps will be achievable, facilitating the new era of big data. Furthermore therefore there has been a large push for low-cost and low-power electronics to reduce the cost and increase throughputs at higher frequencies.

The 2020 horizon will also see a shift from the heavy hand-built mechanical and phased array user terminals, of today, to tuneable metamaterials. Metamaterials can be broadly defined as synthetic materials engineered to have electromagnetic and other characteristics not found in nature. Although this technology remains costly it provides innovative solutions for complex antenna design.

The 5th Generation (5G) of Cellular technology will be next major cellular wireless standard to be adopted. 5G offers a major leap from previous generations in terms of both power and functionality. Seamless connectivity will bring with it improved user experience and will deliver smarter applications. The demand for data access by mobile users has been doubling every year and is predicted to continue into the foreseeable future. As a result of 4G services getting close to their capacity limits millimetre wave cells will be deployed in dense urban areas.

Finally, before the end of the decade, we can expect to see the use of High Altitude Platforms (HAPs). HAPs will have higher payload capability and endurance which can provide an alternative communications platform. This will be particularly important for performance and communication resilience.

The 2020 to 2035 horizon vision will see the move from Terabit satellites, in the 2020 timeframe, to the use of petabyte communication satellites. This will become possible through the use of new material such as Carbon nanotubes (CNT) and graphene's which will have radically changed power electronics. In addition it is likely that antennas will have evolved to be embedded within materials – the development of the metamaterial antenna.

Wireless communication systems will have advanced into intelligent self-organising with self-discovery and distributed routing intelligence. Networks will have the capability to adapt based on data flows and end to end communications needs, spawning the wireless ubiquitous communication era of 6G. Nano cell using millimetre wave technology will provide unprecedented throughputs (100Gbs).

With the Oil and Gas industry pushing the development of low latency communication to support robotic exploration platforms, the 2035 landscape is likely to see the fruition of the next generation of long endurance HAPs along with optical ground based communication.

Position Navigation and Timing

Current PNT technology is dominated by Global Navigation Satellite Systems (GNSS), and particularly the US GPS system. A second GNSS, the Russian GLONASS is used in some applications, particularly where high performance is demanded and equipment cost is less critical. Primary GNSS benefits (and the primary reasons why it has become so successful) include:

- Being free at point of use
- Global coverage
- Available 24/7
- Receivers are low cost & lightweight
- Impressive accuracy
    - Code solutions ~ few m
    - Carrier Solutions ~ few cm
    - Repeatable & Absolute (& no temporal drift)
- Reliable service & equipment

By the 2020 horizon, the World will have four GNSS systems, the evolved versions of GPS and GLONASS plus the European Galileo and the Chinese BeiDou. All are expected to operate using CDMA transmissions, and to provide multiple civil frequencies. This provides users with an enormous number of satellite signals visible simultaneously that will enhance accuracy, integrity and availability. But will also offer multi-frequency capability which gives robustness against single-frequency interference and substantially improves accuracy, since the ionospheric delay (largest normal source of error) may be directly compensated.

GNSS Augmentations enhance performance for applications that require it, and the highest levels of positioning accuracy performance (centimetre-level) are only achievable through augmented services with a reference receiver relaying correction data to a mobile unit.

GNSS has a number of vulnerabilities, but for many applications these have to date been irrelevant and often unimportant for the business context of the GNSS receiver use. Due to further use in critical infrastructure and critical transport applications, coupled with the rising number of attacks (jamming, etc.) on GNSS, robustness is becoming increasingly important. Also sometimes referred to as resilience, robustness can be defined as a characteristic describing a system's ability to effectively perform while its variables or assumptions are altered. For a GNSS Receiver this could be that despite the presence of active threats and/or vulnerabilities:

- The System continues to work with acceptable performance;
- Other systems compensate / back-up for the vulnerability;
- The System alerts (the User) if its output becomes unreliable.

Future robust PNT in the 2020 timeframe is likely to be achieved through a combination of: frequency diversity, enhanced receiver robustness (interference nulling, antenna techniques), spectrum protection (presently protected by international treaty but with very weak enforcement in most States), and integration of GNSS with dissimilar systems and sensors. The latter element will certainly be domain specific, depending upon user robustness needs, support system/sensor availability, and budgets. In the aviation domain, robustness is often considered solved already through widespread use of inertial sensors, certainly for commercial aviation. In the maritime domain eLoran has a place albeit its international acceptance is far from assured. In more price-sensitive fields including land transport, other options including vision systems and radar may prevail.

GNSS dominates and is likely to continue to dominate virtually all environments, with exception to indoor positioning. The tracking sensitivity of typical, mass-market GNSS receivers is insufficient to process satellite signals indoors, and even high-sensitivity GNSS receivers suffer accuracy degradations of up to 100's of metres due to receiving reflected signals. Retailing, emergency services, healthcare and logistics industries have been driving forces for creating the demand for indoor positioning. The major players in this market include Apple, Google, Nokia, Microsoft, Broadcom, Qualcomm and STMicroelectronics.

Key technologies for indoor positioning are short range wireless communications (such as WLAN, Bluetooth and RFID), inertial measurement units (IMUs) and magnetometers. Accuracies of between 1 and 10 m have been demonstrated with most of these systems under development conditions, and substantially better in certain specific cases. All technologies except IMUs require deployed infrastructure in the buildings to be navigated, and the performance will depend on the specifics of the deployment. No individual technology is clearly better than others, and the future in the 2035 timeframe appears likely to be combinations of technologies interworking, particularly since such a variety of sensors are already implemented in modern Smartphones.

The long-term future for PNT may be dramatically different. Quantum PNT is receiving substantial State investment from UK and other Governments.

- Chip Scale Atomic Clocks (CSACs) with Stabilities 1000 times better than current frequency standards are becoming possible, and 100 times further improvement is considered achievable in the laboratory. Miniaturisation has still to be developed. Optimistic projections suggest that commercial products might become available within 10 years.
- Cold Atom Accelerometers may achieve drift rates equivalent to 100m / month. First generation applications may be for underwater navigation in the 10-year timeframe. Vehicle systems and eventually consumer navigation applications may be realised eventually.

Earth Observation

The first Earth Observation (EO) satellite was launched in 1972, the NASA Landsat 1 Mission. Development of the industry in the following 30 years to early and mid-2000s was slow and mostly dominated by pure science missions, such as ENVISAT, and military use. The launch of commercial high spatial resolution (<5m) satellites around the turn of the millennia, e.g. Ikonos, created a whole new paradigm and opened up markets and novel satellite dependent applications. During the period of 2003-2012 164 EO satellites were launched (Euroconsult, 2013) by civil government and commercial entities. Conservative estimates indicate that in the following 10 years, 2012-2022, the industry will see a large increase the number of launches to 360 satellites.

Continual market pull for higher spatial resolution satellites, along with legislation changes to grant the sale of up 25cm imagery in the USA by February 2015, has meant that there has been a decrease in the gap between military and commercial EO satellite capabilities. Furthermore unlike the trend of launching larger satellites seen within the communication industry, the EO sector has experienced the emergence of small satellites. Surrey Satellite Technology Ltd (SSTL) “changed the economics of space” by using commercial of the shelf technology in small cost effective satellites. Companies such as Skybox Imaging, recently acquired by Google, Planet labs and Satellogic have continued this trend, using COTS technology to produce constellations and swarms of small satellites. Although these satellites do not offer the same level of performance as the larger commercial satellite, they are able to offer much greater temporal revisit times and a new level of resilience through sheer numbers.

The vision to 2020 in the Earth Observation domain can be split in to two major subcategories, the upstream technology advancements and then the improvements in the downstream data analytics coupled with new emerging commercial models. The next 5 years will continue to see the proliferation of small satellites within the industry. Skybox Imaging and Planet Labs should see a fully operational constellation of high resolution satellites by 2020, offering unrivalled temporal resolution, with several overpasses a day.

Data relay satellites, such as ESA’s European Data Relay Satellite (EDRS) constellation, will provide a new level of near real time EO satellite data access. The geostationary satellite will provide almost full-time communication with satellites in low earth orbit, which have reduced visibility to ground stations.

Demand for ever greater spatial/temporal/ spectral resolution, in conjunction with the Internet of Things (IoT) paradigm, has led to an increasing trend to use high performance spaceborne sensors in the terrestrial or near terrestrial environment. Examples include ground base InSAR capabilities and the use of optical and SAR sensors or UAVs.

The downstream EO 2020 vision also includes the development of intelligent data analytics, through the use of new computing technologies and algorithms, in parallel with the implementation of linked

data. This will allow the non-expert user to seamlessly use and search EO data, in conjunction with other data sources, in an intuitive integrated fashion. The user will no longer a need to understand or process the data, rather they will only need to extract their relevant information from the data in a near real time environment, facilitated through behind-the-scenes clever computing and analytics.

Cheaper launch and space assets costs as well as increasing data quantities in the small satellite domain will drive the diversification of commercial EO data business models. The business models will allow a more customer oriented experience, with a decrease in emphasis on minimum area orders and the development of "pay-per-pixels" models. This approach is much closer to a vision of mass market uptake of EO. Customers will be given far greater flexibility to match the individual's user requirements, rather than adhering to the data providers requirements.

The vision to 2035 in the Earth Observation domain is largely underpinned by advances in space technologies, such as those with are currently at a low TRL:

- Fractionated spacecraft will enable satellites to distribute their functionality across several small platforms creating the virtual capability of larger satellites. Furthermore fractionated spacecraft in the Low Earth Orbit (LEO) have the ability to offer far greater functionality through continual communication with each other. This overcomes one the biggest limitation with LEO platforms, the inability to be in constant communication with a ground station.
- Synthetic aperture and deployable optics technology will enable much greater spatial resolution. This technology will be applied to geostationary satellites which can offer near continuous surveillances. On board satellite processing in conjunction with satellite programmable hardware will drastically decrease the amount of data needed to downlink to ground stations whilst giving users complete flexibility on the information acquired.
- Multi-functional high altitude platforms will allow the use of a single platform to be used for all three of the satellite services. Due to the low altitude of HAPs technology it offers a step increase in EO performance which means much higher spatial resolutions achievable, as well as offering persistent surveillance capability.

New Space

Current growth in the space sector is being driven by start-ups and small businesses, capable of exploiting current terrestrial technologies for novel on-orbit solutions. As such, today's new missions are not only being planned, but also executed. The pioneers in this sector have demonstrated in practical terms the opportunities to respond to new technological capabilities and introduce disruptive solutions in minimal time. Growth in this way is expected to continue at an accelerated rate over the next 5 years, supporting this approach to the exploitation of space in the long-term future

The technologies and their applications are being exploited now. The cost for a satellite mission – including launch – has dropped to the point where it falls in the scope of venture capital or private equity funding mechanisms. Together, the accessibility of finance and technology opens the space market to the wider population, resulting in an inherent growth in innovation.

High-specification consumer electronics has driven the compact integration of entire computing systems into increasingly smaller solutions. This has coincided with the development of technology demonstration nano-satellites and together these form the technological basis for viable commercial services. By reducing mass, volume and power demands, the small satellite platform brings services with real-world demand and exploits the launch opportunities afforded to small secondary, tertiary and other "piggy back" payloads.

The service mechanisms considered above demonstrate the opportunities offered by owning the entire value chain. A start-up or SME can develop a concentrated, vertical corporate structure, from platform procurement to ops and data acquisition, to ground processing and service provision. Importantly, however, such companies remain small enough to maintain the agility and responsiveness that enable quick, innovative solutions to be exploited ahead of the incumbent industry. This has been clearly demonstrated in several case studies, with indications that many new businesses are poised to exploit this approach for a multitude of satellite service applications.

Annex Three.
Foresight Report 2010

AGI Foresight Study: The UK Geospatial Industry in 2015

Edited by

Andrew Coote

Steven Feldman

Robin McLaren

May 2010

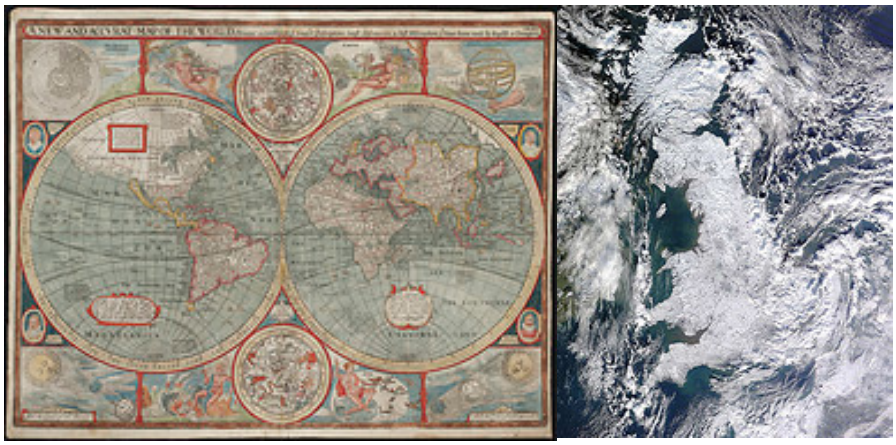

Photo Credits for all illustrations used in this document are given on page 31.

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Introduction

1.1 Background

The geospatial information (GI) industry is undergoing radical change. Stimulated by a range of new global challenges, the balance of power between existing and new players is shifting. UK Government policy is also undergoing transformation with the publication of the UK Location Strategy, the transposition of the INSPIRE Directive into UK law, the passing of the Marine & Coastal Access Bill and plans to change the business model of Ordnance Survey. The economic strictures, under which the public and private sectors will need to operate, as we attempt to handle enormous public debt, are also certain to drive changes in behaviour.

There can be little doubt that in 5 years the industry will look very different.

Over the past year the Association for Geographic Information (AGI) has been exploring the future of the geospatial industry in the UK in the first public foresight project of this kind. The foresight study has a medium-term horizon of 2015, as we believe that any longer-term assessment is not feasible or valuable. In seeking diverse points of view, the study invited almost 40 industry opinion formers to contribute papers in their particular expertise, covering data and technology, vertical market sectors and policy drivers. This was supplemented by: a workshop to debate the main themes of development; a presentation and debate of initial results at an open event; and public participation through an online questionnaire. Reference papers from the wider information technology world and economics and political fields were also consulted to ensure that the resulting analysis took into account influences outside the Geographic Information (GI) industry.

> *"There can be little doubt that in 5 years the industry will look very different"*

1.2 Structure of the document

We first consider the wider context by examining the broad paradigm shifts that are currently affecting the GI industry and how they might play out by 2015. We then attempt to summarise the political, social, economic, technological and environmental impacts identified by the many inputs to the study, see figure 1.

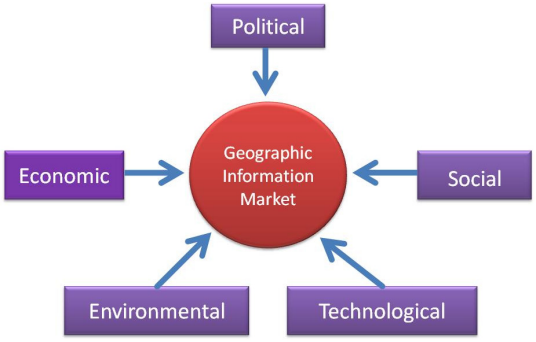


Figure 1: Macro-environment influences

The paper concludes with an outline of the key considerations that industry players need to address. Annexes list the contributors to the study and a summary of the more significant results of the public survey. Throughout, we reference the more detailed discussion of the issues which can be found in the expert papers, which we strongly encourage you to consult at http://www.agi.org.uk/foresight

1.3 Acknowledgements

The authors would like to thank the large number of experts, practitioners and external parties who have contributed to, reviewed or commented on the study results.

We view this study as a process, not a single event. Its publication marks the beginning of a continuous review of what the market wants from the GI industry and how it can be best delivered.

Geography as context

A paradigm shift unseen in our industry for 20 years

Over the last 20 years the GI industry has been changing, but in relatively small increments. There have been a series of significant breakthroughs, many driven directly by the IT sector: client / server to web enabled; UNIX workstations to desktop; proprietary to interoperability; limited data to a 'fire-hose' of data; high to affordable costs; departmental to enterprise solutions; and static to mobile, for example. These drivers of change and their effects emerged at a rate that both businesses and Government could absorb and comfortably adapt to. However, what we are now experiencing, bubbling up around us, is the biggest and fastest paradigm shift the industry has seen in our professional careers – Geography as Context. This paradigm shift is allowing and encouraging serious new players to enter and shape the GI sector as significant opportunities are discovered. The incumbent players have mostly been surprised at the scale and the speed of these investments.

In the past 2-3 years, Google, Apple and Microsoft, amongst others, have entered the GI industry with consumer-focused applications. This has dramatically changed our relationship with geography as electronic versions of mapping pervade our TVs, games, local government websites and our smart phones. A new generation of Internet products, such as Google Earth and Bing, for example, are stimulating a greater interest and use of geography in society. We are much more location-aware and location-based services are reshaping how we plan trips, meet friends and find good local restaurants. While others such as Facebook and Twitter have fundamentally transformed social networking and how we interact socially and professionally.

1.4 So, fundamentally what has changed?

Pace of change – it took the TV 13 years to reach an audience of 50 million world-wide. However, it took the Internet four years, the iPod three and Facebook just two 2 years. These technologies are also highly disruptive and have the power to change entire incumbent industries; the record industry has changed out of all recognition since the iPod arrived.

Speed of Communication – before we had to wait a day for news to be published. However, with the arrival of tools such as Twitter we are seeing news being broadcast in real-time. People were 'twittering' the debate during the workshop held to support this study.

Medium of Communication – Advertising revenues from the Internet overtook the traditional sources of television and newspapers in 2009. The web has become the key channel for communications and Apple's recently announced iPad reflects this continuing transition.

"students starting a 4 year technical degree will find that half of what they learned in their 1st year will be out-dated in their 3rd year"

Ubiquitous Computing – in 1992 there were 1,000,000 internet devices. In 2008 there were 1,000,000,000,000! There are chips in everything and they are all being connected across the Internet.

Cultural Change – to accompany this paradigm shift in technology and globalisation, the generation growing up with this change, the wired generation (or sometimes referred to as Generation Y) has adapted to this new environment. This cultural or behavioural change has included a refreshing view of the work / life balance and social networking has been fully embraced. .

Moving targets - with the amount of new technical information doubling every 2 years, students starting a 4 year technical degree will find that half of what they learned in their 1st year will be out-dated in their 3rd year. Not only is knowledge a moving target, but the job market is also a serious challenge - the top 10 in demand jobs in 2010 did not exist in 2004.

To survive and prosper within this highly dynamic and global environment, the UK needs to produce professionals in the GI sector that have core skills to allow them to adapt quickly, collaborate globally and take advantage of these opportunities within ever decreasing cycles[1]. This is not only a challenge for the education sector, but also for all existing professionals to continue their professional development and keep up with this and future changes.

Political Framework

The Chinese have US$2 trillion and are going shopping

1.5 Context

Political frameworks and the associated policies have a considerable influence in shaping and, in some cases, controlling our sector. We are currently experiencing just how dynamic these policies can be. The UK political framework must also operate increasingly within the European and international environments as we participate in the global economy. Microsoft's recent announcement that it will offer users the choice of browsers other than IE is a response to the investigation by the EU's Competition Commissioner. We wonder how long it will be before the dominance of Google in the online advertising world falls foul of US anti-trust legislation.

Five years ago hardly anyone had heard of Barack Obama, London had not yet won the 2012 Olympic and Paralympic Games, and the role of China in funding the global economy was only just beginning to be recognised. If we had undertaken this exercise five years ago who would have predicted the Credit Crunch and the first black American President![2].

[1] Education, Muki Haklay, AGI Foresight Study (2010)
[2,3] The Public Policy Environment, Mick Cory. AGI Foresight Study 2010.

Most governments have now woken up to the power of information and are formulating policies to either free up or curtail access to information, depending on their political dogma. At one end of the spectrum Google have accused the Chinese of an alleged cyber attack on their website while at the other end the UK government is proposing much more open and freer access to public sector information. We need to establish a degree of commonality on policies across countries to allow global trade in product and services, including information services, to operate effectively. This section discusses elements of the political agenda that will touch our sector.

1.6 Globalisation

We live, work and play in a global economy, influenced significantly by what is no longer a trend but a fact of life – globalisation. The reality of this has been brought home significantly by a disaster in the global financial markets, the way in which political leaders in the world's 20 most developed economies have stepped in to shore up national economies. The financial meltdown of the last two years is not the result of national economic policy decisions; they arise from international markets. The concerted efforts to shore up the banks was taken clearly and explicitly to avoid a total collapse of our banking system and prevent a repetition of the Northern Rock failure with queues of savers trying to withdraw their savings. The consequences of this decision are significant and potentially will be the single most important influence on developing public policy over the next five years.

Information services are also global and the service providers require global coverage for their services. Therefore, if they cannot obtain the appropriate UK data at an affordable cost then they will find alternative sources.

Balance of World Economic Power

The aftermath of the global financial crisis highlighted the shifting economic power across the globe. Once the dust had settled, it was clear that the balance had shifted east to China, who are supporting America's debt directly. Emerging nations like India and Brazil are poised to exert more economic influence.

The Chinese have long been on a shopping spree for natural resources. Now, with US$2 trillion in their pockets, they are shifting their aim towards auto-makers, high tech firms and real estate. Electric cars and mobile phone manufacturing are two areas where the Chinese are challenging the incumbent global players. The GI sector could be on this shopping list, especially since it would help identify global assets for purchase and management.

It is not only the financial advantage of these new global players that is significant, their intellectual capacity is also impressive: China will soon become the number one English speaking country in the world; and India has more honours students than America has children. This will change the global intellectual axis, especially in terms of research and development.

1.7 UK Policy environment

In addition to the obvious drivers of INSPIRE (INfrastructure for Spatial Information in Europe) and the UK Location Program (location.defra.org.uk) there are a number of other UK government policies that will either directly influence the GI sector or provide opportunities for the GI sector to contribute to the support of the policies over the next five years. We expect the majority of these policies will remain relevant no matter which party is in power.

Public Sector Information

Radical but necessary changes in the UK have been too long delayed and are now inevitable[3]. As we write, Government has finalised a consultation on 'Policy options for geographic information from Ordnance Survey'. This followed the Prime Minister's proposal to make available certain Ordnance Survey datasets for free and without restriction on re-use. The consultation was issued in the context of the broad long-term strategic options for Ordnance Survey. The Prime Minister has subsequently announced that Ordnance Survey will be obliged to provide certain datasets for free and without restriction on re-use. This is a significant policy shift and will have a major impact (positive and negative) on the GI sector.

Putting the Frontline First: Smarter Government

The government published *Putting the Frontline First: Smarter Government* White Paper in December 2009[4]. The report outlined a programme of work to reform and restructure government. It focused on developing a more strategic centre, developing new partnerships for performance and value for money in public services, and citizen empowerment and transparency in the information age. This report built on the work and proposals of Sir Tim Berners-Lee and Professor Nigel Shadbolt. It outlined the importance of increasing the transparency and availability of public sector information to better serve citizen and community needs, improve value for money and achieve cashable savings as part of the Making Public Data Public initiative and the subsequently launched data.gov.uk. The data.gov.uk initiative is a programme of work to increase the availability of non-personal public data for re-use and will support the government's objective of being an enabler of public services rather just a provider. We can expect this to be a central part of driving the UK information economy over the next 5 years.

[3] PSI Policy, Michael Nicholson, AGI Foresight Study (2010).

[4] www.hmg.gov.uk/media/52788/smarter-government-final.pdf

"The Prime Minister has subsequently announced that Ordnance Survey will provide certain datasets for free and without restriction on re-use"

Other Priorities

Other priority policy areas that will influence the GI sector will be (i) homeland security in the fight against terrorism, (ii) climate change (with increasing rigour applied to the evidence and modelling following the revelations from the University of East Anglia), (iii) disaster management around the increase in incidents related to climate change, and (iv) energy and food security which will become more important in the global context. And we still have to make serious inroads into the health and education sectors.

EU INSPIRE Directive

The European Union's INSPIRE Directive creates a European Spatial Data Infrastructure by improving the interoperability[5] of spatial information across the EU. The EU INSPIRE Directive was approved by the European Parliament and the Council of the European Union in March 2007 and was transposed into UK law by 31 December 2009. The Directive requires public authorities that create and use spatial information to make their information available to other public organisations across Europe so new products and services may be developed by combining this information. The Directive also requires public authorities to make their information accessible (not necessarily free of charge) to members of the public and to allow re-use. This will significantly change the GI landscape through the UK Location Programme.

Privacy Issues

Location as an application feature is moving from a vertical market characterised by B2B GI processing to a horizontal market characterised by B2C personal location technologies. The traditional GI sector, dominated by players such as ESRI and Intergraph, is set to be overtaken by the giants of the IT industry such as Google, Microsoft and Yahoo who have brought powerful location technology consumer applications into the market. This has set the scene for massive changes to the GI sector over the next few years, in which privacy issues will play a big part[6][7].

1.8 Impact on GI Sector over Next Five Years

Competing in a Re-aligned Global Market

The shape of the GI sector will be significantly influenced by the shift of global economic power to China and emerging nations whose economies have not suffered so badly from the financial crisis. The UK GI sector needs to co-exist and compete for opportunities in this realigned global market. We will need new competencies and skills and our education system needs to respond to these challenges; we are currently preparing students for jobs that do not exist, using technologies that have not been invented in order to solve problems that we do not even know are problems yet.

[5] Standards, Rob Walker, AGI Foresight Study (2010).

[6] Data Privacy policy, Jonathan Raper. AGI Foresight Study (2010).

[7] Spatial Survaillance, Stewart Fotheringham,[7] Data Privacy policy, Jonathan Raper. AGI Foresight Study (2010).

Capacity building will be a key success factor for our sector[8].

Hunting in Packs

The UK GI sector has been successful in generating SMEs, but has not been effective at migrating the SMEs into major companies to compete at the global level; possibly a cultural issue, but in part due to lack of government support in the sector. A more collaborative approach, even across the public and private sectors, is required to increase our capability and competitiveness abroad (the Canadians adopted this approach many years ago[9]).

Generating Welfare and Social Benefits with Public Sector Information

The emerging policy shift towards more open access to PSI is being guided by the belief that this will generate significant innovation leading to high levels of welfare and social benefits[10]. If this is to happen then the GI sector needs to be an integral part of the wider information landscape and provide the tools and capacity to realise these expected benefits. This will require a new generation of innovators who can work in this broader information landscape which will increasingly include crowdsourced data.

Geographic Information Profession

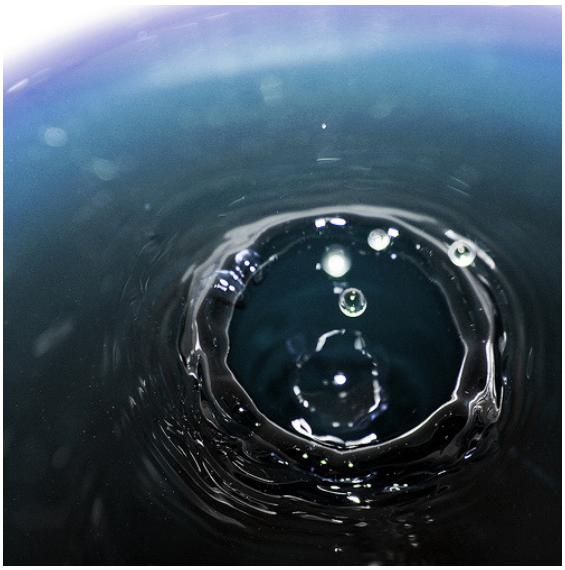
As GI and associated services become pervasive across society through consumer location based services, the GI industry, needs to get itself much better understood, along with the benefits it can bring to the citizen and society, so as to inform the debate on the ethical challenges, such as privacy. Should AGI's role be strengthened by making the long and arduous journey from a representative group to a professional body to better support this change?[11].

Job Opportunities Moving East

In the late 70s and early 80s the UK was in recession and many professionals in the GI sector headed to the Middle East for well paid jobs. As the UK is steeped within another major recession, public sector spending about to be draconically cut and markets shrinking will we see another exodus of skills from the UK to seek more attractive jobs in the Middle East and Asia?

[8] Education, Muki Haklay, AGI Foresight Study (2010)
[9] www.geoconnections.org
[10] Openstreetmap Countries, Charles Arthur, AGI Foresight Study (2010)

[11] Geo-ethics, Iain Greenway. AGI Foresight Study (2010)



Re-engineering the Public Sector

The drive for efficiencies in the public sector will create opportunities for re-assessing our institutional framework. The Northern Ireland model of consolidating 'land' services into a Land & Properties Services agency could be followed in GB.

Avoiding Location Crises

In location technologies people and places are at the centre of the service concept and businesses have a direct relationship with the purchasers of the service: this means that that privacy has had to be actively managed. The current overall picture of location privacy is one of *ad hoc* regulation addressing specific applications as they arise. There is now a case for the Information Commissioner's Office to update the Privacy and Electronic Communications Regulations 2003, and for the mobile operators to update their code of practice. There should in particular be a debate on what resolution of location information is private on a spectrum from "is in the country" to "is located here to a resolution of x metres". Over the next 5 years there will be a number of changes to the environment and capability of location technologies that will combine to create "location crises", unless action is taken to guard against these[12].

[12] Data Privacy Policy, Jonathan Raper. AGI Foresight Study (2010).

Social and Economic Perspective

Are we headed for a slope of enlightenment or a trough of disillusionment??

1.9 Context

The individual papers submitted to this study have identified trends and opportunities within specific markets particularly in the B2B arena, this section builds upon those observations rather than summarise them and focus on the broader GI Industry rather than participants in individual sectors.

Whilst detailed economic or social predictions for 2015 are beyond the scope of this study there are several patterns emerging that will influence the state of GI in 2015.

1.10 Economic outlook

The overall economic context to 2015 is (in aggregate) flat. Most forecasts are for limited growth over the next 2-3 years, predictions from National Institute for Economic and Social Research[13] suggest that overall economic output will not reach the Q1, 2008 level until the end of 2012 and GDP per capita will not reach 2008 peak levels until Q1, 2014.

Government expenditure

There is a particular tension in these forecasts for the GI industry given its high dependence on government expenditure. The limited recovery is currently being fuelled by government spending which has replaced the credit bulge as the engine of growth (albeit a weak engine), however regardless of the election outcome it would seem prudent to plan for significantly reduced government spending from 2011 onwards.

The Institute for Fiscal Studies analysed the impact on central government departmental budgets of the commitment to significantly reduce government debt by 2014. After adjusting for the "protected" budgets of Health and Schools committed by both parties, the reduction could be of the order of 13% up to 2012-13; if protection were extended to 2014-14 other budgets would need to be cut by 23.8% (£47.4bn in total)[14]

1.11 Social outlook

It is not our intention to try to summarise all of the numerous studies of social trends and attitudes that might have an influence on the industry by 2015. However we have identified a few factors that we believe will have significant impact on the industry.

Generational changes

[13] www.niesr.ac.uk

[14] Institute of Fiscal Studies "Public Services: Deep Cuts Coming" http://www.ifs.org.uk/budgets/gb2010/10chap8.pdf

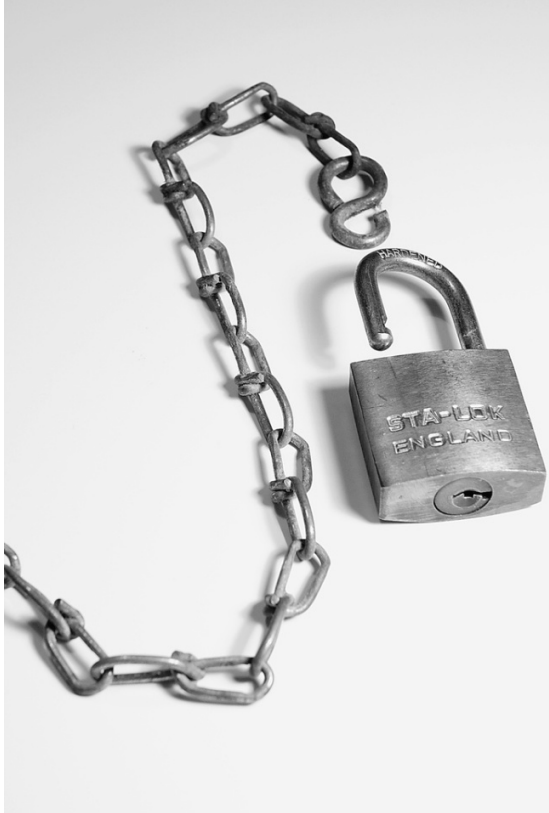
There are distinct differences between the so called Generations X (born in the 1960's & 70's) and Y (1980's & 90's) We can speculate on exactly how those changes will impact the industry but we can be certain that the generation that will become the core of the workforce and increasingly the leadership and decision makers of 2015 will have different values, attitudes and expectations to those who have comprised the customers and consumers of the last decade.

> *"the leadership and decision makers of 2015 will have different values, attitudes and expectations to those who have comprised the customers and consumers of the last decade"*

This generation that has blurred the distinction between their work and social lives will be a major driver of crossover between the user interfaces and tools of the social web and those in the workplace[15].

Openness and participation

There is a trend towards openness and participation which spans attitudes to public data, the use of social media, diminished concern about personal privacy (until the personal impact is recognised) and an expectation that openness will lead to greater participation and influence on public services. This trend can also be identified in the growing interest/commitment to open standards and open source software and data (although open source and open standards should not be considered as the same).



Free

The explosion of free (or apparently free) services on the internet has created an expectation that all digital content can and should be available free online. Media, music and a raft of information industries are wrestling with these expectations, the desire to access new delivery channels and the challenge of determining viable business models.

The culture of free also stimulates innovation both on the producer side and from consumers who appear to be increasingly willing to challenge the legal rights of content owners.[16]

[15] The Energy Market, Berik Davies. AGI Foresight Study (2010)

[16] BMR claim that 96% Of 18-24 year olds have undertaken some form of illegal copying or downloading http://technology.timesonline.co.uk/tol/news/tech_and_web/personal_tech/article4144585.ece

1.12 Impact on GI Sector over Next Five Years

In considering the social and economic context, we will consider the impact on businesses, consumers and the opportunities that may arise within the industry.

B2B or B2C?

Whilst a large part of the GI industry (as represented by the AGI) today is business to business, the widespread usage of personal navigation devices and web mapping services from Google, Yahoo and Microsoft probably represents a substantially larger share of revenue and usage of GI today.

"cuts in public sector budgets will impact the aggregate demand for GI with most GI usage being in the "unprotected areas"

1.13 Business to Business

The traditional B2B markets for the geo industry in the UK have been Government (Central, Local & Defence), Utilities, Transportation, Retail & Marketing, Resources and Financial Services.

Public Sector

Public Sector represents substantially more than half of the B2B sector. Inevitably the cuts in public sector budgets will impact the aggregate demand for GI with most GI usage being in the "unprotected areas" of Central and Local Government expenditure. IT expenditure in general could come under further pressure if the reductions are targeted to minimise impact on front line services.

Our Local Government contributors suggest that Local Government will adopt shared services as a means of reducing costs and also achieving compliance with INSPIRE regulations[17].

The numerous policy initiatives that encourage cross organisational collaboration (including the involvement of the third sector in public service provision) to support more holistic solutions to problems depend on an easy means of sharing and interpreting data[18].

These drivers represent an opportunity for suppliers who can offer cloud based services or for those who are willing to host more traditional services at prices comparable with the cloud[19].

The momentum towards "making public data public" or open data will open up most government data sources of non-personal data within the next 2-3 years. New players will almost certainly emerge to take advantage of the opportunities arising from the availability of this data; they will bring new business models which may represent a revenue opportunity or a threat for the current GI industry.

Commercial Markets

Whilst public sector expenditure on GI is likely to fall up to 2015, commercial markets should deliver some growth as the recovery gathers pace.

In most sectors our contributors anticipate steady growth however there are a couple of markets that they believe do have above average potential.

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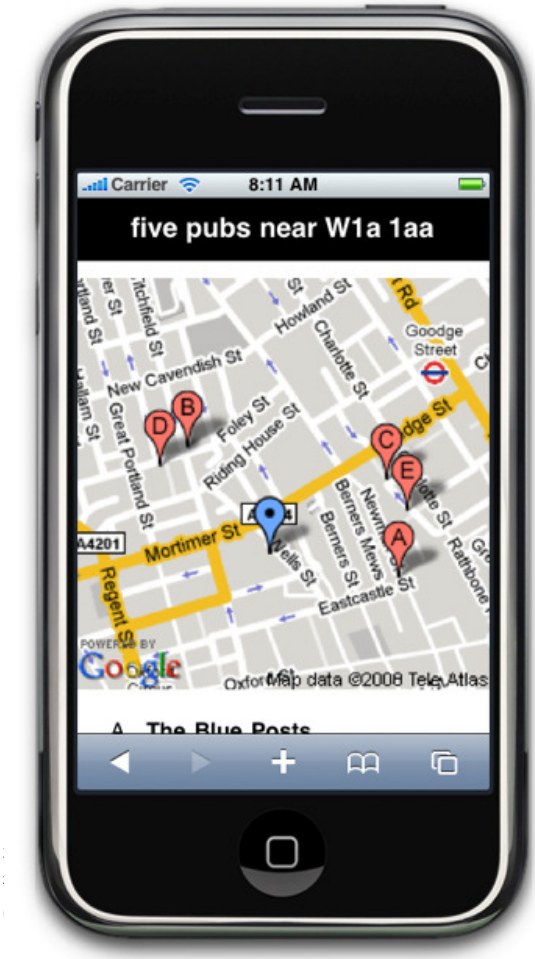
[17] Local Government, Gesche Schmid. AGI Foresight Study (2010)
[18] Third sector market, Muki Haklay. AGI Foresight Study (2010).
[19] Berik Davis and Natural resources, Tim Duffy. AGI Foresight study (2010).

The combination of environmental concerns and the high cost of fuel will provide the economic impetus for a number of smart logistics applications. Additionally the above average growth of internet retail will have a significant impact on home delivery services and a demand for more precise predictions of time of delivery[20].

Whilst the insurance sector has long recognized the geographic pattern of risk distribution, the wider uptake of GI within the sector has been slow. Our contributors anticipate an opportunity for new entrants not encumbered by legacy technology to gain competitive advantage through the use of GI across their businesses[21]. We can envisage a similar opportunity in other mature commercial markets where GI has yet to be widely adopted in core processes.



Location based Services

Location Based Services (LBS) have been widely touted as "the next big thing" since the late 1990s. A significant development in the next 5 years will be the move of applications aimed primarily at consumers into the enterprise space. Just as today vehicle navigation is used in both the consumer and business space, other geospatial applications that emerge in the consumer market will also be adopted, sometimes in a "hardened" form in the enterprise.

Peter Batty[22] considers LBS will impact the enterprise in two broad areas: one is that mobile / field based workers will have much better and simpler access to information; and the enterprise will also have a real time picture of where all its employees are (as well as other resources and assets). Traditionally geospatial applications have been more about documenting and analysing the past and planning for the future, but there will be significant growth in applications focused on real time information.

1.14 Potential changes to current business models

GI in the mainstream

GI proponents have been anticipating GI going "mainstream" for some time, it seems likely that by 2015 we will be saying that "spatial is not special". The widespread adoption of consumer web mapping will influence usage, design and the business models of the current

[22] Location Based Services, Peter Batty. AGI Foresight Study (2010).

GI industry[23]. As spatial ceases to be special it will also cease to attract a scarcity premium which may have a profound impact on businesses and their employees unless they are able to adapt to a much more competitive market.

The cost of free

Several contributors predict substantial falls in price levels for data and software (the distinction between data and software is blurring with the trend towards both becoming services)[24].

The widespread expectation of "free" is moving from the consumer web market to the business to business GI market. Open Source software and data has now become a viable alternative to proprietary models and whilst Open Source is not strictly free as business models are based on provision of services and support rather than licensing, that in itself will be highly disruptive to businesses focused on licensing and maintenance models.

Consumer web mapping API's that are apparently free (or have radically different cost recovery or justification models) have already encroached on several fields of activity for the GI industry (e.g. store locators, tracking and other real time data feeds). The entry of "professional" standard services businesses on top of the free API's will increase competition in web presentation of corporate data. Additionally we can foresee the growth of "enterprise" or "paid for' versions of the free API's offering premium geo services and features to clients who already use other elements of their offerings (advertising, applications, and platforms).

There are, as yet, no indications that volumes will grow in commercial markets to offset this trend and our contributors anticipate that the current industry will need to focus on premium quality products and services to niches within the wider market[25].

1.15 Consumer markets

Nearly all of the market contributions to this study have come from the traditional GI industry membership of AGI, which is almost exclusively focussed on business to business markets. That may in itself indicate the extent to which the explosive growth of consumer applications of GI has bypassed the established UK industry.

Maps have become commonplace on the internet. Over 100 million people use a web map each month, virtually none of these maps are provided by the traditional GI industry players and none of them are paid for by the end user.

[23] The Energy market. Berik Davis. AGI Foresight Study (2010)
[24] Thierry Gregorius et al, AGI Foresight Study (2010)

[25] Value added data resellers, Thierry Gregorius. AGI Foresight Study (2010).

The pace of adoption of Personal Navigation Devices [PND] (90 million worldwide in 2009[26]) and GPS enabled smartphones (28 million worldwide in 2009) is accelerating.

A plethora of applications have developed on the back of the web mapping API's, in the UK there are more than 500 mashups locally focussed with nearly 40 per quarter being added, some recent examples include the locations of Anti Social Behaviour Orders (ASBO), London bus routes, sites of film locations or car parks with spaces available. Increasingly these maps and applications are being accessed from smartphones that can integrate GPS and other positioning technologies with the application. We estimate that there are up to 10 million people in the UK able to access mapping and location based applications from a smartphone today, by 2015 nearly every mobile phone will have this capability implying upwards of 40 million users or potential users.

The increasing functionality of these devices and the mapping API's that they support will drive a new generation of applications. Turn by turn navigation is already appearing on these devices and several providers are offering free services that will challenge the business model of the PND industry. There has for some time been an expectation that consumer focused location based services would become the next lucrative market space for both traditional and new industry players, recently the focus has shifted slightly towards Location Based Mobile Social Networking which incorporates applications like friend finders, local search enhanced by social recommendations and location based gaming.

A recent study[27] has forecast the market for mobile Location Based Services (LBS) to exceed $12.7 billion worldwide by 2014 with the largest share of revenues coming from Europe. These forecasts need to be treated with some caution as the revenue models for these services are still evolving. However the rise of application stores linked to mobile phone operating systems has provided a channel for developers to sell their applications, at prices equivalent to the cost of a newspaper or cup of coffee, to large numbers of consumers with limited investment in sales and marketing or distribution channels. Over 15% of applications on Apple's AppStore utilise location in some way. Advertising has always been seen as a major revenue stream for developers of mobile applications, as the aggregators of advertising inventory start to be able to target more precisely based upon the user's context (which

[26] Berg Insight http://www.berginsight.com/ReportPDF/Summary/bi-pnd3-sum.pdf

[27] Juniper Research https://www.juniperresearch.com/shop/viewreport.php?id=203

includes location, time of day, previous preferences etc) advertising revenues associated with applications that incorporate location will also grow.

The growth in consumer applications envisaged above may be unrecognisable as geographic information to many readers of this study. Even those who have adapted to the use of the term "location" and all it implies may struggle to see these applications as being the natural progression of the asset management, resource planning and spatial analysis solutions that our industry evolved to deliver.

It would seem unquestionable that the growth of consumer applications with varied business models will have dwarfed the business to business sector of the market by 2015. New entrants will reach across from the consumer market to take an increasing share of the business to business market with challenging cost and business models.

"the growth in consumer applications envisaged may be unrecognisable as geographic information"

The next few years will be shaped by a combination of extreme pressures on public sector expenditure (the bedrock of the current GI industry), new business models and rationales, a shift in business focus towards consumer facing applications and a transformation of data markets as public data is made freely available.

By 2015 spatial will not be special, in all probability it will be no different to the incorporation of time in everyday computer applications today. It may well prove difficult to distinguish a GI industry (as we currently know it) within mainstream IT although many of those active in the UK will have found niches based around quality, currency or specificity in which they can prosper.

"by 2015 spatial will not be special"

Technological advances

Geospatial technologies converge over months not years, location is ubiquitous

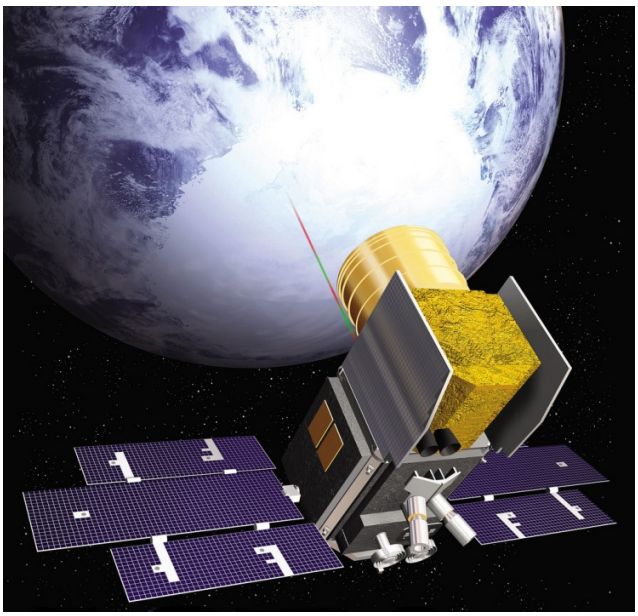
1.16 Context

In this section, we consider how technological change will impact upon the geographic information industry. The individual contributions received in this area cover not only advances in hardware, software and systems but also extend to changes in the nature and availability of geographical information.

The concept of "geography as context" is a recurring theme. Geographical information is becoming ubiquitous and as such is an available component of all applications, much in the same manner as time, is a contextual attribute – all that varies is the extent to which it is useful. As Batty[28] puts it "location tracking will be pervasive in 2015 – all mobile phones will have location tracking ... we will have the ability to know where everyone is all the time."

Technology convergence also emerges strongly from the papers. The smartphone is perhaps the most obvious example, where devices already support communication by both voice and web but also incorporate locational capabilities in the form of GPS and accelerometer and a camera. The next 5 years will see huge improvements in cost, quality and bandwidth of these devices. The ability to combine data in near real time from airborne LIDAR, laser scanned point clouds and digital photographic images to produce high resolution 3D cityscapes is another manifestation of this trend. A major issue however is cellular network capabilities. They are strained now and struggling to cope with 3G uptake. There could be great disillusionment with devices because of limits in the broadband 'back-bone'.

Belward[29] points up another important area of development - "By 2015 Committee on Earth Observation Satellite (CEOS) agencies plan to operate over 200 satellites" leading to the prediction by Dodson[30] that "It can be



confidently expected that within the next 5 years centimetre positioning in a mobile environment will be commonly achievable."

Cloud computing will become the predominant means of software service delivery. Gartner[31] believe "it will mean that users of IT-related services will be able to focus on what the service provides them rather than how the services are implemented or hosted."

[28] Location based Services. Peter Batty. AGI Foresight Study (2010)

[29] Satellite Imagery, Alan Belward. AGI Foresight Study (2010)

[30] Global Navigation Satellite Systems (GNSS), AGI Foresight Study (2010).

[31] Gartner Predicts: 2010 Report.

Open source will become a more significant factor in both software and data accessibility and availability by 2015. Cook[32] believes that "Sharing and making code and data open will be the "de facto" approach" although some doubts remain about functional maturity of some components and support. We also predict a huge growth in active and passive "crowd sourcing" as Osborne[33] sees it "If an application can offer a tangible benefit to the user sharing

their information, with no perceived loss of control or negative impacts, then they become happy sharing their personal information."

More imagery, temporal and 3D data will be created as a consequence of many of the developments above. "This will dramatically increase the size of the underlying databases into the terabyte and petabyte range which all needs to be managed ... and increases pressure for even faster, larger processing configurations" in the view of Turnill[34] from Oracle. What Gale[35] describes as "the *information hosepipe* of the Internet" will also require the semantic web (web 2.0 / 3.0) to deliver by 2015, the ability to deal with the ill-defined and ambiguous manner in which human beings describe "place".

[32] Open Source Software, Jo Cook. AGI Foresight Study 2010.
[33] Crowd Sourcing, Chris Osborne. AGI Foresight Study (2010).
[34] Enterprise Computing, Mike Turnill. AGI Foresight Study (2010).
[35] Web 2.0& 3.0 - Teaching Human Geography to the Internet, Gary Gale. AGI Foresight Study (2010).

1.17 Impact on GI Sector over Next Five Years

Geospatial Enterprise Systems

Geospatial systems are increasingly being seen as a viable component of enterprise IT transformation projects, both in both public and private sectors. This trend will accelerate over the next 5 years.

The requirement for high quality, nationally consistent "reference geographies", which form a Spatial Data Infrastructure (SDI), will continue to be needed in order to manage the UK effectively. The SDI will underpin applications such as land registration, development control, emergency response and defence within Government and other in the private sector.

Augmented reality

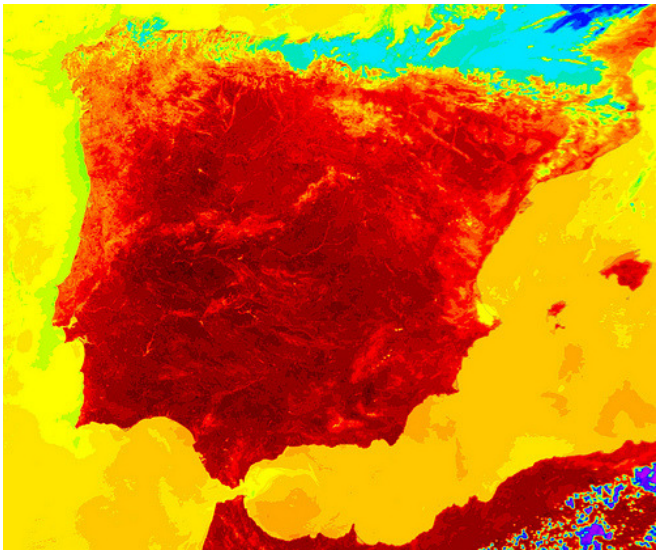
Augmented and simulated reality, together represent one of the most exciting areas where research is starting to move into usable applications. This is being enabled by the incorporation into the basic smartphones of a number of enabling components:

- GPS
- Camera
- Compass
- Inertial positioning using MEMS (Micro-electromechanical systems)
- Inclinometer

In the short-term there are a number of constraints to mass-market implementation of most appealing applications. These include battery life; the ability of the human brain to outstrip the ability of handheld devices to process data synchronised with eye movement; and mobile bandwidth limitations.

However, some of the simpler consumer applications are already becoming commercial available, see Hudson-Smith and Sung Hyun Jong.[36]

Cartography & Visualisation



Mackaness[37] in his study paper foresees a resurgence in cartography in respect to solving the challenges of visualising increasingly complex spatial analyses and 3D and 4D representation needed for augmented reality applications. However, it is not clear if cartographers or visual designers will have more influence in these developments. The contrary view is that we may see the death of the conventional 2D map by 2015. However, we can confidently predict that Google Maps and other consumer applications will produce a much greater map literacy / spatial awareness in population at large during this period.

Global Navigation Satellite Systems (GNSS)

Multi-constellation GNSS launched by India, China, the European Union, Russia, United States and possibly others will mean that over 100 satellites will be available for high accuracy positioning by 2015. The control over high resolution signals by the US will be removed. Using signals from these satellites, centimetre positioning will be routinely achievable in a mobile environment in developed countries. Indoor positioning will still require augmentation with other sensor systems, but will allow sub-metre positioning to be achieved commonly. In examining the necessary enablers for optimum exploitation of the opportunities that this offers, Ziebart[38] believes "the trend is clear: a single, accessible, global datum used to store and model all spatial data will evolve and be mandated."

Satellite Imagery

We alluded earlier to the 385 different instruments which will be launched by 2015. These will provide imagery across virtually all parts of the frequency spectrum and serving many different environmental and other applications. Our contributors believe that all 10m – 30m resolution data from these instruments will be publicly available and free and furthermore, resolution restrictions on access imposed on US imagery will disappear. Sub metre resolution imagery from satellites will also become available, although here there is less certainty about whether it will be released widely for commercial use.

[36] Augmented Reality, Andrew Hudson-Smith and Sung Hyun Jong. AGI Foresight Study (2010).

[37] Cartography and Visualisation, William Mackaness. AGI Foresight Study (2010).

[38] Space Observation, Marek Ziebart. AGI Foresight Study (2010).

Aerial Photography

The major web actors (such as Google and Microsoft's Bing) are driving demand, however, the needs of these organisations are very different from the traditional client base. Their interests are driving traffic to web sites thus creating the potential for advertising, as such aerial photography is a commodity and should it not generate the required interest (or something better is made available), then their interest will wane as fast as it has risen[39]. However, current indications are that consumer interest is likely to be sustained over the period, leading to the assumption that sub-metre accuracy 3D data will be available for all built up areas in UK by 2015. Prices for capture will inevitably continue to be squeezed by the big buyers.

At the opposite end of the spectrum this will force up costs in the specialist high quality market - in future, those requiring guarantees of quality and timeliness may end up paying more.

A significant technological development is the likely increase in the use of Unmanned Airborne Vehicles (UAV). Lavender comments that[40] "UAVs could become an increasingly utilised platform in the future if the legislative constraints are solved".

Ground-based Data capture

It is becoming much less expensive to capture data to relatively high standard through laser scanning[41]. The market for data capture using point clouds will expand as costs of hardware and software reduce. Land surveyors will need to adapt to working with the massive quantities of data produced by laser scanning, otherwise they will be increasingly marginalised as specialist data collectors. There will however still be a need to capture the 10% of data that is difficult to collect automatically by more conventional means.

Semantic Web (Web 2.0 / 3.0)

The number of page views of geospatial content being viewed on search engines is thought to be doubling each year and the increase in advert take up is 5 fold. This rate of increase is expected to continue through 2015 and will keep the big players interested in geospatial. Better interpretation of colloquial and personal geographic inferences is expected to be a major challenge for geospatial web development over the next few years[42].

Software

The move to web services delivery of geospatial systems is expected to force down prices of software licences from the large vendors, causing them to move to enterprise licensing deals to encourage dependence and the spread of usage.

Open source geospatial software will be 'mainstream' by 2015. Our experts believe that just as IBM funded Linux as competition to Windows and also funded Eclipse, substantial commercial companies will create support facilities around open source GIS. This needs a stronger institutional infrastructure and ecosystem to provide adequate support in industrial strength environments is also recognised[43].

[39] Aerial Imagery, Andy Wells. AGI Foresight Study (2010)
[40] Earth Observation Data, Sam Lavender. AGI Foresight Study (2010)
[41] Data capture tools and techniques, Richard Groom. AGI Foresight Study (2010)
[42] Gary Gale. AGI Foresight Study (2010).
[43] Open Source Software, Jo Cook. AGI Foresight Study (2010).

The browser will be the dominant user environment and the desktop confined to a few specialised applications and very challenging or secure environments. User-centred design, as exemplified by Google, will become an increasingly important focus of software development.

A cottage industry will grow around exploiting GI for many applications i.e. a huge number of applications will be developed in garages around the world – there will be many competing offerings, many of which will die quickly but this will have started to "shake out" by 2015 with many of the apps with the highest potential reaching a level of maturity.

The sheer scale of data volumes creates challenging information management issues. Database management systems will need to have evolved to cope with demands of real time 3D geospatial feeds.

There will be little completely new functionality added to GIS products over the next 5 years. Most of the tools required by the vast majority of users exist and many more are so infrequently used that they will probably be removed from mainstream product sets to aid stability and reduce cost. Exceptions are areas such as change detection, process modelling and feature extraction.

"We are all sensors now, your photographs, tweets..'

Specialist accelerator cards, known as Geographic processing units (GPGPU) will become important to handle complex visualisation problems in hardware.

Crowd sourcing

Last but not least, we see the importance of crowd sourced information increasing for a variety of applications and scenarios. Crowd sourcing can be essentially active by which volunteers participate in capture (and updating) of spatial data types or associated attribution; or passive, where data is collected from a device, for instance, travel patterns derived from data transmitted from your smartphone automatically and in real time.

Osborne[44] characterises this revolution as "We are all sensors now. Your photographs, tweets, restaurant reviews, the speed at which you are driving are all geocoded data that is being recorded and can be mined and analysed."

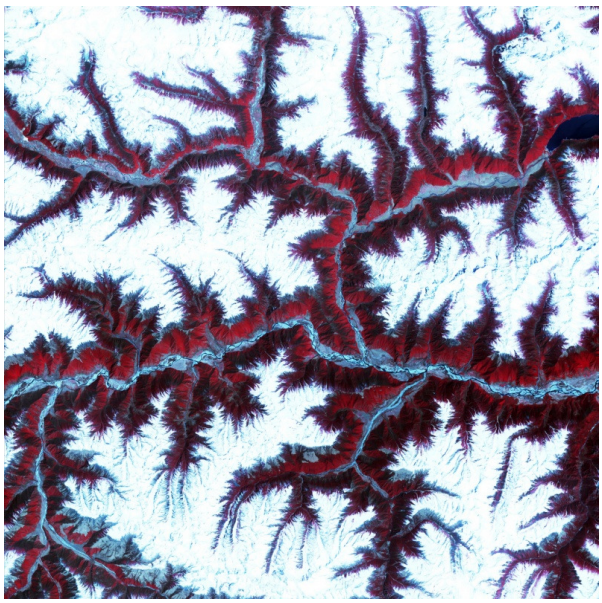
[44] Crowd Sourcing, Chris Osborne. AGI Foresight Study (2010).

Environmental Impact

The key challenges of the new millennium are all interconnected, with many being perpetrated by climate change.

1.18 Context

At the start of the 21st century the world is facing critical global food and fuels shortages, climate change, urban growth, environmental degradation and natural disaster related challenges as today's world population of 6.8 billion continues to grow to an estimated 9 billion by 2040. This is placing inordinate pressure on the world's natural resources. The recent severe winter and the serious flooding in the north-west of England have highlighted that the UK is very much a part of the global problem and solution. This section investigates how environmental issues will impact the GI sector.



The surge in the price of key food products such as rice and wheat, which last year hit record highs, sparked food riots in some countries. Food security has become a key global challenge. In response to the crisis, many countries and private corporations are exploring new ways of safeguarding their supplies of natural resources; especially crops for food and bio-fuels. A global search is now underway to identify 'under-utilised' land in areas suitable for agricultural production and to acquire the land for large scale agricultural production. Significant areas of land in Africa, India and South America have now been bought or leased to foreign countries or corporations – the so called 'farmlands grab[45].'

Although these investments attract capital along with technology and market knowledge to potentially improve agriculture, there are many inherent concerns that are not always covered in the associated contracts: agricultural produce is directly exported from countries with a food deficit; there is no 'unused' land and in many cases local people are taken off the land with little compensation; the easiest land to acquire is government land and the benefits normally go to the political elite rather than the local people; large scale agriculture does not employ significant numbers of local people; and much common land, such as grazing land, is targeted and lost. It is increasingly relevant that we strengthen land governance across the globe to ensure that all stakeholders understand their roles and responsibilities in managing land, property and natural resources within a sustainable and equitable framework.

[45] www.farmlandgrab.org

The key challenges of the new millennium are all interconnected, with many being perpetrated by climate change. Our understanding of the problems and the formulation of potential solutions will only be achieved through a holistic approach involving collaboration across the professions. Professionals in the GI sector have a key role in this alliance through the effective management of GI related to the built and natural environments and the application of good land governance to help mitigate the damaging impacts on our world and society. We need to adapt our approaches to be more sensitive to and supportive of these new challenges and make stakeholders fully aware of the incentives for adopting this paradigm shift. Good geographic information management must assist land governance to not only control and manage the effective use of physical space, but must also ensure sound economic and social outcomes.

1.19 Environmental outlook

European environmental policy

The major floods across Europe in the 1990's and the challenges of climate change are the triggers for change. Effective support of this environmental agenda will be a major challenge for the GI sector in the next five years.

Climate Change

Our understanding of the problems and the formulation of potential solutions to climate change is a key challenge. The GI sector has a crucial support role in collating, managing and modelling the related information. This will only be achieved through a holistic approach involving collaboration amongst those involve in the land, marine and atmospheric domains. Increasing sophistication in the analysis, presentation and understanding of uncertainty issues, for example how to communicate probabilistic-based information sets. This issue is particularly relevant for scenario forecasting such as climate change or flood risk analysis, where there are increasingly sophisticated datasets availability

Carbon footprinting

More immediate and direct "footprinting" of the consequences of everyday decisions – if not direct carbon taxes at least the ability to price and understand the consequences of different courses of action. A typical example would be increasing granularity in the insurance market as better tools and datasets become available to determine environmental risks[46] (Oates).

[46] Environmental Management, Bill Oates. AGI Foresight Study (2010)

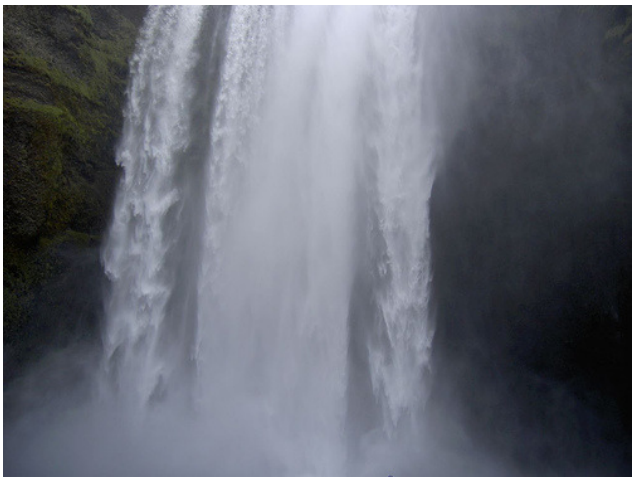
Sources of renewable energy

The UK government and the devolved administrations have set ambitious targets for the contribution of renewable sources of energy. Achieving these targets will involve significant investments in infrastructure, e.g. land and marine based wind farms and the strengthening of power infrastructures. As the recent Scottish Government approval of the Denny – Beauly inter-connector[47] proved, this requires careful assessment and communication of the environmental impacts. The participation of the citizen in the planning process is crucial to this decision making process.

Democratisation of information

Information will increasingly be collected by the public and stakeholder organisations, or if not collected by them, there will be a sense of ownership and entitlement. Data to support the green flag awards for beaches across Europe is increasingly being crowdsourced. This trend is entangled with the mass-market impact of tools like Google Earth, with its climate change data overlays.

Natural resource datasets will be ubiquitously available, discoverable and digitally accessible at much lower access cost to the customer than before. Some forms of data – such as Biodiversity observational data, which lend themselves to public (so called amateur) collection will be increasing in volume and 'real time' usefulness. There will no longer be the need for 'project GIS' collation of natural resource GIS datasets by consultants etc. as the most up to date information will be discoverable and available direct from the data providers' web services[48] .



1.20 Impact on GI Sector over Next Five Years

The Data Deluge

There is a potential paradox at the heart of the information management within this domain, which creates an opportunity in the GI arena: as the cost base associated with data collection is driven down and the volume of data available goes up, the public becomes at best confused and at worst sceptical. In many cases, more information equals greater confusion – another dataset will be around the corner to refute any position. This means that rather than being able to let "the figures talk for themselves" it becomes increasingly important how the information is presented and telling the story associated with the information in a compelling way. This does not mean however to filter the information, to protect it, or to otherwise impede its release – that would be counter-productive. Rather the increasing availability of GIS tools and "geoweb" enthusiasts mean that

[47] www.scotland.gov.uk/news/releases/2010/01/06/06141510

[48] Natural resources, Tim Duffy. AGI Foresight Study (2010).

there is a wider pool of people who can be partners in understanding and communicating the issues[49] .

Data Quality & Transparency

Prior to the Copenhagen climate summit in December 2009, hundreds of private emails and documents allegedly exchanged between some of the world's leading climate scientists during the past 13 years were stolen by hackers and leaked online. The computer files were apparently accessed from servers at the University of East Anglia's Climate Research Unit world-renowned centre focused on the study of natural and anthropogenic climate change. Climate change sceptics who have studied the emails allege they provide "smoking gun" evidence that some of the climatologists colluded in manipulating data to support the widely held view that climate change is real, and is being largely caused by the actions of mankind. The lesson here is that the provenance of data supporting evidence for controversial areas such as climate change must be clearly documented and transparent.

Crowd sourcing

Environmental information is increasingly being collected by the public and stakeholder organisations through crowdsourcing. The GI sector must develop approaches to accommodate this valuable source of data to complement more traditional approaches.

Public Participation

Successful planning processes involve effective public participation. The challenge to the GI sector is to develop approaches that can communicate complex environmental decisions with citizens. This could involve solutions like augmented-reality, for example.

Holistic Environmental Information Management

Environmental information in the land, marine[50] and air domains have traditionally been managed separately. However, the modelling of environmental phenomena, such as climate change, is increasingly demanding fully integrated environmental information across these domains.

Disaster Management & Recovery

The increasing number of environmental related disasters, such as the recent flooding in the north-west of England, requires further initiatives such as Atlantis[51], to more effectively integrate a wide range of environmental information to support prediction modelling and to help manage disaster recovery.

[49] Environmental management, Bill Oates. AGI Foresight Study (2010)

[50] Marine & Coastal, Mike Osborne, AGI Foresight Study (2010)

[51] www.projectatlantis.net

Key Challenges

There are many challenges for the industry over the next 5 years, some are highlighted in this summary paper but many others of a more specific nature are to be found in the expert papers. A few that we believe to be of most significance are:

1.21 Political

- Adapting to global economic power changes;
- Building appropriate GI capacity;
- Creating a UK based global market leader / partnership;
- Supporting a new type of public sector;
- Responding to location privacy issues.

1.22 Economic and Social

- Embracing a continuous turmoil of change;
- Responding to the challenge of free and the different business models that support it;
- Harnessing the crowd;
- New entrants will seize the opportunity to fuse the geoweb and social media – established incumbents will need to react or die;
- Developing the role of location information in socially significant applications, such as participatory democracy, mega city planning and consumer applications;

1.23 Technological

- Discarding the location-specific baggage and enter the mainstream;
- Working with with Google and other emerging global players;
- Engaging with Location-based Services (LBS) developers and service providers;
- Providing services to help users migrate through these paradigm shifts;
- Communicating with end users who don't understand maps;

1.24 Environmental

- Understanding and responding to climate change.
- Encouraging public participation by explaining complex geographic phenomena in simple terms.
- Integrating and modelling land, air and sea aspects of environmental information.

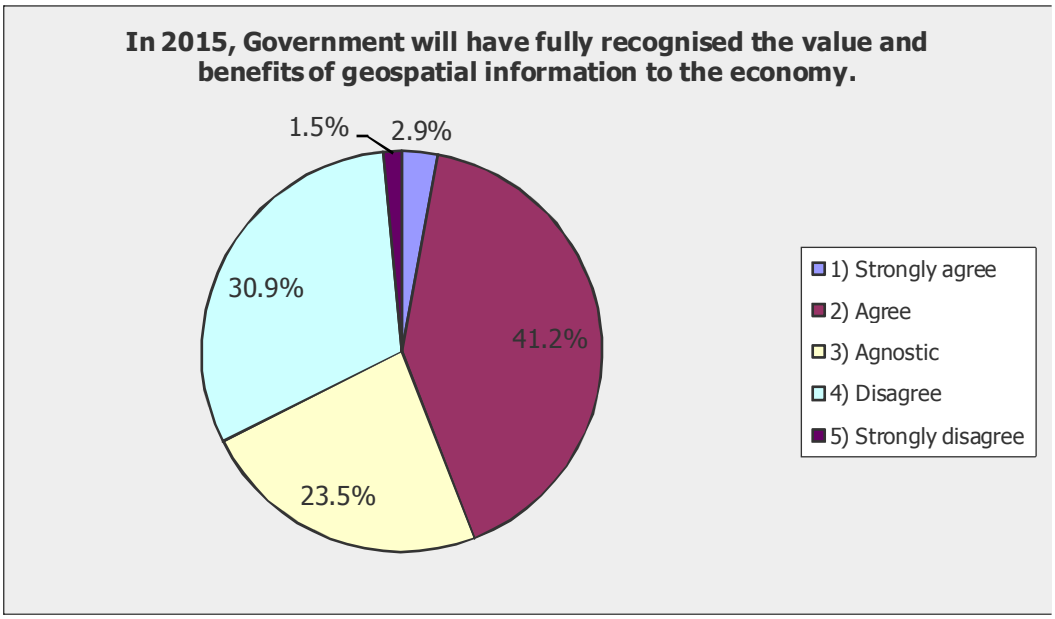
Annex 1: List of Contributors

Title	Author	Organisation
Satellite Imagery	Alan Belward	Joint Research Centre, European Union
Global Navigation Satellite Systems (GNSS)	Alan Dodson	University of Nottingham
	Alun Jones	Geoinformation Group
Augmented Reality	Andrew Hudson-Smith Sung Hyun Jong	University College London Centre for Advanced Spatial Analysis (CASA)
	Andrew Woolf	Rutherford Appleton Laboratory, University of Cambridge
Aerial Imagery	Andy Wells	Infoterra
Retail	Audun Clark	Tesco
Energy	Berik Davies	Shell
Environmental management	Bill Oates	Welsh Assembly Government
The Map is a Weapon of Knowledge	Charles Arthur	The Guardian
Crowd Sourcing	Christopher Osborne	ITO World
Web 2.0& 3.0 - Teaching Human Geography to the Internet	Gary Gale	Yahoo!
Local Government	Gesche Schmid	Local Government Association
Digital Rights Management	Graham Vowles	Independent Consultant
Financial Services	Graham Wallace	ESRI (UK)
The Philosophy of the Crystal Ball	Hugh Neffendorf	Katalysis
Geo-ethics	Iain Greenway	Land and Property Services, Northern Ireland Government
Health market	Jamie Justham	Dotted Eyes
Open Source Software	Jo Cook	Oxford Archeological
	John Pepper	UKHO
Data Privacy	Jon Raper	City University
Space Observation	Marek Ziebart	University College London
Transport market	Mary Short	Map Mechanics

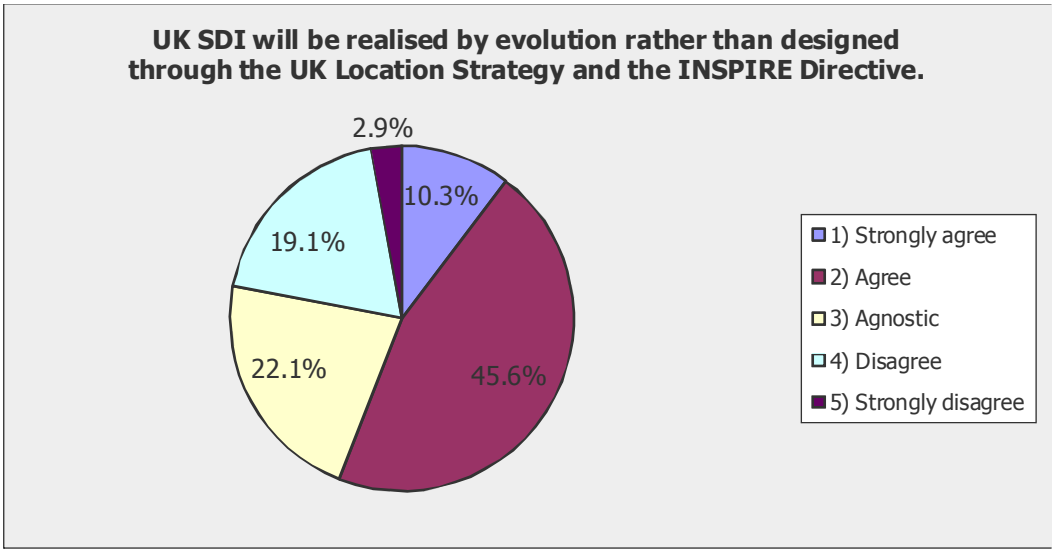
Public Sector Information Policy and Competition The Public Policy Environment	Michael Nicholson Mick Cory	Intelligent Addressing DCAL, Northern Ireland Government
Marine and Coastal market	Mike Osborne	SeaZone
Enterprise Computing	Mike Turnill	Oracle Corporation
Third Sector market	Muki Haklay	University College London
Engagement	Nick Rigby	ESRI (UK)
Location Based Services	Peter Batty	Ubisense
Data Capture Tools and Techniques	Richard Groom	Environment Agency
Standards	Rob Walker	Rob Walker Consultancy
Earth Observation Data	Sam Lavender	Remote Sensing Society
Crime and Public Safety	Spencer Chainey	Jill Dando Institute
Media	Stephen Booth	PV Publications
Surveillance	Stewart Fotheringham	National Centre for Geocomputation, University of Maynooth, Ireland
Value Added Data Natural Resources	Thierry Gregorius Tim Duffy	Landmark
Cartography and Visualisation	Tony Black William Mackaness	Intelligent Addressing University of Edinburgh
Other Contributors		
	John Pepper	UKHO
	Andrew Woolf	Rutherford Appleton Laboratory
	Tony Black	Intelligent Addressing
	Brian Higgs	Dudley Metropolitan District Council
	Alun Jones	GeoInformation Group
	Peter ter Haar	Ordnance Survey

Annex 2: Public Survey

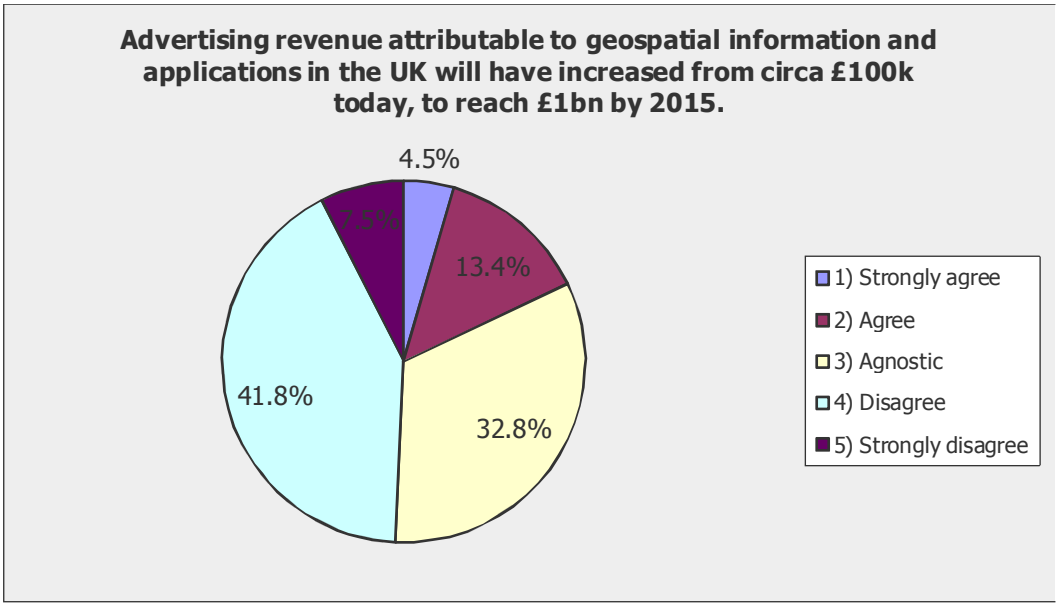
The following charts are extracted from the results of a public survey conducted in January – February 2010 to sample views on some of the key questions raised in the study. There are about 70 valid responses included in the analysis.



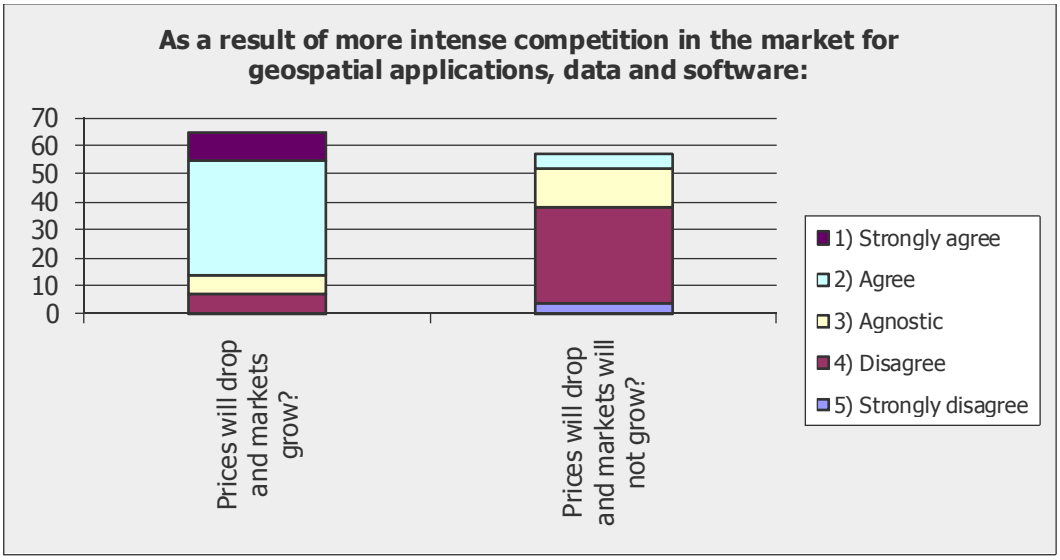
This indicates that although while there is a significant percentage who believe that industry messages about the importance of GI will be recognised, there is still a strong degree of scepticism.



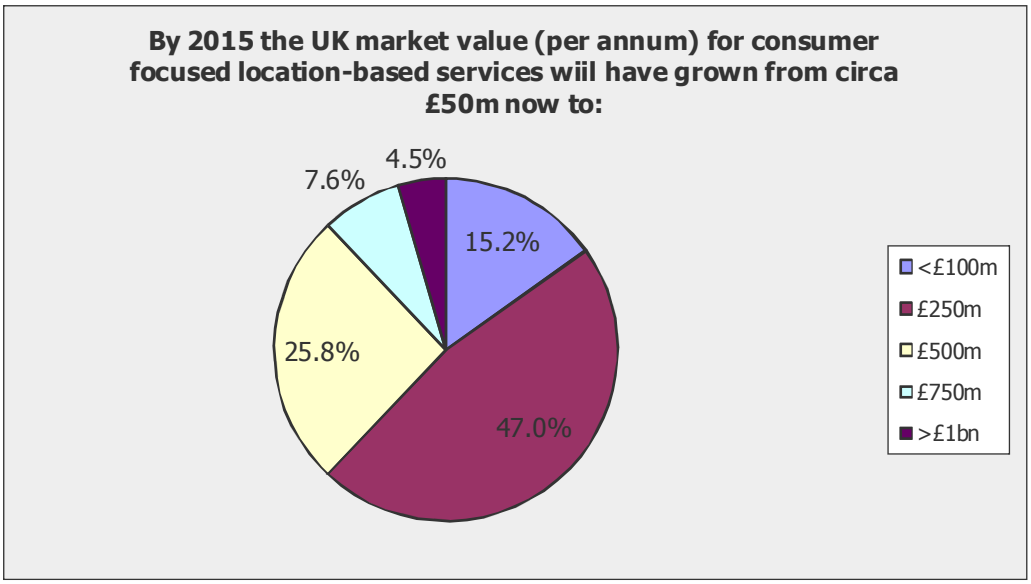
Well over 50% of respondents believe that institutional initiatives will be overtaken by the market.



There is relatively little support (13%) for the view that geospatial advertising revenue will grow exponentially over the next 5 years.



The predominant view seems to be that the market will grow in size but product prices will decrease.



The predominant view is that the UK market will grow strongly to about £250m by 2015.

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