The little book of

National Mapping





Mapping new territory

National Mapping Agencies (NMAs) – custodians of a country's vital geographic records are changing.

From the Royal Registry of Ancient Egypt, through the age of the great, global explorers, accurate mapping and land records have been the very foundation of economic development.

Since those earliest days, NMAs have been recognised as the source of cartographic excellence, keepers of their nation's geospatial truth. But, mapping in great detail and with great accuracy has traditionally required significant investment.

Today, NMAs are under pressure. Their customers (government departments, defence departments, citizens and commercial users) want more. Recognition of the value of geospatial data has grown with the increasing prevalence of location-aware products and services, such as smartphones and social media. There is a growing demand for authoritative data, but users also want it to be ever more current and in a variety of formats.

In many markets, private competitors – perhaps with less attention to detail and accuracy – appear to provide timely data in user-friendly formats. And, like most public organisations, NMAs are also under pressure to achieve all of this with fewer resources.

Faced with increasing demand and decreasing budgets, some successful NMAs are exploring new territory. As the focus of mapping has moved from paper maps to digital, geospatial objects, they are adopting new approaches to maintaining the quality of their critical data. Organisations like Ordnance Survey. Ordnance Survey Ireland and the German Lander consortium Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV) are adopting automated, rules-based approaches that deliver greater accuracy, faster.

With previously time-consuming processes like data validation, integration and map generalisation automated, valuable expertise can be freed to focus on innovating with new products for eager customers.

This book explores the pressure that NMAs face in today's market and how some have successfully adopted automation to save time, money and expertise.

By automating data management processes, these agencies can focus their expertise on innovation, finding new ways to meet demand for authoritative geospatial information; helping to make their national economies smarter.



Custodians of the truth

The earliest records of land ownership date back to 3000BC and the Royal Registry of Ancient Egypt. The Romans surveyed their empire in 300AD and the Chinese were taxing land ownership in 700AD. History's most famous explorers created maps of the world, opened trade routes and fuelled the great economies of their day.

The same is true today. NMAs are recognised in every country as the custodians of authoritative, geographic data and enablers of economic growth. And their role is evolving.

The explosion in data generally, and geospatial data in particular, is driving demand for NMAs' services along three dimensions:

- The increasing prevalence of geospatial data in everyday life
- The need for an authoritative source of geospatial data
- The growth of emerging markets

We are the custodians of the digital, geographic record for the state.

Colin Bray, Chief Executive, Ordnance Survey Ireland

Geospatial everywhere

Almost by accident, we all use geospatial data every day. The intersection of social media and mobile devices like smartphones and tablets is just one, more obvious. example of a growing consumer and business appreciation of the value. power and usefulness of locationspecific data. The emerging "Internet of Things" is another powerful example, as are the deployment of utility smart-meters to consumer homes and the imminent explosion of low-cost RFID tags. All of these devices, and the data they produce, have a spatial dimension. The information's usefulness is seriously impaired if you don't know where it's coming from.

The volume of geospatial data is forecast to grow at a remarkable rate, and it is easy to see why. Networking technology company Cisco Systems estimated that in 2013 there were 10 billion objects (devices and sensors) making up the Internet of Things. That figure is expected to be 50 billion by 2020, as everything from fridges to home heating systems to utility company smart meters start producing data.

At the same time, the richness of data being captured is increasing. Not so long ago, even professional researchers could only access satellite photography at a resolution of one pixel per 30 x 30 m area. Today, Google Earth offers a resolution of 2.5 x 2.5 m to everyone. Three-dimensional modelling is increasingly common, as is the desire to capture geospatial data indoors – within shopping centres or large factory plants, for instance.

To be effective, all of this data needs to be understood with reference to a single, authoritative set of geographic data.

A source of authoritative data

As Colin Bray, Chief Executive of Ordnance Survey Ireland, observed, "Across government, there is now an understanding of the value of spatial information in more effective decision making."

Investment in geospatial systems is forecast to increase by 10 per cent per year over the next few years.² As geospatial data underpins more decisions, organisations are beginning to realise the importance of authority and provenance.

For example, in 2010 Australia's State of Victoria identified that existing geospatial data, published by third parties, had significant quality issues in its currency, completeness and reliability. In response, the state developed Vicmap API,³ a publicly available data-set designed and maintained to be "authoritative, current and clear".

Victoria had commissioned a report from Sinclair Knight Merz, entitled "Business Case for a Spatially Accurate Map Base" which found that local government bodies within the state faced ongoing costs of A\$3 million a year associated with manually adjusting accurate GPS data to align with the variable absolute positions recorded in the cadastral map base.

The need for asset owners, such as local governments and utility companies, to develop their own more accurate versions of the map bases to support their business needs also resulted in duplication costs exceeding A\$1.8 million a year. The report cited one example of a housing development in the urban fringe area of Melbourne, where spatial information errors of up to 20 metres across the site resulted in costly delays and redesign works estimated to cost A\$1 million.4

In registering land transactions, dispatching emergency services, civil engineering and military defence, metres matter

Government and businesses look to their country's NMAs to provide an authoritative point of reference.

At a multi-national level too, initiatives like the European Commission's (EC's) INSPIRE and the European Location Framework (ELF)⁵ projects seek to provide a consistent record across regions, with a clear eye to the vast economic benefits that derive from having an open, standard and authoritative source of geographic data.

Enabling emerging markets

As economies develop, they require increasingly accurate geospatial data: to locate natural resources, to record and enable property rights for individuals and to plan new infrastructure. Demand comes from government and from the private sector: utilities, telecommunications and transport companies. But often, developing countries are starting with little more than a room full of outdated maps and dusty records.

The World Trade Organisation's (WTO) Doha Declaration, affirmed the importance of having "stable, credible and reliable national geospatial information in each country built on internationally recognised standards that will integrate, manage, and deliver geospatial information for timely, evidence-based and authoritative decision making and policy formulation on location-based development issues, including disaster and humanitarian needs."6

Around the world, countries like Botswana are investing in establishing a single, authoritative source of geospatial information and in making that information available in a timely and accessible manner.⁷

In many countries, the issue of open data is seen as an economic enabler by not only making data freely available to the citizen, but in freeing that information from vested interests. In repressive regimes, map data is often a closely guarded military secret.

The challenge of recognition

Growing demand for authoritative geospatial information from NMAs recognises those agencies' longstanding investment in data quality; in maintaining the geographic record for their state. This welcome recognition is not without its challenges.

"Location-based and geographic services produce a global, gross value added (GVA) of

\$100bn

per year."8



Meeting increased demand

NMAs' customers (government departments, defence departments, citizens and commercial organisations) want more. They want more granular, and more accurate data, they want their data to be more current, and they want it in a variety of different formats.

At the same time, NMAs are being asked to achieve all of this with less money and are facing increasing competition from private, commercial organisations.

An investment in accuracy

As the State of Victoria (and many others) found, inaccuracy is expensive. However, the production of accurate geospatial information doesn't come cheap either. It requires investment in the time of skilled surveyors capturing realworld features in sufficient detail. It requires that data to be validated and integrated with existing data, managing and resolving any time-conflicts or apparent inconsistencies with previous data, to form a complete, accurate and consistent model of the surveyed world.

Accuracy also demands that the information be converted into maps (either digital or paper) that accurately and consistently represent the area at every scale. Where NMAs store data in separate databases for every scale or map-product, this means that data must be managed for consistency across all datasets. Inconsistencies between maps of the same area at different scale, or in the way that maps of different areas treat similar features, create uncertainty and could be dangerous for the user.

Equally, consistency builds confidence. Accuracy in generalisation – the creation of small scale maps from large scale detail – is vital to ensure consistency at every scale. Traditionally though, generalisation is a manual, time-consuming and expert-intensive process.



Currency costs

Landscapes change. Urban areas expand, new roads are built, coastlines erode, land floods and lakes dry up.

Users demand up-to-date information and the increasing use of geospatial information in digital apps means that updates are expected at internet speed.

However, the process of surveying to capture changes takes time. Transferring data into the main repository can be a time-consuming exercise of validation and integration that locks out large geographic areas for other data extractions or updates. Bottlenecks occur, work gets backed up, new releases are delayed.

Stepping up

How can NMAs successfully meet growing recognition for their expertise without jeopardising that reputation through lower quality?

For many agencies, the digital revolution has simply been a further step in the evolution from etching limestone tablets, through copper plates, to a digital rendering of a paper map product. Often, these organisations maintain their data in separate databases, one for each map area or "tile".

However, some NMAs are taking a step back and reappraising the way things have always been done.

Efficient creation of new product

The growing demand for faster, better information, without the luxury of additional resource, can render mapmaking a chore. There is little time to innovate and meet customer demand for new solutions. Even meeting mandated changes like the provision of open data – free to the customer but costly to create – or alignment with supranational initiatives like the European Commission's European Location Framework (ELF) can be a challenge.





Example: Ordnance Survey

Ordnance Survey (OS), Britain's National Mapping Agency, has a data-set of half a billion geographic features. Historically, this data was arranged in 286,000 discrete geographic "tiles", each tile being held as a separate database. When a feature within a tile was being updated, the entire tile was lockedout for other users. Where updated features crossed tile boundaries, all related tiles were locked out, too.

OS updates more than 300,000 features each day and editing data soon became very slow, cumbersome and costly.

Malcolm Havercroft, Head of Operations for Data Collection & Management, explains, "A new data model and Geospatial Data Management System was needed, combining all of our data into one place to be accessed by the whole business."

OS drew up over 4,500 detailed system requirements. These included the need to handle up to 30 million feature transactions per day, managing the complete process of data extraction, validation and reintegration with the core data-set.



Together, 1Spatial and OS developed a highly scalable solution that would manage the concurrent editing of features. As a result, the agency now has the largest database of its kind in the world and is enjoying significant benefits

Having all the data in a single database gives the agency far greater flexibility in managing the ongoing work of updating the database. The new data model also enables OS to capture and store more data about real world features. This combination of greater agility and richer data means that OS can develop new, richer products to meet customer demand.

1Spatial's data management tools automate the constant validation of data updates so that OS always has a "product-ready database": a reliable data-set from which new mapping and geographical products can be produced. Data is now routinely available to customers within 24 hours of being surveyed.

The ability to schedule data management tasks concurrently has made the entire process more cost and time-efficient. The system processes the equivalent of 21 real-world changes every minute.

OS is now focused on automatic cartographic generalisation. As a result, the organisation is launching new products such as Street View Plus, an Open Data product providing generalised data to businesses and the public, free of charge.⁹

"The involvement of 1Spatial in this project has given us immense confidence in our ability to manage the quality of our data, which in turn protects our revenues by maintaining customer satisfaction."

Malcolm Havercroft, Head of Operations for Data Collection & Management, Ordnance Survey

Example: Ordnance Survey Ireland

Ordnance Survey Ireland (OSi), Ireland's National Mapping Agency, had seen a steady increase in demand for reliable, spatial data.

"With the everyday use of information on our smartphones or tablets, there is a greater understanding of the value and use of spatial information," explains Chief Executive Colin Bray. "With spatial information, we link all those data-sets whose only common point is location. This has been recognised by all government bodies and there is demand to use spatial data for more effective decision-making."

Like Ordnance Survey, OSi realised that the usual expensive and time-consuming method of managing map data was no longer adequate for their needs.

The agency worked with 1Spatial to develop PRIME2, a real-world, object-oriented database made up of over 50 million individual objects, each with its own GUI (Globally Unique Identifier).

PRIME2 uses rules-based automation to ensure that its data is safe, accurate and always in a validated, publishable state.

Surveyors now receive their projects, along with all required data and imagery, direct to their tablet or laptop.

As the survey work progresses, the system runs over 200 rules on the surveyor's device to ensure his or her data complies with data model requirements. Once the updated information is transmitted back to OSi's offices, a further 400 automatic rules are run before any new data is accepted into the core database. Expert intervention is only required to resolve flagged exceptions in the data

Because only the required data is extracted for any survey, several projects can run concurrently. The system automatically resolves any conflicts and, as Colin notes, "activities that would typically have taken two weeks in the past, can now be done in just one day."



With PRIME2, OSi can now provide its customers with richer, more current information in a standards-compliant format. For example, a utility company planning a new underground cable can gain a much better understanding of the target environment; which surfaces are hard or soft, the form and function of nearby buildings, etc. Richer information enables more accurate costing and more effective planning.

For government departments, PRIME2 provides a standardised and authoritative way for referencing all information that has a location. In turn, this supports more effective decision-making for government. As Colin observes, "No longer is OSi information just a back-drop map, it is actually a fundamental part of our users' business solutions." 10

Quality without compromise

An automated, rules-based approach to data management is helping NMAs to deliver even greater value. They can meet increasing demand for their expertise without compromising quality or increasing operating costs.





The value of rules

NMAs all around the world, along with other large users of geospatial data, are discovering the business value that automating data quality processes can bring. Agencies like Ordnance Survey, the US Census Bureau, Ordnance Survey Ireland and others are automating as much of their data management as possible.

A rules-based, automated approach not only reduces the scope for manual error, it enables complex but routine tasks like data validation, integration and generalisation to be carried out more quickly and at lower cost. The time that experienced cartographers previously spent on these tasks can be focused instead on the truly complex aspects of their role, or on innovating with new approaches and products to meet the growing demand for NMAs' valuable data.

Land Information New Zealand (LINZ) realised a 52 per cent saving on production costs using an automated production flow-line.¹¹

The Survey Department of the Ministry of Development in Brunei Darussalam set itself a goal of reducing production time for topographic maps to 47 days. In the event, production time was reduced to less than 25 days, 50 per cent faster than their initial goal.¹² As the US Census Bureau prepares

for its 2020 decennial national census it is developing an automated data conflation process. Tim Trainor. the Bureau's Geography Division Chief explains, "This is a large, complex and mission-critical spatial database that is growing at 10-15% annually. There are huge demands from the user community for spatial and temporal accuracy and quality. together with stringent processing deadlines. We believe that 1Spatial and LSI's solution will meet our expectations to build an agile. service-orientated architecture, whilst reducing our storage requirements".13

But, how do organisations begin to automate for efficiency? Software alone is not the answer.

"There are huge demands from the user community for spatial and temporal accuracy and quality, together with stringent processing deadlines."

Tim Trainor,
Geography Division Chief,
US Census Bureau

Defining the destination

The most important first step for many organisations is to clearly understand the journey they are on.

Where are they starting from? As described above, many NMAs hold their geospatial data in a large number of separate databases, often one per mapping tile or area; sometimes with a separate set of databases for every map-scale required. Step one often involves building a clear understanding of how current (and accurate) data within each set actually is.

Where are they going?
Unlike less specialist users of
geospatial data, most NMAs have a
good understanding of the current
quality of their data. However, many
haven't fully considered the quality
level that they need.

"Perfection" is not the answer. It is too often unattainable and overengineering comes at a high price.

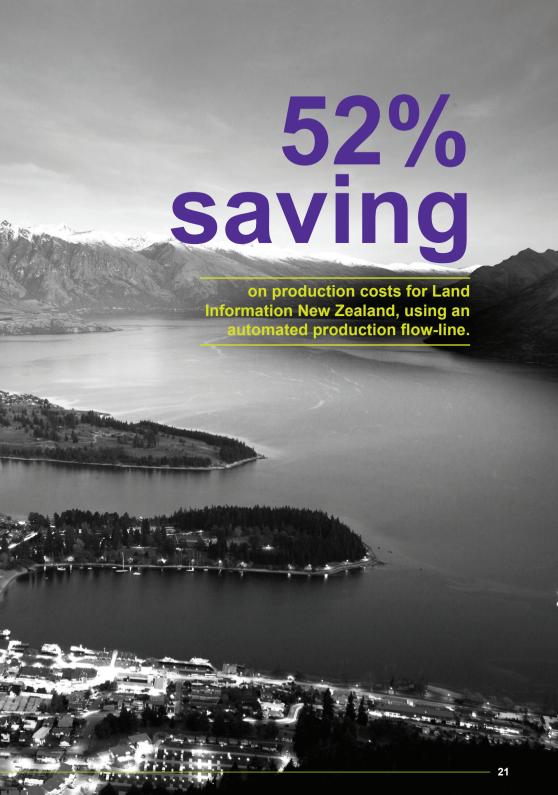
Many agencies – often working with experienced and objective, external consultants like those from 1Spatial – work through a process of defining what Data Excellence means to their organisation.

The cost of quality

Defining data excellence requires an explicit recognition of the cost of quality. This is not just the expense of "yet another data quality exercise", or of having even more surveyors in the field. It is also the cost of having data at a given quality level – acknowledging the potential financial, competitive, reputational or litigious costs and risks of holding data at the agreed level of quality.







A Data Improvement Process

Organisations that have worked with 1Spatial in the past have found it useful to follow 1Spatial's Data Improvement Process.

The process helps organisations to "discover" their data and to define their own required level of excellence. It then supports agencies in defining data rules that can be used to validate their existing data, resolve any issues or inconsistencies and integrate corrected data back into the database

Those same rules are then applied to regular data updates, from field surveyors and other sources, to automatically validate and integrate new data.

Organisations with large geospatial databases deploy tools like the 1Spatial Management Suite (1SMS) to maintain data quality to required standards in a cost-effective and time-efficient way. These allow for sub-sets of geospatial data to be extracted, updated, validated and then returned to the database without affecting the usability of the core data. Such systems ensure that data maintenance can be carried out in a timely and cost-effective manner so that the master dataset is always as accurate and reliable as possible for all users.

As seen in the earlier example, data from OSi's field surveyors is subject to 200 automated rules while still in the field, enabling the surveyor to check his or her findings while still in the survey area.

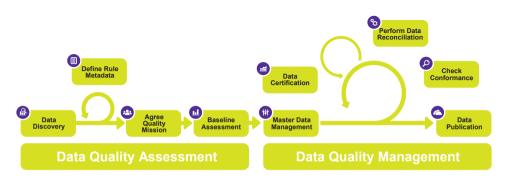


Figure 2: The 1Spatial Data Improvement Process

The data is subjected to 400 further rules once transmitted to HQ before being accepted into the core database. This approach is saving OSi significant amounts of time and money, reducing some activities from two weeks, to a single day.

Rules-based automation also helped No.1 AIDU (the Aeronautical Information and Documentation Unit of the UK's Ministry of Defence) to reduce the update cycle for critical aeronautical data from 28 to just two days.¹⁴

"1Spatial has a good understanding of what's required and over the last couple of years we've developed a very collaborative relationship. It's helped us massively. Not only does it save us a lot of time and money, but it means we end up with the best solution for our needs."

Richard Jennings, No. 1 AIDU, Joint Forces Intelligence Unit Data Excellence Principles

Automation and the European Location Framework

The European Location Framework project (ELF)¹⁵ is a European Commission project to "deliver a Pan-European cloud platform and web services to build on the existing work of the INSPIRE Directive and enable access to harmonised data in cross-border applications."

By connecting the data of each EU country's mapping agency, ELF will provide authoritative, interoperable, cross-border geospatial reference data for accessing information connected to places and features.

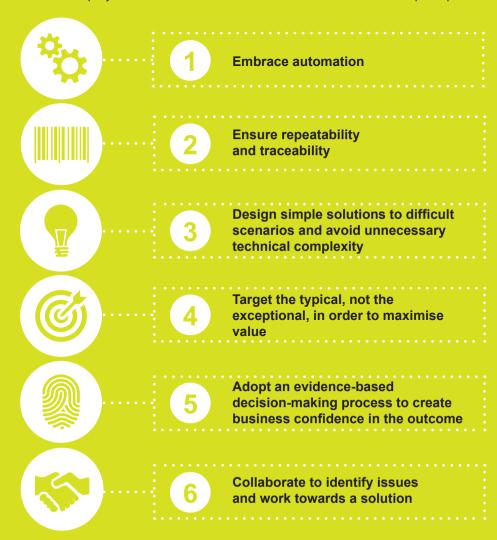
The processes of validating agency data against ELF's data quality rules is ideally suited to an automated rules-based approach. Tools like 1Spatial Cloud enable ELF partners to validate their data against centralised, pre-configured ELF data quality rules prior to edge-matching and generalisation.

Similarly, combining data from several NMAs and managing the once tedious process of edgematching can be achieved using automated rules. ELF data providers have agreed rules that are included in tools like 1Spatial's 1Integrate to enable the process to be as seamless as possible.

Data Excellence Principles

Driving data quality can be expensive and time-consuming, especially without a clearly determined goal. Too many initiatives are planned and run as one-off exercises, and too many run aground by targeting the most difficult problems, rather than considering where the return will be largest.

Successful projects are run in accordance with six data excellence principles:



Generalisation

Generalisation, the process of translating a map product (either a paper map or a digital product) from one scale to another, is typically a time-consuming process. As the level of detail in a map is reduced, it is important that similar features and situations are treated in a similar way. Inconsistencies can be confusing and even dangerous for the map user.

The process of generalisation is also well-suited to a rules-based approach. Agencies that manage their geospatial data in a single, object-oriented database (like Ordnance Survey, Ordnance Survey Ireland and others) benefit from managing a single set of core data. Taking a rules-based approach to generalisation, they benefit from significant time-saving at the production stage, as well.

A number of NMAs have completely automated their model generalisation process and are working towards automating the more complex process of cartographic generalisation.

Using a high level of automation, AdV (the agency that coordinates Germany's sixteen surveying authorities) established a continuous, concurrent and consistent set of data for the whole country at 1:50,000 scale, from its higher resolution data. Rules-based automation enabled AdV to achieve this for the first time and enabled them to provide half yearly updates to their customers, compared to a previous update cycle of 1-5 years.

Benefiting NMAs

The automation of data management is helping NMAs and other large users of geospatial data by:

- Driving business value with cost-effective, time-efficient processing
- Providing customers with more updates, more quickly
- Freeing valuable experts to innovate
- Reducing manual error
- Ensuring an always-ready database



The 1Spatial approach

1Spatial manages the world's largest spatial big data. We work with users – and creators – of the largest geospatial databases on earth, helping them collect, store, manage and interpret location-specific information.

We have clients across the globe: in national mapping and cadastral agencies, utilities companies, defence departments and at all levels of government. Our customers include: Ordnance Survey, Ordnance Survey Ireland, the US Census Bureau, Land Information New Zealand, AdV and the Brazilian Army.

As leader in our field, we have over 45 years' experience and a unique approach, built on a rich heritage of geospatial innovation. This is reflected in our range of software tools (such as 1Validate, 1Integrate and 1Generalise) and in our consultants who are recognised across the industry as experts in geospatial data. 1Spatial is also a partner of the other leading players in the GIS and geospatial sector.

We believe that your view of your data is what matters most. We will work with data-users as well as database administrators to understand how your data is used. You know best what you need from your data and we won't shoe-horn your data into the limitations of any given solution. 1Spatial is committed to supporting open standards in geospatial data and we strive to work seamlessly with all leading GIS systems.

1Spatial's success is built on longterm relationships as a trusted advisor to custodians of geospatial big data. We work alongside you, in partnership, towards long-term goals.

To learn more about how 1Spatial can help to automate your agency and make your data smarter, visit 1Spatial.com/national-mapping



National Mapping
Authorities and
Land Management



Utilities



Telecommunications



Transport



Emergency Services



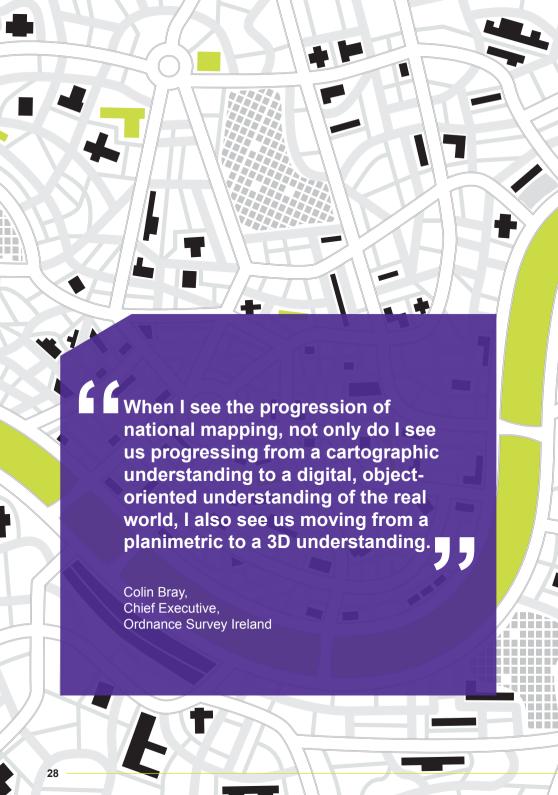
Government



Natural Resources



Defence



Conclusion

These are exciting times for the world's National Mapping Agencies. Increasing use of – and recognition of the value of – location data has led to demand for a single source of authoritative geospatial data.

NMAs have a proud tradition of being their nation's custodians of geographic truth. The challenge today is to meet increasing demand with reducing resources, without compromising on quality.

Successful agencies are achieving this by rethinking their traditional cartographic focus and moving towards a digital, object-oriented approach. These agencies are using an automated, rules-based approach to data management to drive greater business value from their limited resources.

As a result, they benefit from: more cost-effective, time-efficient processing; faster product and data updates; reducing manual error and freeing experts to innovate with more products that unlock the power of their data

1Spatial has 45 years' experience working with the largest geospatial databases on earth. We help national mapping agencies, utility companies, defence departments and the governments of countries, regions and cities to collect, store, manage and interpret location-specific information. Our open approach to data excellence ensures that our tools, processes and the data we manage work seamlessly with other leading players in the geospatial sector.

We hope you have found this guide interesting. We'd like to hear how we could help you improve your data quality processes.

Please visit: 1Spatial.com/national-mapping to request a call from one of our NMA specialists.

End notes

- ¹ Rob Kitchen, The Data Revolution: Big Data, Open Data, Data Infrastructures and Their Consequences (Sage Publications, 2014)
- ² See reports by analyst firm Technavio covering various sectors and regions, http://www.technavio.com/search/reports//GIS
- ³ See: http://api.maps.vic.gov.au/ for further history and information about Vicmap API.
- 4 See: http://www.cio.com.au/ mediareleases/17192/victoria-in-need-of-amore-accurate-map-database/
- ⁵ See: http://www.elfproject.eu/
- 6 See: United Nations Economic and Social Council, Development of a global map for sustainable development (2013), https://ggim.un.org/docs/meetings/3rd%20UNCE/E-C20-2013-6%20Global%20Map%20for%20 Sustainable%20Development%20Report.pdf
- ⁷ See, for example, http://1spatial.com/ customer/department-of-surveys-and-mapping hotswana
- 8 Source: Oxera (for Google), What is the economic value of Geo services? (2013), http://www.oxera.com/Oxera/media/Oxera/ downloads/reports/What-is-the-economicimpact-of-Geo-services_1.pdf

- ⁹ To read more about Ordna ey's Geospatial Data Manager tem, see the 1Spatial case study spatial.com/ customer/ordnance-su
- 10 To read more about line Survey Ireland's approach, at http://1spatial.com/mer/ordn/nce-survey-ireland
- 11 See the 1Spatial tudy at http://1spatial.com/customer/land
- 12 See the 1Spatial com/customer/surver tment-min ry-of-development brunei-d
- 13 For further information the electronic press release at http://lsp.
 news/2013/11/13/1spatial-ls
 3m-u-s-census-bureau-contraction. LSI is 1Spatial's distribution partner.
- ¹⁴ To understand more about this projective see the 1Spatial case study at http://1spatia.com/customer/no-1-aeronautical information-documents-unit
- 15 See: http://www.elfproject.eu/



