Topographic Mapping in Australia: The Future State

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SUMMARY

Geoscience Australia (GA), and its national mapping predecessors, has been responsible for mapping the topography of the Australian continent at national scales since 1956. The State and Territory mapping and land titles agencies have the mandate and responsibility to map their jurisdictional topography and cadastre at medium to large scales. These activities are coordinated through ANZLIC – the Spatial Information Council, and the Intergovernmental Committee for Surveying and Mapping (ICSM). GA represents the Australian Government on each of these peak bodies.

The National Topographic Information Coordination Initiative (NTICI) was established by GA in 2004, with the mantra 'capture once and use many'. NTICI takes a whole of Australia approach to the collection, provision and maintenance of topographic and related information to meet the needs of governments and the public – adding value to the topographic layers of Australia's spatial data infrastructure.

Along with other national mapping agencies around the world, GA is attempting to balance a number of factors within its business, including: the relevance of the traditional paper map in a digital world; the cost of capturing and maintaining data at multiple levels of resolution; how we 'capture once, use many'; and how we use the available technologies to enable consumers to easily discover, access, analyse, visualise and package spatial data.

Achieving a sustainable topographic mapping program in Australia relies on three factors:

- Improvements in and leveraging of technology;
- Changes in the federal government's business ethos; and
- Collaboration.

As described in this paper, GA's objectives are three fold:

- Achieving a whole of Government understanding and articulation of the need for information about the surface of the continent as an underpinning national topographic data infrastructure;
- Appropriately resourcing the collation and integration of new information themes, not only within central mapping agency's business, but with the traditional topography themes and databases; and
- Acknowledging that investment will be required to facilitate a national 'state of the land' dynamic digital database.

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1. INTRODUCTION

Since 1956, initially to aid post-war development, Geoscience Australia (GA) and its national mapping agency predecessors has been responsible for mapping the topography (depicting natural and man-made features of the Earth's surface) of the Australian continent at national scales, and producing and distributing paper maps. In recent times this has included the production of digital versions of these maps plus associated data products for emergency managers, defence, government departments, industry and the public.

Over the past half century the goals of the 'national map' have evolved and changed significantly commensurate with data capture, imagery acquisition, and mapping techniques and technologies. As these have evolved, so too have government mapping agencies. However, recent change has been driven in response to the contemporary needs of an expanding range of users of spatial information. The days of agencies systematically mapping the topography of their jurisdictions have gone, replaced with business driven organisations focussed on responding to the needs of clients, whilst doing their core business in a leaner and more demanding business and government environment.

GA is no exception as it strives to keep abreast of developments within the spatial community and present its topographic and other data to an increasingly spatially aware and enabled society. Mapping the nation at various scales has been, and will continue to be, an enormous task, with the maintenance of this large and valuable data collection, plus collection of new thematic data sets presenting unique challenges. However, technologies such as Google Earth have opened new innovative ways of looking at geography, introducing the use of imagery and maps to the masses in a manner that the traditional map has never been able to do. The availability of large scale mapping built from low cost, high quality data is now the rule rather than the exception.

Before articulating and understanding the challenges of the present and possibilities for the future it is necessary to provide some context from the past. This paper is therefore divided into three fundamental sections with regard to the topographic mapping of Australia:

- Where have we come from?
- Where are we now?
- Where to from here?

2. WHERE HAVE WE COME FROM?

Australia is a vast continent (7.7 million square kilometres of land and 8.1 million square kilometres of sea) with a relatively small population (less than 23 million), the majority of

which live close to or along the coast. Administratively, it is comprised of one federal government, eight State and Territory governments and over six hundred local governments. These arrangements alone have been instrumental in shaping Australia's topographic mapping activities.

When Australia's Constitution was created in 1901 the responsibilities for national topographic mapping was split between the State/Territory and federal governments. State/Territory governments were given the responsibilities for large scale topographic mapping and the federal government for medium to small scale topographic mapping. Over time the involvement of the private sector and local government in topographic mapping has grown. In 1901 it was virtually non-existent. Today, the private sector tends to focus on niche markets – such as car navigation and tourism; while local government focuses on its specific administrative region. Neither plays a significant role in the production of national topographic mapping.

In the federal arena the Australian defence forces have had mapping responsibilities since 1901 – with the Royal Australian Army focused on medium to small scale topographic mapping of the land, and the Royal Australian Navy focused on charting the sea. Many of these maps and charts were restricted to military use only. The Division of National Mapping was created in 1956 as the civilian (or public) producer of national topographic mapping, seen as being essential for post-war reconstruction and national development, and began mapping the entire country at a scale of 1:250K with the Royal Australian Survey Corps.

Remembering that this was an era of manual map production, the first national coverage was completed in 1968 with 544 map sheets using a regular grid of 1^{o} by 1.5^{o}. In the 1980's a number of these map sheets were modified to better cover a geographic feature (eg a city) and/or remove sheets which contained mostly ocean. These 'specials' reduced the number of map sheets to 513. The 513 1:250K map sheet format still exists today as shown in Figure 1. The 1:100K National Topographic Map Series (NTMS) commenced in 1965, with 3,062 map sheets being completed in 1988. 1,460 of those were unpublished line compilations covering Australia's remote interior, and still remain as compilations today.

A new chapter then began in the history of topographic mapping in Australia. The final 1:250K and 1:100K map series, representing more than 3,600 maps at a cost of $600 million, fed into a new 1:250K map series. GEODATA TOPO 250K Series 1 was innovative in that the data was first created in GIS format and then derived the printed map products. Completed in 1995, the 1:250,000 data were branded as GEODATA 250K and the associated 1:250,000 scale National Topographic Map Series (NTMS) maps were branded as NATMAPs.

In September 2003 GA completed another ambitious project – GEODATA TOPO 250K Series 2 – in which, for the first time, all the 1:250,000 scale maps had been produced using a consistent mapping specification to provide high quality data for GIS and mapping via one process. One interesting side effect of this is that the printed maps were consistent and could be joined together, as the photograph (Figure 2) taken in the Great Hall of Australia's Parliament House proves.

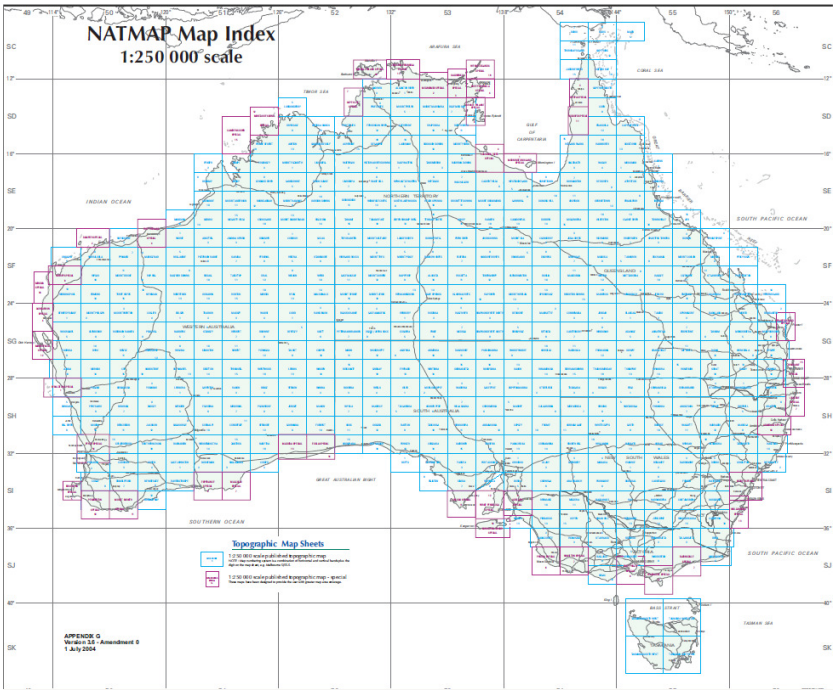

Figure 1: NATMAP 1:250 000 Map Index of Australia.

Figure 2: A new era had begun! No longer was Geoscience Australia locked into (1) producing maps and then producing data and (2) using a regular map grid and all its inherent problems.

GA achieved a major milestone in 2005 with the completion of GEODATA TOPO 250K Series 3, a seamless national digital topographic database that is consistent, rigorous, and built to a uniform specification. Data is held as continuous 'themes' in a spatial database environment, not constrained by map sheet boundaries (tiles), and also web enabled. The 250K NTMS (the printed maps) now represent a direct hardcopy extract from the data. At the

same time, a new raster-based 250K digital product was launched and became the flagship product for GA, with revenue at its peak of around $300,000/year for NATMAP Raster 250K alone.

3. WHERE ARE WE NOW?

3.1 Coordinating Activities

As stated in Section 2 the responsibilities for mapping within Australia is fragmented. For example:

- GA has responsibility for mapping the topography of Australia at medium to small scale (such as GEODATA 250K).
- Defence has the mandate for topography mapping over their properties (such as military training ranges), for air navigation and marine navigation.
- The State/Territory mapping agencies have responsibility for topographic mapping at large scale (such as 1:100,000 to 1:25,000 and greater in urban environments).
- The State/Territory land titles agencies have the mandate to record and map their jurisdictional cadastre.

As part of recognising the challenges associated with this fragmentation, and in a time of reduced government funds, over the last few decades the level of cooperation and collaboration between government agencies (local, State/Territory and federal) has grown enormously. This resulted in the creation of two peak bodies – the first was established to develop national policy and the second to implement that policy:

1. ANZLIC – the Spatial Information Council; and
2. the Intergovernmental Committee for Surveying and Mapping (ICSM).

GA represents the Australian Government on each of these bodies.

In 2004 a vital collaboration tool was established to offset the ongoing and increasing cost of data capture, revision and maintenance – the National Topographic Information Coordination Initiative (NTICI). Created with the mantra of '*capture once and use many'*, and operating under the umbrella of ICSM's Permanent Committee on Topographic Information (PCTI), NTICI is the enabling framework under which a collegiate approach to the topographic mapping of Australia is undertaken. This has the advantage of adding value to the topographic layers of Australia's spatial data infrastructure, whilst recognising the different but complementary roles and responsibilities of the spatial data agencies in each of the States/Territories.

Now in place for 6 years, the NTICI model has focussed on collaboration with State and Territory mapping partners, mapping at large scales in priority areas, aligning with government priorities of the day, and minimising duplication. A cost/benefit analysis, undertaken in 2008, concluded that many projects would not have been undertaken without NTICI and participants believe that the benefits in having updated data far outweighed new costs in production and data integration. New priorities such as social inclusion, water

management and climate change are being aligned with the needs of traditional stakeholders such as emergency management.

3.2 A Change in Thinking

Significantly, the Australian Government Policy on Spatial Data Access and Pricing (2001) was released at the same time as GEODATA 250K was being developed. The aim of this policy is to maximise benefits for the Australia community by increasing access to spatial data. For GA this meant that maps and data could be distributed at little or no cost, and with minimal licensing restrictions. This policy has ensured that GEODATA 250K is readily available for use by the community at no cost.

The policy is also a reflection of a significant change in federal government thinking. Prior to this, products developed by federal government agencies were to be sold to maximise income for the government. The intent was that this income would generate funds for future activities. The change in thinking reflected in the new pricing and access policy represented a move away from an ethos of cost recovery to one of ready dissemination of information to empower the community. This change in ethos continued throughout the 2000's and continues to impact on the work of GA positively.

3.3 Fundamental Australia Wide Topographic Data

When finalised in 2003, the 1:250,000 scale data were contained in ArcInfo coverages based on the extents of each individual topographic map. By 2005 these coverages had been 'joined together' and an Australia wide geodatabase created with GEODATA Series 3. This geodatabase represented a massive technological progression and was the starting point for a new way of working with comprehensive topographic databases. A number of topographic themes are available (such as roads, drainage, elevation, cultural features, administrative boundaries, etc.), all contained within seamless geo-referenced, spatial digital databases and available on the web.

Today, the GEODATA 250K data and the associated NATMAPs are GA's largest scale topographic products. They are fully-maintained and continue to be the flagship topographic product for Australia. Indeed they are the only products which offer complete national coverage of Australia and are a key fundamental resource for such activities as spatial analysis and government policy development. They are used across a broad range of government portfolios covering the environment, water, defence, infrastructure and transport, as well as across a broad spectrum of private industry players for analysis, reference, and planning and product development. In many remote areas of Australia GEODATA 250K and NATMAPs are the only detailed data/map products available and industry, government and the general public are reliant solely on them.

However, GEODATA Series 3 was just that, the third iteration GEODATA product that had first been delivered in 1995 from what was 40 years of hard copy mapping repromat. This history means that it was also largely a cartographic derived database. Many features were

represented as they would be on a map, and not necessarily in their true 'real world' position on the ground. Roads, railways and drainage are such examples, especially where they are closely aligned or coincident with each other. Increasingly users are demanding that the data have positional accuracy that supports its use with GPS. Having data that is of lower positional accuracy encourages the development of alternative data sets and is in conflict with the modern 'point of truth' digital database concept.

Another major dilemma with GEODATA is the fact that it has not been comprehensively or systematically updated since the Series 3 2005 release. A GEODATA Series 4 regime was never initiated, as the resources required were too great, and the benefits too difficult to justify/quantify. Further, the 'series mapping' model had run its course and was no longer relevant in a more dynamic digital data age. The result is that parts of GEODATA are now ten years and more out of date. If we look at this pragmatically from a cost/benefit perspective, much of this is due to Australia's geography and popoulation. The vastness of our continent, combined with a relatively low population, both validates the past approaches described above, and also complicates the veracity of modern up-to-date database concepts. Change in the topography for many remote areas in Australia is infrequent, with updates to the data in these areas often on a 10 year cycle. This is acceptable. In other areas, for instance where there is population growth or infrastructure development, a shorter maintenance cycle is required, particularly with certain cultural themes. GA is not alone with this problem, several of the larger State/Territory mapping agencies are facing the same challenges, as are other nations.

The solution for Australia is leveraging appropriate technology and collaboration. GA has recently created a multi-scale national topographic database that will eventually supersede 250K GEODATA as GA's flagship product, and will relegate 1:1M, 1:2.5M and other smaller scale databases to the past. It is envisaged as a mosaic of national and larger-scale topographic data, so that for any one locality only the largest scale data is stored, and which could be directly imported into State/Territory large scale topographic mapping systems.

The NTICI collaboration (managed via PCTI) has successfully applied a resilient whole of government approach to topographic data collection, integration, dissemination and delivery. NTICI has realised significant regions of new and revised topographic data. In some cases new datasets in areas previously devoid of GIS data have been created and, in other instances 30 year old information has been significantly improved in currency. GA has funded a considerable amount of these data capture and revision programs under NTICI, but it is a partnership – the State/Territory jurisdictions would not have had the ability to capture such data themes alone, and nor would GA.

There is now an increasing reliance by all government mapping agencies on data produced out of this collaboration. With the expected continuation of this successful initiative in coming years, it is envisaged that, in time, data maintenance, rather than base data capture, will become the focus for mapping authorities across all scales and in all jurisdictions.

4. WHERE TO FROM HERE?

So what does the future state of topographic mapping in Australia look like? GA (as are many other national mapping agencies) is cognisant that the days of systematically mapping the nation in a methodical manner, as happened with GEODATA 250K, are no longer viable, and must be replaced with more business oriented approaches focussed on responding to the needs of Government, clients and stakeholders. From a mapping perspective, this requires a cultural transition from a data/product owner/provider philosophy to that of a geographic information content provider, enduring data custodian, integrator, and implementer in order to present data to an increasingly spatially aware and enabled audience. Easier said than done!!

Across the world, there appears to be a poor appreciation, not of the importance of fundamental spatial data and mapping, but of the resources required to build and maintain high quality, authoritative databases. This is not seen as important work and does not have a high profile. Recent discussions with many national mapping agency representatives around the world confirm this lack of appreciation and understanding, and Australia is no different with fundamental topographic information. There is an expectation that it is all being done, that the databases are accurate, consistent and up to date. However, this expectation is not often reflected in reality, moreso when fiscal budgets are tight.

Aware of the increasing pressure to provide richer, dynamic and authoritative data that is 'fit for many purposes' GA is attempting to balance a number of factors within its business, including: the relevance of the traditional paper map in a digital world; the cost of capturing and maintaining data at multiple levels of resolution; how we 'capture once, use many'; and how we use the available technologies to enable consumers to easily discover, access, analyse, visualise and package spatial data. These are being driven by a number of priority incentives including, the new and emerging policy directions of government requiring spatial enablement, agencies needing to 'partner' more to address limited funding and avoid duplication, and the reality that the face of mapping is changing quite dramatically (driven by the user community).

Achieving a sustainable topographic mapping program in Australia relies on three factors:

- Improvements in and leveraging of technology;
- Changes in the federal government's business ethos; and
- Collaboration.

4.1 Technology

To state the obvious, technology has improved dramatically over the last 25 years. At this time PCs first started to appear on our desks, maps were still drawn by hand, and CAD/GIS packages were beginning to emerge as the 'go to' methods of handling spatial information (although this term wasn't in common use then).

This technological revolution has totally changed our thinking and is now a capability that we not only rely on, but expect to help us provide answers to our problems in the future. Consider such things as:

- we now produce authoritative spatial data and then derive by-products that include topographic maps and web services;
- we don't draw maps and then produce topographic data;
- we have in-car navigation systems which talk to us and we rarely use paper maps;
- the web has totally changed how we (and the community) deliver or look for information;
- increasingly services are being provided over the web;
- users expect to be able to access accurate, up-to-date information instantly and do not accept flawed or out-of-date information;
- users are increasingly technologically savvy; and
- these same users do not care where the data comes from. They just want to use it!!

For topographic data producers technology change means that:

- **on the up side**
  - much more can be produced (quantity and quality), in less time and needing less staff resources;
  - data services and products can be derived at multiple resolutions;
  - 'representing' data at several scales is possible;
  - authoritative data is available 24/7 on the web for others to access; and
  - mapping agencies are able to be more flexible, adaptable, and customer focussed.

- **on the down side**
  - users are demanding more complex products and services, and they want them now!
  - staffing is an increasing challenge due to the highly skilled and geographically mobile nature of GIS trained personnel;
  - agencies need to be constantly aware of technology and be prepared to change operations in line with developments. Getting locked in to one single approach is not always beneficial; and
  - the role of the traditional cartographic 'niceties' is no longer so important. Culturally, this reality is perceived as a threat when considering the software making the decision rather than the human.

Recent technological change has resulted in a paradigm shift at GA. Namely that national topographic mapping is no longer systematically produced based on a regular map grid, with a regular update regime and production is now totally digitally based. Challenges remain in streamlining processes in data collection, management, editing, cartographic production, dissemination, and quality assurance. The need to be able to produce the data and cartographic products much more easily from a single database is widely recognised. Further, geography is now more mobile, with data and user-generated content at the fingertips of users and being harnessed as social networks are built in a growing consumer environment.

Although simple, these services are extremely effective in delivering content to the broader community.

4.2 Government

As an Agency of the Australian federal government GA acts in accordance with the policies and guidelines of the current government. With regard to mapping, GA is mandated to '*provide fundamental geographic information at a national scale in a form that facilitates Australian Government and community decision-making and industry development'*.

Today's Australian Government is increasingly demanding more efficient and effective service delivery, policy monitoring and evaluation, underpinned by a strong evidence base to enable better informed decisions. It also sees the spatial environment becoming increasingly more valuable and relevant to government and the community. However, many Government agencies do not effectively use spatial data, technologies and services to support their business or policy evidence base. GA is recognised as the Australian Government's 'spatial agency', and the realisation of the benefits of spatial technologies is growing, bringing with it greater expectation that GA will be able to readily support and/or deliver on such technologies.

The last 12 months in particular has seen an increasing trend in requests to GA for the development of spatial product and service delivery by a diverse portfolio of government departments. These include agencies responsible for driving policy in the areas of water resources, climate change, social inclusion, energy, defence, health, transport, information management, and emissions trading. The majority of these spatial outcomes are underpinned by fundamental spatial information, including topography-related themes. Some, for example water and climate change, are actually building upon and value adding to the existing national drainage and elevation data networks.

This activities represent an important opportunity for GA, through the commonality and convergence of some of these projects, to strategically influence current and developing spatial strategies and maximise the Government's investment in spatial information while significantly contributing to the evidence base for decision making. It also significantly reinforces GA's evolution from a provider of spatial products to a provider of information and services for the Australian Government.

4.3 Collaboration

Continuing the NTICI discussion in Section 3.3, in these resource constrained times the jurisdictional mapping agencies are now finding that alone they do not have the capacity to maintain their data custodial responsibilities. This has led to renewed interest for collaborative projects thereby allowing scarce resources (people and funding) to be spread further. So, initiatives such as NTICI will continue to be the most effective mechanism for maintaining and improving the investment that exists in Australia's topographic mapping. The greater the level of cooperation, the greater the potential for a coordinated approach to value-adding of

the national spatial framework. However, this cooperation and coordination needs to be efficient and effective, rather than a data maintenance burden.

At the most recent PCTI meeting in Brisbane (5 August 2009) GA (as Chair of PCTI) proposed that the future collaborative approach to topographic mapping would need to resemble a distributed data sharing arrangement. Such an arrangement would have multiple benefits including: leveraging smart enabling technologies; improving turnaround times; consistent specifications; a continuing focus on maintenance of priority themes and areas; and integration of NTICI data into jurisdictional and GA databases as 'single point of truth'. Such an approach was acknowledged.

Effective discovery and access to topographic data is vitally important, and will be contingent on a robust national spatial information framework. As long as we persist with a 'stovepipe' approach to data management we deny users and ourselves the opportunity to benefit from all the data available. We are all able to provide examples of such stovepipes, and they certainly exist within government. For example, in GA it is not possible to readily access both the topographic data and satellite imagery without accessing two different systems. The objective should be the collaborative sharing of national spatial information portal that provides access to a virtual network of custodians' data. One in which users will be able to explore pathways to successive datasets unaware that they are moving between custodians sites (government or for that matter the private sector organisations) to acquire what they need.

Technically, given the increasing level of cooperation between jurisdictional mapping agencies, we are not too far short of a prototype being developed. This could potentially be achieved with PSMA's LYNX data management system currently in the advanced stages of development, and presently being built within GA to help serve the outputs of the Commonwealth Spatial Data Infrastructure (CSDI) technical pilot. LYNX combines web technologies with an integrated data model to integrate layers of spatial data within an online environment, and significantly improves the movement of data between suppliers, data managers and clients, as well as incorporate a series of quality assurance functions to enable online acceptance testing. Conceptually, such an approach forms the future for GA's national topographic data consumption and delivery mechanisms with the State/Territory jurisdictions.

5. IN CONCLUSION

Here we are in 2010 entering a brave new world, where there are an enormous number of unknowns which will impact on us, both in the long term and short term. These include:

- What is the future of 'traditional' topographic mapping (if any)?
- How will the emergence of scaleless databases impact on our work?
- How do we ensure that we anticipate and manage change in an appropriate way?
- What technology changes are likely to impact on our production methodologies?
- How will government changes (both in policy and personnel) impact on our work?
- How do we ensure that we remain relevant to the thinking of the current government and position ourselves for future governments?

- How will societal changes and expectations impact on our work – for example the demand for real time and customised mapping?
- What is our relationship to other players 'in this space' – eg Google Earth?
- How will the ongoing skills shortage impact on our ability to undertake work?

In these times of change we must ensure that the things we do are relevant and deliver the information that our stakeholders and the community need, including the ever-increasing needs of the Australian Government. So GA needs to move its work into a new generation of business. The shape of this business is not necessarily clear. The existing mix of fundamental data, leveraged through joint data capture, and data management and delivery skills gives us a solid platform to build on.

We have approached the task of mapping the Australian continent pragmatically and acknowledge that we will always be challenged by scale and our ability to keep data current. Many other nations do not have these challenges. However, we are also much more 'tuned in' to the needs of the Government of the day, and are flexible and adaptable in our approaches to delivering to clients and stakeholders.

While demand for fundamental topographic information will always remain, the future will require new sets of information to detect change of the Earth's surface and measure and monitor the impact of that change over time. Examples of these new information demands we are experiencing already include:

- high resolution national Digital Elevation Models, rather than contour maps;
- connected hydrological drainage networks, that can model water flow across the landscape both in drought and flood, instead of river course or outlines of water bodies; and
- data on the state of the land, such as the dynamic health and moisture of vegetation and soils.

Modern topographic data has the capacity to provide the underpinning thematic framework for many spatial questions, especially when carried out on time series basis. Such data and information will provide a rigorous evidence base to aid Australia's future development. However, despite the potential benefits, many government agencies do not effectively understand or use geospatial data, technologies and services in support of their business. Worse still, they do not know where to go to find it. Further, mapping agencies are typically seen as data content providers rather than applying data and knowledge to contemporary problems.

As described in this paper, GA's objectives are therefore three fold:

- Achieving a whole of Government understanding and articulation of the need for information about the surface of the continent as an underpinning national topographic data infrastructure;
- Appropriately resourcing the collation and integration of new information themes, not only within central mapping agency's business, but with the traditional topography themes and databases; and

– Acknowledging that investment will be required to facilitate a national 'state of the land' dynamic digital database.

BIOGRAPHICAL NOTES

Greg has prepared this paper from two perspectives, firstly as Leader of the National Mapping and Information Group in Geoscience Australia, and responsible for Australia's national topographic mapping program. Secondly and equally as pertinent to this subject, as the Australian Government representative on the Intergovernmental Committee on Surveying and Mapping (ICSM), and Chair of the ICSM Permanent Committee for Topographic Information (PCTI), a working group whose terms of reference are primarily aimed at the Commonwealth and other jurisdictions taking a collaborative approach to topographic mapping of Australia.

Prior to these roles, Greg spent six years leading the development of the Australian Government's spatial analysis and decision support modelling for national security and critical infrastructure protection programs. With over 30 years experience in geoscientific, topographic, hazard and risk analysis mapping, Greg possesses formal qualifications in cartography and survey mapping, has a Graduate Diploma in Science (Geography) from the Australian National University, and has a strong spatial analysis background.

Greg is a member of the Surveying and Spatial Sciences Institute, and Australian representative and immediate past Chair of the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP), and recently Chaired the United Nations Regional Cartographic Conference for Asia and the Pacific (UNRCC-AP).

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