

100 YEARS OF NATIONAL TOPOGRAPHIC MAPPING IN AUSTRALIA

– are we there yet?

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Abstract

The first 100 years of topographic mapping in Australia has been marked by some tremendous achievements such as the Emergency Mapping Scheme of World War 2, the R502 series, the national geodetic network, the National Topographic Map Series, and the first national digital topographic database. Along the way new technologies such as aerial photography, photogrammetry and electronic distance measurement have been adopted early and harnessed in a very practical way to meet the unique challenges of the Australian terrain. However, the ambiguity of roles created at Federation and the multiplicity of players at the federal level sometimes led to institutional conflict. The future will also be challenging given the accelerating rate of change of technology, the empowerment of map users and the heightened expectations around accuracy, currency, completeness and convenience of geospatial information. There will be important issues to resolve relating to the appropriate roles for the government and private sector. To be successful in this environment Australia will need to continue the innovative, persistent, pragmatic and collaborative approach that characterised most of the first 100 years of national topographic mapping.

Introduction

This paper provides an overview of 100 years of national topographic mapping in Australia, commencing with the embryonic establishment of the Survey Section Royal Australian Engineers in February 1910. It traces the slow progress prior to World War 2, the major boost to coverage and capability following the emergency mapping scheme initiated in 1939, the substantial impetus given by the drive for post war reconstruction and development, the glory days of the national mapping program in the 1960s-1970s and the more difficult periods in the 1980s and 1990s when government priorities were reassessed. It concludes with an examination of the current state of topographic mapping in Australia with an eye to future technology drivers.

Along the way we look at some of the personalities and politics as well as the amazing developments in technology that have happened over this period. In particular we examine two seminal reports that were arguably turning points in Australia's national topographic mapping journey: the 1951 report by Major General R L I Brown and the 1985 review by Prof J Richardson. Geoscience Australia has arranged for these reports to be declassified and made publicly available for the first time at this conference.

This paper focuses on the national topographic mapping of continental Australia including Tasmania. This is not to downplay the significance and achievement of work to map Australia's continental shelf and offshore territories, but these are complete stories in themselves.

Early mapping of Australia

For the early settlers, most of Australia was literally an undiscovered country. Mapping of 18th century Australia was therefore primarily about exploration and discovery. The explorers fanned out from Sydney, and their trip maps and reports slowly started to fill in what previously was a blank canvas. Despite this activity, concepts like the belief in an inland sea lingered into the 1840s. By 1850 seventy percent of the continent was still unknown to the new settlers (Lines, 1992). In fact it was to be more than 150 years after the arrival of the first fleet before the first comprehensive delineation of Australia's topography was achieved. This was not really surprising given the magnitude of the task and the lack of skilled resources and technology.

The arrival of Major Thomas Mitchell in NSW in 1827 and his subsequent appointment as Surveyor General was a significant milestone. He resolved to commence a trigonometrical survey to better control the surveys and mapping required to support land grants and other development. In 1834 his map of the triangulation of the 19 counties surrounding Sydney was published as the *Map of the Colony of NSW* and is recognised as one of the best examples of early Australian mapping.

Another early impetus for mapping resulted from the gold rushes of the early 1850s. The Geological Survey in Victoria was founded in 1852 with the aim of developing detailed and accurate geological mapping of the colony. The Survey was headed by Alfred Selwyn who was recruited from the British Geological Survey. Selwyn was an experienced structural geologist who did not believe in half measures. He refused to do small scale reconnaissance maps and at one stage his detailed maps (at a scale of two inches to the mile) were being produced so slowly that administrators estimated 400 years would be needed to cover the Victorian colony! (Wilkinson, 1996) Selwyn was the first geologist in Australia to base maps on a regular grid pattern and to use a uniform scale. Given there were no topographical base maps available at the time, geological mapping at regional scale had to be plotted onto parish cadastral maps produced by the colonial survey departments. Many of these maps did not fit together properly and this introduced distortions. Because the parish maps lacked topographic relief and geodetic control it became usual for geologists to spend the majority of their time on topographic surveying before they could begin recording the geology.

By the time of Federation even the surveying professionals conceded that the colonies had failed to deliver a consistent topographic survey. While the early surveyors were undoubtedly aware of the desirability of planning land development on the basis of good topographic maps, the non-availability of funds and the lack of skilled manpower resulted in cadastral surveys getting higher priority. In a paper for the Victorian Institution of Surveyors in 1901, surveyor and engineer H.E. Coane stated:

'In none of the Australian Colonies has any serious attempt been made to conduct a general systematic topographical survey, although the necessity has long been urged by the Technical Associations. The Geological and Mining Departments of the various Colonies have certainly compiled some excellent geographical maps of the more important gold fields, and together with the Lands Departments, have insisted on their surveyors showing general topographical features on lease and selection plans, but these latter as we know, are usually sketched in the roughest manner...' (Coane, 1901)

Federation

Federation in 1901 did not result in the granting of any direct powers on mapping or coordination of surveys to the new Commonwealth of Australia, and the former colonies did not concede any powers to the Commonwealth concerning land administration.

However, Section 51 of the Constitution through the defence powers together with the Defence Act enacted in 1903 provided authority for the Commonwealth to undertake topographic mapping and hydrographic charting for “Commonwealth purposes”.

The resulting shared authority between the Commonwealth and the States coupled with the lack of clarity in the division of responsibilities was to prove both a burden and a blessing at times over the next century.

It was the Commonwealth’s defence powers that are generally regarded as being the impetus for the first serious attempts at national topographic mapping in Australia. Included in the initial establishment of the Australian army was the Assistant Quartermaster General. This role had a primary responsibility for intelligence but also for military organisation, mobilisation and topography. Major W.T. Bridges was the first incumbent in this role in 1902. In the following years he built up a fledging military topographic mapping capability, generally utilising part-time militia, and firmed up his views on what was required through overseas experience and through seeking advice of foreign military experts. He was particularly convinced of the need for a more systematic approach to the task. In May 1909 Bridges, by then a Colonel, put a submission to the Military Board for the appointment and funding of permanent officers and staff for topographic fieldwork and drafting.

‘There are many places which must be mapped such as Townsville, Albany and Coode Island, where no Intelligence Officers are available. Maps are often required by a fixed date for special purposes such as Staff Rides and Manoeuvres. The time that Militia Officers in the Intelligence Corps can, in addition to their ordinary business, devote to the preparation of military maps is limited. If necessary maps are to be produced within a reasonable time some continuous element must be introduced.’ (Bridges, 1909)

The acceptance of Bridges’ recommendations led to the advertising and recruitment of personnel for the Survey Section of the Royal Australian Engineers. The section became operational on 12 February 1910 with a complement of 7 staff. It is this event that we can justifiably recognise as the true commencement of national topographic mapping in Australia and the trigger for our centenary celebrations.

However, given the shared responsibility for mapping in Australia, an equally significant event took place shortly afterwards. In May 1912 a meeting was held in Melbourne between Charles Scrivener, the Director of Commonwealth Lands and Survey, and the Surveyors General of the States and New Zealand. It was triggered by renewed interest from the Commonwealth following the agreement by NSW in October 1909 to surrender areas of the State for a national capital. There were also other issues relating to surveys and mapping that required consultation with the States.

The meeting discussed the need for a geodetic survey of Australia, the revision of the *Map of Australia* then in preparation, place names, the participation of Australia and New Zealand in the production of the International Map of the World, survey work by the States for the

Commonwealth, and other matters. It was resolved that a geodetic survey of Australia be carried out at a federal level, given it was essential for the production of accurate maps and to provide a standard of accuracy for surveys of every description throughout the country. Despite the constitutional position, the States clearly saw responsibility for both the geodetic survey and the International Map of the World as resting with the Commonwealth even though they would provide “all available information”. However, the meeting didn’t seem to result in much concrete action or momentum, and no doubt the outbreak of World War 1 in 1914 shifted the focus elsewhere.

Another significant milestone was the establishment of the Australian Survey Corps on 1 July 1915. In late 1913, unease about impending war and the lack of mapping caused the commander of the Survey Section Royal Australian Engineers, Lieutenant C.V. Quinlan, to request a re-organisation of the Section. Among other matters his submission recommended that the field operation should be divided into one trigonometric and two topographic sub-Sections based on the premise that triangulation was always to precede topography. His submission received a sympathetic hearing and was ultimately successful. However, the newly created Survey Corps was heavily depleted during the war with most of its members volunteering for overseas service. For this reason mapping in Australia stagnated until the soldiers returned in 1919-20.

Between the wars

While World War 1 further delayed the progress of systematic mapping in Australia it had at least reinforced military views on the importance of complete and current topographic information. Artillery survey functioned most efficiently where gridded maps were available and the use of conformal projections provided gains in gun-fire accuracy. Despite this raised awareness and widespread calls for more and better maps of the continent little progress was made. There seemed little enthusiasm within governments for mapping and the budgetary constraints imposed by the Great Depression only reinforced this.

Another impact of the Great War was a growing paranoia about the use of maps by foreign agents. This resulted in a decision in 1921 to cease the sale of Survey Corps maps to the general public and to only issue maps to government agencies in small quantities for official use. This decision was made despite the knowledge that the use of Survey Corps maps had delivered wide public benefits and saved some users considerable costs. However, this policy did nothing to engender widespread public support for a national mapping program. It was not until 1929 that this policy was abandoned.

One clear driver for topographic mapping to emerge after the war was the growth of the civil aviation industry. Pilots were forced to rely on their skills in visual navigation using ground features such as roads, fence lines, rivers, and railways to navigate by. Given the absence of virtually any topographic mapping outside the capital cities this was no mean challenge, particularly in unfavourable weather conditions.

Here finally was an important, civilian, national driver for topographic mapping in Australia. As a pragmatic initial response strip maps were developed to provide basic route information for the major flight corridors such as between Sydney, Melbourne and Adelaide, using Cootamundra as the common staging point. These first strip maps were produced under the auspices of the newly created Civil Aviation Branch within the Department of Defence. Over the next 20 years a large number of strip maps were produced covering all the major aviation

routes. The aviation industry knew that this was only an interim solution and a map sheet series that conformed to international standards was the real requirement. However, it took major disasters such as the crash of a Douglas DC2, the *Kyeema*, near Melbourne in October 1938 to stir up any political appetite for further action.

Aerial photography comes of age

The usefulness of aerial photography for reconnaissance and mapping started to become clear during World War 1. Much technical progress was made during the war and aviators with the Australian Flying Corps gained valuable experience with these new technologies. After the war, in parallel with the growth in the civil aviation industry, interest in the use of aerial photography for peacetime applications increased. In 1923 the RAAF carried out some experimental aerial photography in the Westernport region of Victoria. The experience gained from this exercise was used in a larger scale trial the following year in the Great Barrier Reef.

In September 1924 the Chief Government Geologist of Queensland (B. Dunstan) organised the first systematic aerial photography over a minerals deposit in Australia. An area of approximately 15 km² was photographed at Mt Isa. Dunstan reported that *“The results, however, were very satisfactory and will enable us to put in a great amount of detail when we are prepared to make a geological map of the Mt Isa field”* (Lines, 1992)

By the mid 1920s professional interest was growing in the techniques for extracting topographic information from aerial photography, later known as photogrammetry. By the 1930s these techniques were sufficiently developed for the Survey Corps to use aerial photography supplied by the RAAF as part of the standard mapping process.

The Australian Survey Committee

In 1927 the first interstate meeting of the Australian Surveyors' Institutes was held in Melbourne. One of the conference addresses focused on the lack of maps that could be used as an aid to the economic development of the States and bemoaned the fact that governments were disinclined to spend the large sums of money required on mapping unless this expenditure could be offset by savings directly generated through access to mapping. Of course, this was a difficult proposition to prove. However, the conference did resolve:

“That the delegates to this conference be asked to prepare a statement setting out the reasons they would urge for the completion by the Commonwealth and State governments of a geodetic and topographical survey of Australia, and to forward the same to the President of the conference with a view to having such statements correlated and arranged as a single document for presentation to the various governments” (Lines, 1992)

As a direct result of the conference a group of professionals from the Victorian Institute of Surveyors, calling themselves the Australian Survey Committee, submitted a report to the Development and Migration Commission on 19 November 1929. It set out the poor rate, poor state of, and lack of coordination in geodetic surveying and mapping, and the duplication and opportunity costs of this failure. It emphasised the importance of a first order geodetic survey on which to base topographic maps for the country. While a summary of the report was actually submitted to the federal Cabinet it was accompanied by a recommendation that consideration of adoption be deferred until financial conditions were more favourable.

At about the same time the Department of Defence was taking steps to persuade the States to contribute financially to the national mapping effort. At a conference between the Commonwealth and the States in May 1929 the Commonwealth asserted that only 0.01% of Australia had been adequately mapped. It was agreed to hold a further meeting between Defence and the State Surveyors General.

This meeting was duly held in December 1929. Recommendations centred on the need for topographic maps of Australia, at 1 inch to 1 mile, that such mapping and air photos used in compilation would meet with ready sale if made available to the public, and that compilations would be most economically produced using existing State information, air photos and ground survey. Defence should provide air photography and maps of military importance, States should provide maps of State importance to field sheet stage, and a State/Commonwealth meeting should be held to set the annual program. The thorny issue of financial contributions by the States was unsurprisingly absent from the recommendations. While the report from this meeting was distributed by the Prime Minister to the State Premiers there was a distinct lack of response.

In May 1935 the chairman of the Australian Survey Committee approached the Prime Minister J. A. Lyons regarding the coordination of a number of major Commonwealth projects including a northern Australia survey and navy hydrographic charting. Following this intervention, the Defence Department recommended establishment of a Commonwealth Survey Committee comprising the Commonwealth Surveyor General and representatives from the three Defence services for the purposes of coordinating the efforts and results of the various departments. The Committee was duly established by the Prime Minister in November 1935. The States were advised and invited to cooperate.

The Northern Australia Survey

In 1934 the Commonwealth agreed with the Western Australian and Queensland State governments to conduct a geological and geophysical survey of Australia north of latitude 22 degrees south. This was to be known as the Aerial, Geophysical and Geological Survey of Northern Australia. Funding was provided under a Commonwealth Act of Parliament where the Commonwealth contributed 50% and the two States contributed 25% each. This was the first time the Commonwealth and the States had pooled their technical and financial resources in the search for mineral deposits.

An important element of the survey was the acquisition of aerial photography as an aid to the field parties on the ground. Tenders were called for from the private sector but these proved to be too expensive. Eventually the RAAF offered to provide assistance. Over the 5 years of the survey the RAAF provided aerial and ground support using Gannet and Westland Wapiti aircraft. In the first 3 years of the program the RAAF photographed an area of 36,000 km². (Lines, 1992)

The survey was quite successful in discovering a number of mineral deposits including gold at Tennant Creek. However, the extensive aerial photography coverage generated was not useful for mapping given it was not adequately georeferenced. Some attempts were made to liaise with the relevant State Lands Departments to acquire suitable ground control but these were ultimately unsuccessful.

The period between the wars was marked by many conferences, meetings and committees but not by a corresponding improvement in the progress of the topographic mapping of the nation. The outbreak of hostilities in 1939 consequently found Australia without adequate map cover and with no coordinated survey and mapping program.

World War 2

With war looming in May 1939, the Department of Defence commenced design of an army/civilian structure to bring together the country's mapping resources. At this stage the Survey Corps only comprised 36 military personnel supplemented by some civilian support staff. The Emergency Mapping Scheme eventually emerged out of proposals put to the Prime Minister by the State Premiers at about the same time. Its objective was to urgently prepare maps of Australia for wartime use. In each State civilian liaison officers were appointed to work side by side with the military.

Initial focus was put on accelerating a one inch to the mile program. This involved preparing maps based on the cadastre adjusted to match whatever triangulation existed. To this was added any available height information in the form of spot heights or hill shading. All available material was used in rapid compilation with the end product not necessarily the result of precise surveys. By war's end 170 of these maps had been published as emergency editions (limited relief) and a further 172 as contoured standard editions.

It soon became clear that smaller scale mapping would have to suffice in many areas in order to enable more rapid coverage. It was decided to incorporate maps at the scale of 1 inch to four miles. The series would cover the coastal strip from Townsville in Queensland to Port Augusta in South Australia to a depth of 200 miles, and another strip from Albany to Geraldton in Western Australia to a depth of 100 miles, along with certain strategic areas of Tasmania and around Darwin. More remote areas of Australia would be covered at an even smaller scale of eight miles to an inch. (Coulthard-Clark, 2000.)

In reality, at the time when Australia faced its greatest threat of invasion, there was still a major deficiency in available coverage as the emergency program had been commenced far too late. The Emergency Mapping Scheme was phased out in 1944. In addition to the impressive quantity of mapping product generated, the program fostered Commonwealth State cooperation in a time of adversity and set the scene for continued cooperation after the war. However, while the increase in topographic coverage during this period was impressive it was clearly not of suitable content or quality to meet the future needs of the nation.

The war also resulted in a considerable increase in the size of the Survey Corps. During 1944 the Corps reached its peak with a total complement of 1680, 90 per cent of the authorised war establishment of ninety-seven officers and 1766 other ranks.

Post-war reconstruction

By 1943, with the prospect of invasion of the Australian mainland receding, the Commonwealth Government was already starting to consider the issue of post-war reconstruction. In February that year the government established the Rural Reconstruction Commission under Dr H.C. Coombs, who had just been appointed Director-General of Post-War reconstruction. He was given a broad charter to propose measures for reorganisation and rehabilitation of the rural economy after the war.

Because Coombs was widely respected his reports attracted considerable attention. In early 1944 his third report addressed the issues of mapping and general surveying in relation to land utilisation and farm settlement. The report recommended that the Commonwealth should cooperate with the States to formulate a progressive mapping service where the Commonwealth would provide triangulation surveys and aerial photography while the States contributed “cartographical groundwork.”

At the same time some jockeying for position commenced as to who should be responsible for leading the Commonwealth mapping effort in the post-war era. Colonel Lawrence FitzGerald, commander of the Survey Corps, believed that the Corps should become the “National Survey Organisation” and “take over responsibility for certain mapping for the States” (Coulthard-Clark, 2000). On the other hand the Commonwealth Surveyor General, Frederick W. Johnston, clearly envisaged a strong role for his Department of the Interior as had been envisaged pre-war, and for the Commonwealth Survey Committee which he chaired.

In August 1944 a meeting of the Commonwealth Survey Committee was addressed by a member of the Department of Post-War Reconstruction and Harold Raggatt, Director of the Mineral Resources Survey. They argued in favour of the creation of a new civilian authority to coordinate and prioritise the survey requirements of the departments involved in development projects. Colonel FitzGerald maintained that the national survey authority should be the Australian Survey Corps under the Department of the Army. The ensuing disagreement between the military and civilian members of the Committee was the first appearance of a tension that would persist for a further 50 years.

Subsequent to this meeting the Prime Minister wrote to the States proposing a further meeting between members of the Commonwealth Survey Committee and the six State Surveyors General. This meeting commenced on 15 January 1945 and lasted for 5 days. The key result was the unanimous decision to establish the National Mapping Council. The Council was envisaged as a permanent body with the task of coordinating the mapping activities of Australia. It was to comprise “*The Commonwealth Surveyor General, who shall be Chairman, a member of the Commonwealth Survey Committee, who shall represent the Committee, and one representative of each State, who shall be its Surveyor-General and who shall represent the co-ordinated requirements of his State.*” (Lines, 1992) In practice the Director of Survey, Army was to represent the Commonwealth Survey Committee.

A further significant recommendation was No 3: “*this conference recommends the appointment of the Commonwealth Surveyor-General as the Director of National Mapping, who shall be responsible for the co-ordination of the activities of the Commonwealth and State authorities in planning and carrying out the national mapping of Australia with full regard to the recommendations of the National Mapping Council*”

Federal Cabinet approved the recommendations in March 1945 and the Prime Minister wrote to the States seeking their agreement to establish the Council. Agreement was granted in time for the first meeting of the National Mapping Council to be held in Melbourne on 18 September 1945.

At the same time Johnston decided that he needed to appoint a full time deputy to focus on his new national mapping responsibilities, given his other commitments as Commonwealth Surveyor General. There was consensus that the appointee would most appropriately be a senior officer of the Survey Corps. Following a selection process that included national

advertisements, Major Bruce P Lambert was appointed to this position. This was to prove a very significant appointment as Lambert was to remain at the helm of the Commonwealth's civilian mapping effort for more than 30 years. The appointment was not without an element of controversy. While Lambert saw active war service with the Survey Corps he had been a civilian surveyor prior to the war. He was reported to not be the preferred candidate of Colonel FitzGerald who instead had a preference for Major Donald McDonald, later to become the commander of the Survey Corps himself (Coulthard-Clark, 2000).

In 1947 Lambert established a National Mapping Section within the Property and Survey Branch of the Department of Interior. The new section was to have 53 personnel in three sections: National Mapping Records Information and Research, Photogrammetric Survey, and Cartographic (Coulthard-Clark, 2000). The National Mapping Council met twice a year to provide the guidance necessary to develop new national programs in the areas of aerial, photography geodesy and topographic mapping. In 1951 the States agreed to the Commonwealth proposal that Lambert be re-designated as Director of National Mapping and take over as chair of the Council with the Commonwealth Surveyor General reverting to being an ordinary member.

In late 1947 there was a discussion at a Commonwealth Survey Committee meeting about the relationship with the National Mapping Council. The military view was that the Council was subordinate to the Survey Committee while the civilian view was that it was the reverse. The relationship between Johnston as Surveyor General and FitzGerald as Director of the Survey Corps declined rapidly from this point (Coulthard-Clark, 2000).

The Brown Review

The Department of Defence was becoming increasingly concerned with the emerging evidence of rivalry between Commonwealth civilian and military mapping organisations. In May 1948 FitzGerald put to the National Mapping Council the idea to obtain advice from a neutral overseas expert such as UK Brigadiers Hotine or Bomford on preferred organisational structures, priorities and methods. Defence had a long tradition of employing this approach such as the visit by Lord Kitchener in 1910. However, the civilians in the Department of the Interior and the States were less enamoured with the idea, arguing that there was sufficient home-grown expertise to provide the advice required including those that had knowledge of the latest overseas surveying and mapping techniques. Interior suggested that if Defence wanted to engage an overseas expert then the focus should be on advising the Army on the best program of work to be undertaken by the Survey Corps for Defence purposes. This is in fact what eventuated.

The expert that eventually came to Australia as a result of the Prime Minister's August 1950 invitation was Major General R.L.I. Brown. Brown was Director General of the Ordnance Survey of Great Britain but he had also previously been Director of Military Survey at the War Office.

Brown's Terms of Reference as stated in his report were to answer the questions:

- What is the best programme of work for the Royal Australian Survey Corps for defence purposes;
- To what extent can the Corps co-operate with civilian survey authorities;
- To what extent can the civilian survey authorities co-operate with the Royal Australian Survey Corps. (Brown, 1951)

However, in the best traditions of such reviews Brown did not feel constrained by his brief. *“Wide though these terms of reference are I find it necessary to comment on matters that lie outside them in order to achieve your purpose.”*

Brown consulted widely. Over 60 Commonwealth and State politicians and bureaucrats are listed in his report including the Commonwealth Ministers for Army, Air, National Development and the Interior, and the Premier of South Australia.

Brown’s report still makes an interesting read today. The following extracts demonstrate the wide ranging territory it covered.

On the state of mapping in Australia:

- *The present position of survey and mapping in Australia is one of transition. Until recently the size of the country, the sparseness of its population, the limitations of resources and of technical methods, have placed any comprehensive survey of the country beyond the bounds of immediate practicability. In consequence most surveys of the past have been aimed at meeting particular rather than general needs.*
- *The war gave a great impetus to mapping. Considerable parts of Australia were mapped under the threat of invasion and, in general, great advances were made in the "know how" of mapping extensive areas in a short time.....In spite of this Australia is still largely unmapped*

On what was holding Australia back:

- *There seem to me to be two factors which particularly militate against an increased rate of mapping at the present time and which would be worth examination:
(a) The lack of an authoritative assessment of what mapping is worth to the nation;
(b) The organisation of commonwealth mapping.*

On the value of mapping:

- *The making of maps is not an end in itself. It is useful only insofar as it helps some other activity..... When a map is to hand its existence is usually taken for granted and the evils that its guidance has avoided seldom come to mind at all.*
- *All the evidence of the value of maps is thus not easy to assemble and much is a matter of opinion and therefore requiring shrewd judgment. Although it may therefore be difficult to assess the value of national mapping, it is none the less important that it should be assessed.*
- *...so far as I can ascertain, no assessment of the need for national mapping in the general interest has ever been made by an authoritative and independent body after due enquiry.*

On the division of responsibilities:

- *The responsibility for surveying and mapping Australia is divided. The Department of the Army is responsible for mapping for defence. The Department of the Interior is responsible for mapping for civil flying and for mapping Commonwealth administered territories. Neither department is responsible for mapping in the general interest. The Governments of the States have the widest responsibility for general mapping of their own territories but are not responsible for the mapping required for the performance of the functions of the Commonwealth Government.*

- *Between these two agencies there is considerable friction, which is almost inevitable so long as there is substantial overlapping in their respective spheres of territorial and technical activity.*
- *The States are extremely sensitive to any incursion by the Commonwealth into their province of mapping for the State. Nevertheless, I gained the impression that they would welcome almost any Commonwealth surveys which would assist the mapping of their States, provided that they themselves remained free to use those surveys as they wished and to continue their own State mapping activities unimpeded.*
- *The general mapping of Australia for the benefit of the many activities of the community, including defence, needs to be treated as a whole. It is a single problem which cannot be divided or treated piecemeal without disadvantage.*
- *Perhaps the least satisfactory form of division is that towards which Australia is now tending, that of each government department fulfilling its own needs without regard to geographical frontiers or to the survey functions involved.*
- *Surveys for defence, however, are not limited to those necessary for the repulsion of invaders, but extend to those necessary for any general developments of the country which sustain the defence effort. These merge gradually into surveys of general civil use. No firm dividing line can be drawn between the two, and, indeed, the problem of surveying Australia for national purposes is a single problem, one aspect only of which is the defence aspect; and this problem cannot be divided, either functionally or territorially, without difficulty and without detriment to its ultimate solution.*
- *The chief factors which make co-operation difficult at present are (i) the lack of a clear definition of respective duties, and (ii) an organisation which tends to create overlapping of responsibilities and friction.*
- *The National Mapping Council is primarily a consultative body. Its purview is specifically limited in certain aspects of Service mapping, which forms the greater part of national mapping. Since there is overlapping between surveying responsibilities of the Commonwealth members, which also overlap those of the States members, it can only procure executive action with certainty in matters that are not controversial and can only resolve differences by persuasion. It has little executive power and its principal business is consultation. In that field it does valuable and necessary work.*
- *Until the problems of overlapping have been solved and satisfactory spheres of activity agreed upon and defined, advisory and executive bodies will have difficulty in functioning.*

The report also contained an interesting Appendix D on the “Nature of the evidence of the need for mapping” which included perhaps the first description of spatial data infrastructure:

“Though it is dangerous, because sometimes misleading, to argue by analogy, the analogy between a national survey and the foundation of a great building is singularly appropriate. The foundation is buried underground, out of sight and often out of mind, only guessed at by the uninformed, catches no votes like the superstructure; and yet without it the superstructure does not hold together. A national survey is the foundation on which many of the activities of a nation rest, indeed there are few that do not rest directly or indirectly on it to some extent; geology, forestry, engineering defence, development, motoring, flying, taxation, the law, and so forth.”

Brown's report concluded with the following main recommendations:

- That the need for mapping Australia be examined by an authoritative and impartial Commission.
- That the fundamental geodetic and topographic surveys of Australia be reorganised as a national undertaking.
- That the reorganisation should include arrangements that ensure close and friendly relations between the Royal Australian Survey Corps and the civil survey organisation.

Fundamental to the second recommendation was Brown's concept of what the "national undertaking" would look like. The key features were:

- A single Authority would be responsible for all geodetic and topographic surveying and mapping of Australian territory required for all the general purposes of the Commonwealth;
- The Authority would have a separate parliamentary vote, but having no departmental reason to need its services for special purposes;
- All general mapping and aeronautical charting of Australian territory needed by more than one section of the community would be included in the national program;
- Should any part of the national program be an immediate requirement of one department only, e.g. defence, and not obtain the priority thought necessary by that department, the department would be required, rather than do the work itself, to get it done by the Authority, finding if necessary the money and the manpower allotment from its own resources;
- The Authority would not undertake, except by special arrangement, any survey that was not required to meet the normal and general mapping needs of the nation.
- The Authority, although primarily a civil organisation on a civil vote, would employ, in addition to civilians, officers and survey technicians on the active list of the Royal Australian Survey Corps.
- The Authority would be empowered to invite the Royal Australian Survey Corps to undertake agreed parts of the national survey programme.
- The States would be encouraged to undertake parts of the national program. This encouragement might take the form, for instance, of reimbursement for work done to specification of the Authority.

Response to the Brown Review

Major General Brown completed his report, which was classified as "Restricted", in December 1951. It was received by the Minister for the Army and subsequently distributed to the Prime Minister, the Ministers for Defence, Navy, Air, Interior, National Development and the Public Service Board. Consideration of the report was protracted as some elements were unexpected and even seemed contradictory. For example, while the report recommended a single civilian national mapping authority and even suggested in an Appendix that the Department of National Development might be an appropriate home, it also suggested in another place that "*it would clearly be possible to charge the Royal Australian Survey Corps with the responsibility for national mapping and with the functions of the proposed authority*".

There were also significant issues relating to the concept that the authority should have its own parliamentary vote and that it could employ officers and technicians drawn from the Survey Corps.

An interdepartmental conference took place in September 1952 to formally consider the review. While the recommendations of the report were broadly endorsed there was disagreement around the nature and feasibility of the proposed Authority. Brown was consulted and provided some clarifications in November 1952. His response indicates that he was surprised that his report was viewed as contradictory (Brown, 1951). However, Brown's clarifications seemingly did little to dispel the ambiguity.

In March 1954 the Public Service Board, recognising that a consensus was unlikely to be reached, commenced its own Cabinet Submission on the structure, role and responsibilities of the new Authority. This led to a decision by Cabinet on 22 July 1954 to establish a single Authority with full responsibility for all topographic and geodetic surveys and mapping required for Commonwealth purposes and for the coordination of these activities with the States. These responsibilities were for "all general purposes of Australian development and defence." The Authority was designated as the Department of the Interior. All responsibilities for geodetic and topographic surveys and mapping in the Department of the Army were to be placed with the Authority, with military staff normally employed on these activities to be seconded to the Authority. The decision also included the abolition of the Commonwealth Survey Committee.

Understandably this Cabinet decision was not a popular one with the Army. Not only did the decision seem to spell an end to Colonel FitzGerald's aspirations for the Survey Corps to become the Authority recommended by Brown, it even threatened the continued existence of the Corps itself. To add to the consternation was the perceived haste and lack of consultation involved in reaching the decision and the misleading nature of the brief provided by the Secretary of the Department of the Army to his Minister supporting the Public Service Board's proposals (Coulthard-Clark, 2000). While the Survey Corps did manage to survive, the ill feeling and resentment arising from the 1954 Cabinet decision lingered for many years and was to re-emerge in dramatic fashion in the 1980s.

Advisory Committee on Commonwealth Mapping

A further element of the Cabinet decision was the establishment of a new coordination body, the Advisory Committee on Commonwealth Mapping (ACOCM). The Committee was to comprise the Secretary of the Department of the Interior, a nominee (other than a surveyor) from the Department of the Army and a nominee from the Institute of Surveyors. Its role was to advise the Minister for the Interior on the proper coordination, planning and development of geodetic and topographic surveys, mapping and air photography. It was clear that the intention was to create a body that rose above the feuding factions and had a level of impartiality. To this end ACOCM was quite successful and managed to come up with a workable model for the survey and mapping of Australia over the next 20 years.

ACOCM held its first meeting in Canberra in September 1954. An important early decision was to recommend against seconding Army staff to the Authority as there were a number of practical difficulties associated with doing this. Instead it was proposed that the Survey Corps would carry out specific parts of the approved national mapping program. This is what eventually happened in practice. There was also negotiation around the process by which mapping for defence purposes would occur. In this way ACOCM worked around the most contentious parts of the 1954 Cabinet Decision.

Another important early decision of ACOCM was to set an initial priority on complete mapping of the continent at 1:250,000 scale (the R502 series). This scale was seen as the most practical means of completing a consistent national coverage based on aerial photography in a reasonable timeframe. The decision to adopt metric scales was in accordance with advice in the Brown Review and accorded with Defence's desire for standardisation with key international allies.

The 3rd meeting of ACOCM in June 1955 also agreed to the early production of photomaps prior to publishing of final maps and aeronautical charts and completion of the national geodetic survey. It was further agreed that no larger scale mapping would be contemplated as part of the national program until the national geodetic survey and the 1:250,000 scale mapping were substantially completed.

A further development occurred in May 1956 when the Prime Minister R.G. Menzies announced the move of the Department of Interior's national mapping functions to the Department of National Development, where they would co-exist with its other scientific/technology based activities such as those undertaken by the Bureau of Mineral Resources. A separate Division for these functions was established within the new Department, the Division of National Mapping (Natmap) and funds were specifically earmarked in the federal Budget for the first time. The move of the civilian mapping function to the Department of National Development was viewed as a positive development by Defence as it accorded with the Brown Review's original recommendation and passed responsibility to a new group of bureaucrats with fresh perspectives (Coulthard-Clark, 2000). Harold Raggatt, by then Secretary for National Development, took over as chair of the ACOCM, a role he held until his retirement in 1964.

Mapping moves ahead

The 1960s proved to be a period of achievement for the national mapping program and relative goodwill between all the cooperating parties. Guided by ACOCM and the National Mapping Council, national coverage of the R502 series was completed in 1968. The appointment of Colonel Donald Macdonald to succeed FitzGerald as commander of the Survey Corps also provided a chance to smooth the relationship between the civilian and military mapping agencies.

The R502 series consisted of 540 sheets each of 1 degree of latitude and 1.5 degrees of longitude. While the entire series was based on aerial photography, only 23% of the final products were contoured. RAAF and commercial contractor aerial photography at a scale of 1:50,000 were used. Maps were based on a Transverse Mercator projection and the Clark 1858 spheroid. The Survey Corps and Natmap contributed equally to the program supplemented by a significant contribution of source material from the States.

Field work for the R502 series involved acquiring suitable control for the aerial photography. This involved the use of astro fixes and barometric heighting techniques. This was supplemented by survey control information from State mapping agencies and other sources. Slotted template techniques were used to extend field control to each individual photograph. Topographic detail was extracted from the photography using stereoscopic plotting instruments such as the Zeiss Stereotope and Kail Radial Line Plotter.

Completion of the national geodetic survey

Completing the national geodetic survey of Australia was one of the key initial priorities of the National Mapping Council following its establishment in 1945. This was a massive task given the size of the continent and the fact that the progress made to date had been very piecemeal. The Council was eager to investigate methods of accelerating the process such as the use of airborne radar techniques. Experiments were conducted with the *Shoran* system but in 1949 a decision was made not to use it because it couldn't meet the required accuracy among other reasons.

Undaunted, the National Mapping Council proceeded with the design of the ground-based horizontal and vertical control surveys that would be required to build a consistent national geodetic network. The program received a major boost in 1954 when Lieutenant-Colonel H.A. Johnson joined Natmap as its senior geodetic surveyor. Johnson was an experienced Survey Corps Officer whose last posting had been as Chief Instructor of the School of Survey. Johnson's dedication and expertise were to be the driving force behind successful completion of the survey. In the same year Natmap took delivery of its first electronic distance measuring equipment, the *Geodimeter*. This revolutionary technology was to have a major impact on the quality of the geodetic framework.

In 1957 a successor to the Geodimeter, the *Tellurometer*, was introduced. The Tellurometer was lighter, more portable and could be operated in a wider range of conditions. As confidence in the Tellurometer increased it began to be used for trilateration. It was demonstrated that this method produced comparable results with traditional geodetic survey methods and it was accepted as a first order technique. All surveys necessary for the national geodetic network were completed by 1965. It had been a truly collaborative effort with significant contributions from Natmap, the Survey Corps and all the States.

In 1965 the National Mapping Council adopted the spheroid then recommended for general use by the International Astronomical Union and named it as the Australian National Spheroid. In June that year Natmap commenced re-computation and adjustment of all geodetic surveys in Australia based on this spheroid. In March 1966 this task was completed and a new national coordinate set produced on the Australian Geodetic Datum. This created a unique system for geodetic surveys across Australia free from the discontinuities caused by the use of the various State coordinate systems.

The grid coordinates derived from a Universal Transverse Mercator projection of the Australian Geodetic Datum coordinate set was designated as the Australian Map Grid.

The Australian Geodetic Datum was proclaimed in the Commonwealth of Australia Gazette of 6 October 1966. This proclamation included the parameters of the Australian National Spheroid and the position of the origin point – the Johnston Geodetic Station, named after the inaugural chairman of the National Mapping Council.

The National Topographic Map Series

Following a successful trial by the Surveys Corps of 1:100,000 scale mapping in Papua New Guinea, ACOCM agreed to the use of this scale in Australia. The National Mapping Council resolved in April 1963 that the Commonwealth should proceed with national coverage of topographic maps with metric contours at scales of 1:100,000 and 1:250,000.

On 28 September 1965 federal Cabinet approved a submission for an accelerated program of topographic mapping with the object of completing the mapping coverage of Australia by the end of 1975. This was to be last time that Cabinet formally approved a major national mapping program. The Government had decided that the basic map coverage should be at 1:100,000 scale with 20 metre contours. Natmap was given the responsibility for carrying out the project but the Army had also agreed to the Survey Corps undertaking a substantial portion of the work.

The basic unit of the NTMS was an area 30 minutes of latitude by 30 minutes of longitude. This comprised a single 1:100,000 scale map sheet. A 1:250,000 scale map was formed by combining and generalising its six constituent 1:100,000 maps. All NTMS products were based on the Australian Map Grid. The National Mapping Council set the required horizontal and vertical accuracy standards.

It soon became obvious that the resources allocated to the program would be insufficient to allow publication of all 1:100,000 and 1:250,000 scale map sheets within 10 years. In an attempt to address this problem it was decided that the 1:100,000 maps in a large area of central Australia comprising 48% of the series would only be produced to compilation stage. The boundary of this area became known as the “red line”.

Aerial photography for the NTMS was initially acquired using the Wild RC-9 camera with super-wide angle lens. It was found that the most cost-effective method was to acquire photography at 25,000 feet which resulted in a nominal photo scale of 1:80,000. Natmap utilised private contractors to acquire the photography to the specifications adopted by the National Mapping Council in its publication *Standard Specifications for Vertical Aerial Photography*.

By the time the NTMS program commenced Australia had the advantage of a consistent national geodetic network based on the Australian Geodetic Datum. To provide supplementary aerial photography ground control points, both Natmap and the Surveys Corps used the airborne *Aerodist* system developed by the South African company *Tellurometer*. Aerodist enabled the accurate positioning of unknown ground stations using the position of known stations and trilateration via continuous distance measurement from the aircraft.

For some time Natmap continued to use the slotted template method to control each stereoscopic model, given that a large number of staff had experience in this methodology. However, the Surveys Corps moved to using analytical techniques for numerical block adjustments taking advantage of the rapidly improving performance of computers. Eventually Natmap also transitioned to analytical methods.

Various methods were tried for intensifying vertical control. These included the *Airborne Profile Recorder* (APR) which was developed in Canada in the late 1950s. The system worked on the basis of a continuously measured radar distance between an aircraft maintaining a constant height and the ground. A complication was the need to apply corrections for the effect of atmospheric pressure variations on the aircraft's altimeter. Operational issues with the APR led to Natmap discontinuing use in 1970. An alternative system based on laser technology was developed in Australia by the Weapons Research Institute. The system, known as WREMAPS or the Laser Terrain Profiler, was used successfully by Natmap and the Survey Corps for a period of 10 years.

Digital technologies introduced to map production

With the rapid development of computers in the 1970s it was natural that their application to mapping would be explored. Digital map production methods offered attractions such as the ability to change projection, scale and content quite easily. There was also the belief that the resulting data would probably be useful for other applications at some future stage.

In 1976 the Surveys Corps purchased its first digital cartography system AUTOMAP from the Canadian company SYSTEMHOUSE. Natmap also purchased the same system several years later. It would be fair to say that there were many teething problems with these early systems and the hoped-for productivity benefits were very slow in arriving. While the final phases of map production were faster and less labour intensive, the data capture and editing phases usually involved more time and effort than traditional methods. However, these systems did provide a glimpse of the potential of what was possible and encouraged the Corps to proceed with the acquisition of the more sophisticated AUTOMAP II system from Intergraph Corporation in 1984. Natmap purchased a GeoVision Geographic Information System (GIS) and Scitex scanning system in 1986.

Commonwealth coordination issues re-surface

After a lengthy period of cooperation and achievement, problems started to reappear in 1970. Director of National Mapping Lambert became aware of arrangements between the Survey Corps and the NSW Department of Lands that he believed amounted to an unreasonable Commonwealth subsidy of the NSW State mapping program. He also believed that the arrangement contravened the 1954 Cabinet decision as it had not been formally notified to either National Mapping or ACOCM. An acrimonious exchange of letters followed and Lambert was forced to take a more conciliatory approach (Coulthard-Clark, 2000). The final meeting of ACOCM was held in Canberra on 22 March 1972. With the demise of ACOCM the coordinated approach to national mapping at Commonwealth level started to unravel and it was only the National Mapping Council that provided a continuing measure of national coordination.

The 1:100,000 scale program authorised in 1965 continued on as a joint Natmap/Survey Corps/State project, but was not completed by the original 1975 deadline. For Natmap the main reason was that the allocated financial resources rapidly dwindled as successive governments made staff and expenditure cuts. In addition, new priorities emerged in areas such as bathymetric mapping that further reduced Natmap's topographic mapping capacity.

In 1981 continuing tensions between the Commonwealth agencies involved in mapping, charting and surveying combined with the Government's desire to find expenditure reductions led to the establishment of a review into the scope for merging Commonwealth surveying and mapping organisations. The review was chaired by Peter Moran from the Public Service Board. The Moran report recommended against the merging of the mapping and charting activities of Natmap, the Army Survey Corps (RASvy), the RAN Hydrographic Office and the Australian Survey Office. However, it did recommend a stronger coordination structure and this resulted in the establishment of another interdepartmental committee, the Commonwealth Co-ordinating Group on Mapping, Charting and Surveying. This committee had Departmental representation above the heads of the respective agencies but unlike the AOCM was focused on voluntary coordination and did not have the power to make binding decisions.

In July 1983 the Department of Defence announced a major new initiative, a 1:50,000 scale topographic mapping program covering a large portion of the Australian continent. This drew a strong negative reaction from Natmap due to the lack of prior consultation with both itself and the National Mapping Council. The Department of Defence contention was that this was purely a defence mapping program and consequently there was no need for consultation. However, in 1984 the Ministers for Defence and for Resources and Energy agreed to undertake yet another inter-departmental review of Commonwealth topographic mapping resources and requirements. Unsurprisingly the departments were unable to reach agreement and this led to the issue being referred for resolution to the Public Service Board.

At about the same time Natmap took over responsibility for operation of the Australian Landsat Station (later known as ACRES) from the Department of Science. The Station had been established in 1979 to receive and process data from the USA's Landsat series of satellites. While the resolution of the data at this stage was quite coarse, there was clearly potential for the use this imagery in map production as technology improved.

The Richardson Review

In July 1985 the Public Service Board appointed Professor Jack E. Richardson as its consultant to conduct a review of "Australia's topographic mapping facilities". Richardson was a lawyer by profession and Emeritus Professor of Law at the Australian National University. He was the first Commonwealth Ombudsman, appointed by the Fraser government in 1977. While ombudsman he had not been afraid of confronting the senior bureaucrats such as the Treasury Secretary John Stone. Given this background he seemed a good choice to tackle the seemingly intractable issue of Commonwealth mapping coordination. However, he had no background in the subject matter and no accounting expertise.

Richardson's terms of reference were to:

- Describe current and planned Commonwealth topographical mapping programs for both civilian and defence purposes;
- Describe the topographic mapping programs of the States.
- Identify the resources currently available to Defence and Natmap for topographic mapping and those required to meet planned programs over a forward three year period and proposals for later years;
- Identify and describe the nature and extent of Defence specialised topographic mapping needs.
- Identify the cost structure and productivity of RASvy and Natmap for the production of topographic maps and derived products, and develop product cost indicators for use in assessing future program options.
- Identify options for rationalisation (if any) between Defence and Department of Resources and Energy, assess the benefits and penalties associated with each option and recommend mechanisms for carrying out programs that would meet Commonwealth needs, including the allocation of responsibilities to make the most effective use off available resources.
- Examine and advise on the scope for better coordinating and implementing Commonwealth topographic mapping programs for all civilian and defence purposes.

Like Major-General Brown 30 years before him Richardson felt no need to be constrained by his terms of reference:

“I have not sought to respond to each of them but have taken my task to be that of concentrating on issues in dispute and possible future policies. Inevitably it caused me to examine related matters such as the mapping programs of the States and their abilities to participate in a Federal program.” (Richardson, 1986)

Richardson soon found that he had walked into a complex assignment:

“The areas of agreement on substantial issues between the Department of Defence and the Department of Resources and Energy which I was given to understand were extensive turned out to be practically non-existent. There is a long history of unsatisfactory relations between the Royal Australian Survey Corps, and the Division of National Mapping. It surfaced in 1984 mainly because Defence had decided to embark on a 1:50 000 scale mapping program solely for defence purposes. The unilateral decision was seen by Natmap as violating its traditional role of coordinating Commonwealth topographic mapping programs.”

In examining the business case for the Defence 1:50,000 scale program Richardson noted that it was authorised solely by the Defence Chiefs of Staff Committee in October 1983. This was in contrast to the national 1:100,000 scale program which was specifically endorsed by Cabinet in 1965. Richardson didn't appear fully convinced of the merits of the 1:50,000 program:

“To have a program entirely based on Australia's defence policy which will take at least a quarter of a century to completeseems odd and barely consistent with the claim that there is a real military demand for the entire program.”

Rather than dispute the need for a 1:50,000 program of this magnitude Natmap attempted to demonstrate a parallel civilian requirement and claim that it should share in the delivery of the program on the basis of cheaper cost profile. Richardson felt there was a self-preservation motivation in this stance:

“If Natmap does not acquire a substantial role in 1:50 000 mapping the continuing tasks remaining after the completion of the 1:100 000 and 1:250 000 mapping series would not justify the continued employment of staff at its current level”

Richardson believed the program should be the subject of a specific Cabinet decision and recommended that it be submitted to Cabinet *“for specific approval in the combined interests of defence and national economic and social development”* and with an accelerated timeframe. This recommendation was never followed through.

Richardson became convinced that the two key issues were:

- Natmap's claim to be the national topographic coordinating authority by virtue of the 1954 Cabinet decision; and
- Its claim that it could perform the work at significantly lower cost than Defence utilising the resources of the private sector.

In relation to the first claim Richardson acknowledged the 1954 Menzies era Cabinet decision that clearly established Natmap as *“a single authority with full responsibility for surveys and*

mapping required for Commonwealth purposes and for the coordination of survey and mapping with State authorities.” However, his view was that *“nothing has happened to annul or invalidate the 1954 Cabinet decision but the decision stands as one of little, if any, operative effect in recent years”*. Richardson further suggested that *“if Natmap is to have a coordinating role in the 1:50 000 program it now has to be pursuant to a specific (new) decision by the Government.”*

The examination of the costing claims was a more complex exercise and a quarter of the review report is devoted to this. Richardson was clearly frustrated by the lack of resources at his disposal to examine these issues. *“Most of my time was spent not in leading the review but undertaking it, including most research tasks. My report has a higher personal content than Henry Ford's first motor car.”*

His basic premise was *“if Natmap's costs are lower than RASvy's, it would have a good case to share in the program”* There were many difficulties in doing a valid costing comparison, particularly in relation to Defence costs. RASvy believed they should only be compared on the basis of marginal costs and that their overheads should not be included given *“the raison d'être for RASvy was to provide military personnel trained in mapping and capable of serving in the field and supporting military operations in the event of hostilities on Australian territory”*

Richardson disagreed with the way Defence attributed costs and could not reach agreement despite trying over a period of many months. In the end, with time running out, Richardson gave up: *“with agreement unlikely in the long run I chose to accept the Defence statement as providing a sufficient basis for my purpose to compare costs with Natmap.”*

Despite the difficulties in making a valid comparison, and not helped by Richardson's lack of qualified professional accounting support, he came to the conclusion that Natmap could compile 1:50,000 scale maps at significantly lower cost than RASvy. Looking at the total proposed 1:50,000 scale program he concluded that *“for compilation alone the total saving to the Commonwealth if Natmap had an equal share of the program would be of the order of \$21 million”*

Given the fact that RASvy and Natmap didn't seem to agree on anything, it was inevitable that Richardson would turn to other parties to seek independent advice about policy and technical issues. He consulted with the State Surveyors General, the Commonwealth Surveyor General (John Sleep) and the Navy Hydrographer. He clearly gave considerable weight to their opinions – *“I was much assisted by the Surveyors-General and Directors of Mapping in the States and the Australian Surveyor-General. As will be seen I was guided by their combined wisdom and experience in several aspects of the Review which required the exercise of informed judgement.”*

However, it was doubtful whether any of these advisors could be considered truly independent. Some of Richardson's eventual recommendations were certainly favourable for their organisations. Richardson proposed four options.

Option 1 involved sharing the 1:50,000 scale program between RASvy and Natmap in a way that minimised both the total cost to the Commonwealth and the program completion time. There would be clear lines of demarcation based on the Defence priority areas. While Richardson concluded that *“the advantages outweigh the disadvantages”* for this option and

that it was “*a big advance on the current position*” he recognised potential problems, particularly in relation to the settlement of disputes. To address this he proposed establishment of “*a panel of arbitrators and where an issue arises for settlement the particular arbitrator be appointed by agreement*”

Option 2 involved a variation on Option 1 in that while the program would be shared, the allocation of areas would be the responsibility of Defence. Natmap would also be “*subject, if need be, to direction from Defence on matters which arise from time to time, for example as to the nature of data to be captured, mapping processes to be employed, application of the 1 : 25 000 accuracy specifications, mapping of particular areas within a priority and utilisation of State mapping and survey resources.*”

Option 3 was not about topographic mapping at all but about a proposal to merge Natmap and the Australian Survey Office – if accepted it was compatible with both Options 1 and 2.

Option 4 involved the dismemberment of Natmap by moving the topographic mapping function into Defence (to ensure better coordination), transferring the bathymetric program to the Navy Hydrographer, with the residual functions transferred to the Australian Survey Office. Richardson concluded his report with the melodramatic statement that “*The fourth option is my first preference.*”

Consideration of the Richardson Review

Richardson presented his report to the Public Service Board on 19 July 1986. Two weeks later *Canberra Times* investigative journalist Jack Waterford published a major article “*Mapping Australia well off bearing*” which quoted liberally from the report. Waterford published a second article in the *Canberra Times* on 17 August 1986. In this article titled “*Bureaucrats indulge in a power play to control mapping facilities*” he outlined actions taken by the Commonwealth Surveyor General and head of Australian Survey Office, John Sleep. Waterford noted that the disharmony between the Natmap and Defence exposed in the Richardson Review was just “part of a much wider war going well beyond the mapping domain”. Based on leaked documents he reported that Sleep had written to his counterpart in South Australia asking him to write to his State colleagues “suggesting to them that they each write to their respective premiers...advising of a withdrawal of support for the National Mapping Council.” (Waterford, 1986)

Richardson’s recommendations were put back to the respective Ministers and Departments in an attempt to reach an agreeable compromise. The responses were quite predictable. Defence hotly disputed Richardson’s cost comparisons and virtually all other criticisms of RASvy in the review, but supported Option 4. Natmap supported Option 1 with clear lines of demarcation. The Australian Survey Office put in a submission supporting Option 3.

In November 1986 the National Mapping Council was dissolved in the way envisaged by the Commonwealth Surveyor General. The Council had achieved much in its 41 years of existence but the tensions between the Commonwealth members since 1981 had lessened its effectiveness as a coordinating mechanism. Its lasting legacy was probably the excellent work done initially by its Technical Sub-Committee and later by the Technical Advisory Committee in developing agreed technical standards and sharing expertise on technical issues. This work continues today in the Intergovernmental Committee on Surveying and Mapping.

The Ministers for Defence, Finance and Resources and Energy continued their consideration of the Richardson Review into 1987. At some stage prior to the federal election they reached agreement on the preferred response. The return of the Hawke government was accompanied by a major shake-up of the bureaucracy and the creation of “mega-departments”. As part of this process, under the Administrative Arrangements Order announced on 24 July 1987, Natmap was transferred to the Department of Administrative Services and subsumed within the Australian Survey Office. Eventually the merged organisation became AUSLIG (The Australian Surveying and Land Information Group). Natmap’s bathymetric program was transferred to the Navy Hydrographer. These moves effectively implemented Richardson’s Option 3 and part of Option 4 but without the civilian involvement in the Defence 1:50,000 scale program that he envisaged under either option.

Separate pathways - civilian

AUSLIG was given a strong commercial focus. It was required to implement full cost recovery from the outset, and major Commonwealth clients such as Defence, the Australian Bureau of Statistics and the Australian Antarctic Division were soon free to source their surveying and mapping services from other providers. Topographic mapping was still seen as a “public interest” activity but there were pressures to minimise the costs and maximise any possible revenue returns.

The mapping component of AUSLIG now had a very clear focus. To start with there was the completion of publication of the National Topographic Map Series (NTMS) at scales of 1:250,000 and 1:100,000, which had commenced in 1965. The fact that this 10 year program had still not been completed after 20 years had been the subject of much criticism in the Richardson Review. The publication program was completed in 1988. Of the 544 maps published at 1:250,000 scale 68% had been completed by Natmap/AUSLIG, 30% by RASvy and 2% by the States.

In addition, focus turned to revision of the early NTMS maps as many of these were now badly out of date. In 1988 AUSLIG commissioned a review of “The Commonwealth’s Requirement for a Map Revision Program” by former Victorian Surveyor General Ray Holmes. Holmes believed that AUSLIG staff needed to switch their mindset from producing maps to “managing the ongoing and timely revision of a national asset in the most cost effective manner” (Holmes, 1988). He believed that AUSLIG should maintain a 10 year median revision cycle for NTMS maps in populated areas with a 15 year cycle in remote areas. He also recommended that AUSLIG develop a national digital topographic database sourced from data at 1:100,000 scale. Holmes believed that an annual investment of 1% of the total sunk cost of the NTMS per year in revision would be well justified. He believed this equated to \$6 million per year in 1998 dollars, which would be about double this amount in present day terms. Despite Holmes’ recommendations a decision was made to initially concentrate on bringing the 1:250,000 series up to date as there were simply not enough resources available to maintain the 1:100,000 series as well.

Digital versions of the NTMS products had been produced and distributed by Natmap since the early 1980s. However these merely replicated the appearance of the map and were not structured topologically in a way that was useful for GIS analysis. AUSLIG initiated a program to build topographic mapping data products specifically designed for GIS. This meant major changes to specifications and quality assurance procedures. The new product range was branded as GEODATA and the first major product was to be based on the

1:250,000 NTMS (GEODATA TOPO-250K). In order to deliver this product quickly a “selective revision” process was introduced which focused on only incorporating major changes such as new roads and railways. AUSLIG started working with non-traditional partners such as the NRMA to source revision intelligence which pointed to where such changes were occurring. Landsat and SPOT satellite imagery were used extensively to capture the spatial geometry of changed features. In November 1994 national coverage of GEODATA TOPO-250K was completed and received a favourable reaction from stakeholders

Following the election of the Howard government in 1996 a decision was made to sell AUSLIG’s commercial business and to market test its public interest activities, including mapping, for outsourcing. This eventually led to the closure of the Dandenong Office which had been the hub for AUSLIG’s topographic mapping activities and the engagement in 1997 of a panel of private sector map producers with AUSLIG acting in the role of expert purchaser. Later in the same year the Department of Administrative Services was abolished and AUSLIG was moved into the Department of Industry, Science and Tourism.

In 1998, AUSLIG established a separate external commercial panel for 1:100,000 map production. This was a two year pilot program intended to update the 1:100,000 topographic maps. While the outsourced 1:250,000 program had got off to a slow start it was successfully completed. However, the outsourcing of the 1:100,000 mapping was less successful and the program was not extended.

In September 2001 the remainder of AUSLIG, essentially the elements inherited from Natmap, merged with the Australian Geological Survey Organisation (AGSO) to form Geoscience Australia. Unlike the situation in the 1980s this was a merger that both former agencies welcomed.

Separate pathways - military

Following the demise of Natmap in 1987 the Survey Corps was left to pursue its 1:50,000 mapping program unhindered by outside interference. However, this situation did not last for long and over the next 10 years the Corps was subjected to a range of internal Defence reviews and initiatives.

In August 1988 a report on the Survey Corps commissioned by the Chief of General Staff recommended that the field survey squadrons be combined into 1st Topographic Survey Squadron based at Enoggera. The report also recommended more work on design of the Corps database format so that it was capable of meeting all defence geospatial needs into the future.

In 1990 the Government commissioned a wide ranging review *The Defence Force and the Community* (Wrigley Review). This included an examination of Defence GIS capability and the role of the Survey Corps. Wrigley concluded that “*Defence could and should withdraw from the operational side of land mapping and concentrate on developing a management team committed to obtaining good value for money in contracting the input needs of its geographic information requirements...*” (Wrigley, 1990)

In March 1991 the Army responded to the report of an inter-departmental committee set up to investigate the geographic information components of the Wrigley Review. The committee had concluded that the surveying and mapping activities could be civilianised but expressed

some doubts on commercialisation because of the possibility of a monopoly situation developing which would end up being more costly. The Army responded that there was scope for civilianisation but that any action should wait until the Army had defined the levels necessary for the topographical element of its combat force and those associated with its technology upgrade program *Project PARARE*.

In 1993 Army concluded that standard topographic mapping of Australia was a ‘non core’ activity and hence would be subject to the Commercial Support Program. As a result of a tender process the ‘in-house’ option, which was based on the establishment of new civilian organisation called the Army Topographic Support Establishment (ATSE) in Bendigo, was successful. ATSE retained many of the Survey Corps staff although many of the officers transferred out of Bendigo or left the Army. It continued the 1:50 000 production program using the ‘newheart’ system due to delays in commissioning the *Project PARARE* systems.

In July 1996 the Survey Corps was merged with the Royal Australian Engineers and the Directorate of Strategic Military Geographic Information (DSMGI) based in Canberra became responsible for managing the ATSE work program. In November 2000 the DSMGI and the Australian Imagery Organisation were merged to form the Defence Imagery and Geospatial Organisation (DIGO).

A new era of collaboration

Within a short period of time in 2000-2001 both the civilian and defence mapping agencies had undergone significant administrative changes. This created the opportunity for a fresh beginning and offered the potential for a new era of collaboration. This commenced with an early visit by the inaugural head of DIGO Chris Stephens to meet the AUSLIG General Manager Peter Holland. The ensuing discussions revealed opportunities for mutually beneficial collaboration in the areas of map and data production, printing, storage and distribution.

The arrangements were formalised through an exchange of letters between the Minister for Defence and the Minister for Industry, Tourism and Resources in May 2002. The Ministers indicated that Geoscience Australia and DIGO should work closely together with the shared goal of achieving greater coordination and cooperation in the collection and management of geospatial information over Australia.

The renewal of the Geoscience Australia map production panel in 2002 included categories of work for the production of onshore, unclassified geospatial products for Defence. Around this time ATSE was absorbed into DIGO and the first cover of Defence 1:50 000 topographic maps was completed with the publication of the ‘Prince Regent’ blocks in 2003. Over 1600 sheets were completed north of latitude 20° south. DIGO’s focus was by now predominantly offshore.

In 2003 the last of the GEODATA TOPO-250K Series 2 tiles and associated maps were completed by Geoscience Australia. This program achieved complete coverage of Australia to a single specification in a five year period. As part of the program all of the existing data from the NTMS series was moved to the new Geocentric Datum of Australia (GDA94). The program relied on the work done for the NTMS and GEODATA Series 1 and built on this. Map and data products were derived from the same dataset ensuring consistency between the two products. The new coverage was launched at a function in the great hall of Parliament

House which featured a mosaic of all of the maps. The next stage in the development of the 1:250 000 data was Series 3. This was a program to combine all of the data into a single seamless database and was completed 2005. It facilitated web-based delivery of the information through the *Map Connect* application to allow users to view an area of interest without having to move between tiles based on map sheet areas.

In November 2003 the Intergovernmental Committee on Surveying and Mapping (ICSM) established the Permanent Committee on Topographic Information (PCTI). This resulted from the need to improve the coordination of topographic mapping activities particularly between the States and Territories and the Commonwealth. There was a recognition that each of the jurisdictions had limited resources and that by working cooperatively more could be achieved. This process was accelerated by the identified need to improve mapping for emergency response which was apparent in the aftermath of the January 2003 bushfires in Eastern Australia and was to be highlighted in '*A Nation Charred: Report on the inquiry into bushfires*' by the House of Representatives Select Committee.

Market research at this time identified the need for topographic information with higher positional accuracy to be compatible with the GPS units in widespread use by the emergency services. At the same time there was increasing focus on targeting the revision of data of specific features rather than systematic revision of all features in an area. In 2005, the ICSM launched the National Topographic Information Coordination Initiative (NTICI). NTICI resulted in much closer cooperation between the States and the Commonwealth with collaborative projects jointly conducted by Geoscience Australia and the relevant jurisdiction. The NTICI program is based on the maxim 'capture once use many times'. Under this program work has been carried out over significant areas of Australia. The projects have directly contributed to preparation for emergency response, in particular in the provision of data for topographic atlases produced for fire authorities.

Geoscience Australia's current focus is on improving the efficiency of these projects as a vehicle for updating its small scale products and improving commonality of the structure and schemas between the various agencies. There is also an increasing emphasis on the delivery of data in both vector and raster formats across the web, in preference to distribution of hardcopy printed products.

Recent years have also seen a significant increase in the resolution and quality of the national Digital Elevation Model (DEM) products available from Geoscience Australia. Version 3 of the 9" DEM released in 2008 was supplemented by data derived from the Shuttle Radar Topography Mission with data at 3" resolution publicly available and data at 1" resolution available to government agencies.

The future

So what are the lessons of the first 100 years of Australian topographic mapping? Does topographic mapping in Australia have a future, or are we entering a totally different paradigm?

Mapping has gone through the classic cycle of science development. It has operated under a 'normal' paradigm for a period, then encountered a disrupting crisis from which a new 'normal' emerges. The cycle then repeats itself. This model applies to both the technology and purpose of topographic mapping.

Over the last 100 years, we have seen a sequence of normals and crises. From a technology perspective we have seen the disruptive influences of aerial photography and photogrammetry, electronic distance measuring, satellite positioning and imagery, digital computing and information systems and most recently the internet. From a purpose perspective we have seen the disruptive influences of land development, war and other emergencies, demand for resources, and concern for the environment.

Traditionally, hardcopy topographic maps have been used as base maps for other data (eg geology), for navigation at a local level, to locate points on the ground, and as tools for interpretation of the landscape. Even until as recently as ten years ago, the demand for mapping was still mainly for systematic series coverage over the Australian continent, with the hard copy map being the core component of output. However the last decade has seen accelerated growth in digital information and communications technology including availability of GPS and mobile navigation systems. The need is no longer focussed on delivery of a hardcopy product for input to decision making or situational analysis, but increasingly for digital spatial information as input to intelligent information systems.

User expectations have changed dramatically. They want information that is more *accurate* – with a spatial accuracy compatible to what can be delivered by GPS. They want information that is *current* – 10-15 year median revision cycles won't satisfy today's near real-time applications. They want information that is *complete* and that is structured so more and more detail is revealed as you zoom in. And finally they want data that is *convenient*, preferably available on-line in a form that can be customised, shared and 'mashed up' with other information.

Printed topographic maps will struggle to meet all of these expectations – accuracy, currency, completeness and convenience. Despite this there will undoubtedly still be some demand for the traditional paper map in providing contextual overviews and formal records. For some users and applications, the printed form will continue to be attractive – the internet has not (yet) killed the printed book!

The expectations around currency of data have changed enormously due to the demands of applications such as vehicle navigation, logistics, and evidence-based policy. Richardson, in his 1986 review, saw a five year update cycle for paper mapping as a pipe dream. But for many applications now this level of currency would be totally inadequate.

In the 21st century the increasing penetration of services such as on-line mapping systems and the ready availability of GPS for navigation are reducing the need for traditional style topographic maps. There is, based on these systems, an increasing demand for data that facilitates analysis. Such data are expected to be authoritative, national in coverage, well attributed and timely. All the signs are that after a long period of gestation the demand for this kind of spatial data is finally taking off.

Given the efforts of the new private sector players, the question arises whether government mapping agencies have a future role in providing geospatial information to the general public and for other areas of government. There is debate about the generalised level of information provided into the public domain through non-government sources, of data that is designed to be 'fit for purpose' and 'just good enough' for simple generalised applications. For example, data for free on-line mapping applications needs to be 'good enough' to meet the needs of

advertisers and is not therefore necessarily based on the latest or most authoritative sources. It is certain there is still a public and government demand for ‘authoritative’ data and arguably that there is a public expectation that government should be the source of data with the highest level of integrity. An example of this is the recent 2011 Queensland floods, where insurance companies claimed that provision of authoritative data on areas prone to flood should be a government responsibility.

Consequently, if the approach to the future is a rigid definition of ‘national topographic mapping’ in its traditional sense, then there will be a clear misalignment between the outputs of traditional agency map producers and the current and future needs of government, industry and the broader community.

So what are the current alternatives to government developed geospatial data?

Crowd sourcing of datasets is a phenomenon that cannot be ignored. In the geospatial context it has been tagged as ‘Volunteered Geographic Information’ (Goodchild, 2010). This is clearly most appropriate for sourcing near real-time, point based information. While crowd sourcing has its problems, particularly regarding authenticity and accuracy, it surely has a role in the collection and quality assurance of large datasets and thematic, geographically spread, information. The challenge for government is to harness this resource in the same way as it is now making use of on-line social media in its public communications strategies. By no means is this an easy task as it will need to ensure that there are appropriate methods for cross verification of information and quality assurance processes in place when verifying data quality and accuracy.

The ‘topographic’ element here is also critical. The future government topographic mapping function will not be about collecting every piece of geospatial information, but will be about acquiring and maintaining the authoritative, fundamental topographic layers that will be critical for a wide range of applications. This will require increased levels of cooperation between tiers of government. The traditional concept of ‘division of responsibility on the basis of scale’ has been made redundant by advances in technology.

One thing is for certain. Just as experienced in the first 100 years, the disruptive progress of technology will continue but at an accelerated pace, and it will bring with it new opportunities for topographic professionals. The challenge will be to embrace these opportunities with an open mind and be prepared to harness the collective capabilities of the government and private sectors as well as the public at large.

Conclusion

100 years of topographic mapping in Australia has been marked by some tremendous achievements. After a slow start, the Emergency Mapping Scheme during World War 2, the R502 series, the national geodetic network, the National Topographic Map Series, and the first GEODATA coverage are achievements that Australia can be justifiably proud of. Along the way new technologies such as aerial photography, photogrammetry and electronic distance measurement have been adopted early and harnessed in a very practical way to meet the unique challenges of the Australian terrain.

The ambiguity of roles created by the loose arrangements for mapping created at Federation has led to inertia and conflict at times between the States and the Commonwealth. There have

also been unfortunate disputes between the various players at the federal level that have reduced the overall effectiveness of what could otherwise have been achieved. However, for a large part of the last 100 years the various parties have worked well together and each contributed their particular expertise and resources to the daunting task of mapping Australia. Cooperation is certainly the current state of play and this needs to continue given that the resources of the agencies involved are nothing like what they were in the glory days of the national mapping program, yet the expectations of users are more demanding than ever before.

The future will be challenging given the rate of change of technology, the empowerment of users and the heightened expectations around accuracy, currency, completeness and convenience of geospatial information. There will be issues to resolve relating to the appropriate roles for the government and private sectors. To be successful in this environment Australia will need to continue the innovative, persistent, pragmatic and collaborative approach that characterised most of the first 100 years of national topographic mapping.

For better or worse we aren't quite there yet. In fact the most challenging and exciting times are probably still ahead. The 'undiscovered country' is no longer geographic – it is institutional and technological.

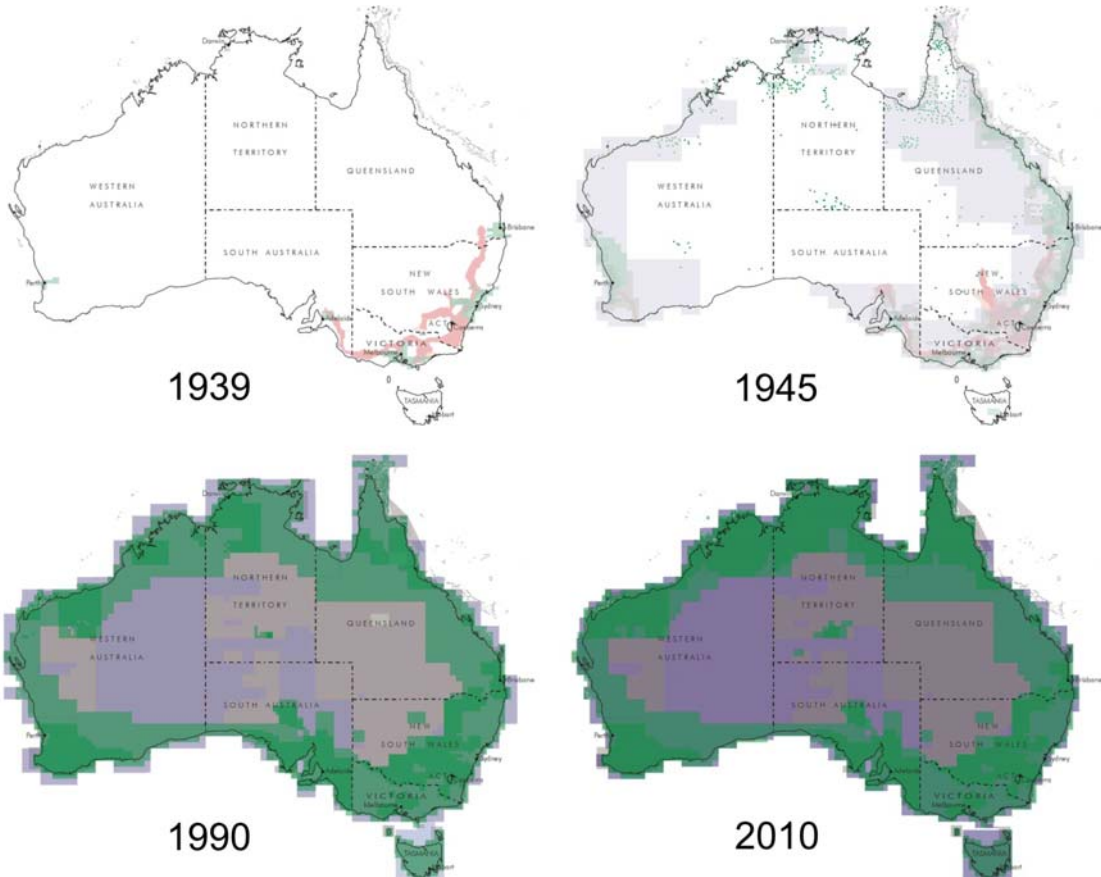


Figure 1 – Progress in the topographic mapping of Australia

1939: Limited coverage of 1 inch to 1 mile maps (pale green) and photography (grey), geodetic control linking South Australia, Victoria, New South Wales and Queensland (pink)

1945: Extended 1 inch to 1 mile coverage, photography and Emergency 4 inch to 1 mile coverage and geodetic control. Astro positions (green dots).

1990: Completion of 1:250K and 1:100K NTMS, some 1:50K coverage. 1:100 K orthophotomaps best scale for some areas inside the red line. Geodetic control established.

2010: 1:250K coverage revised, limited change in 1:100K coverage but increase in 1:50K coverage particularly in the north. 1:100K orthophotomaps are still the largest scale mapping for many areas inside the red line.

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