100 YEARS OF NATIONAL TOPOGRAPHIC MAPPING

Post-World War II Topographic Mapping by the Royal Australian Survey Corps

Peter Jensen, Lieutenant-Colonel, ex-RA Svy (pajmjensen@gmail.com)

Abstract

After post-World War II demobilisation and Army structural changes in 1946/47, the Australian Survey Corps personnel strength was less than 300, being only about a sixth of the Corps' wartime strength. Army was not prepared to diminish this essential capability to the unsatisfactory state of preparedness that existed before the war when there were fewer than 50 members of the Survey Corps. The Corps reverted to its peacetime role of conducting surveys and mapping to meet priority military needs, but it was soon called upon for nation-building projects where there was limited capability and capacity in early post-war civilian organisations. From the mid-1950s to the 1980s, Royal Australian Survey Corps elements which were not required for solely military purposes were employed on priority defence areas of the national survey and topographic mapping programs that were approved by Government. By the early-1980s the Corps had largely completed its commitments to the national programs and embarked on a Defence program of larger-scale topographic mapping of Australia. In part this led to a number of reviews in relation to arrangements for mapping for Commonwealth agencies including Defence. Defence had also committed to administrative efficiency programs of its support functions and the Corps' activities were submitted to testing under the Defence Commercial Support Program. This was a major contributing factor that led to decisions to totally reorganise the Army survey and mapping force, with the non-core strategic work being contracted to a new Army agency staffed by civilians, the core land combat and training survey force being augmented and reintegrated with the Royal Australian Engineers in 1996 and the core strategic mapping function transferred to Defence and later Defence Intelligence. The post-war Royal Australian Survey Corps played a prominent and influential leadership role in the survey and topographic mapping of Australia and most nations in Australia's region. This paper addresses the Corps' post-war role, organisation, policies, tasking, achievements, influences in the development of topographic mapping in Australia, legacies and the key decisions that were part of the major reorganisation in the mid-1990s leading to the end of the Royal Australian Survey Corps on 1st July 1996.

Introduction

The Royal Australian Survey Corps rendered no greater service to the Commonwealth of Australia, in all of its 81 years of existence, than it did during World War II. But perhaps the most evident, most recognisable and most enduring record of all of the work of the Survey Corps is the more than 5000 maps with the Corps badge, signifying it as the publishing agency, available to the governments of Australia and the public through libraries and map shops.

The Australian Survey Corps, formed by Order in Federal Executive Council on 1st July 1915 as the Permanent Survey Corps of the Military Forces of the Commonwealth of Australia, was the direct successor of the Survey Section Royal Australian Engineers (Permanent) formed in 1910. Individual Survey Corps members served in France/Belgium and the Middle East in World War I, including in ANZAC Corps Topographical Sections, but no Survey Corps unit was assigned to the First Australian Imperial Force as all standard mapping of those theatres was provided by British Army Royal Engineer Survey Companies. The major task of the Survey Corps for the next 25 years, until the beginning of World War II, was to produce strategic military mapping of the defence priority areas of Australia, firstly the major cities, ports, industry areas and the nearby military training areas and later areas adjacent to the coastline but further afield. The war changed that tasking to include not only strategic mapping for the defence of Australia, but also the other element of the Corps' role, that being to provide direct tactical survey and mapping support to military forces on operations.

It was a Royal Australian Engineer survey company, although manned by Survey Corps personnel, which served with the Second Australian Imperial Force in the Middle East in 1941 and 1942. But after that initial campaign, the Survey Corps assumed responsibility for topographic survey and mapping in the areas of operation in addition to continuing to produce strategic mapping for the defence of the homeland. From a small force of 50 Permanent Military Force officers and non-commissioned officers at the beginning of the war, the Corps grew to a force of more than 1800 all ranks of the Second Australian Imperial Force, the Militia and the Australian Womens' Army Service at the end of the war, although altogether nearly three times that number served in the Corps during the war. The Corps' wartime reputation of initiative, innovation and providing quality products under difficult conditions and with limited resources was duly recognised in letters of commendation from General D. Macarthur, Commander-in-Chief, South-West Pacific Area and Lieutenant-General E.F. Herring, General Officer Commanding New Guinea Force. Perhaps the greatest acknowledgement of the value of survey elements as part of the combat force was Survey Corps field survey sections landing with the combat units of 7th and 9th Australian Divisions in Borneo, in June and July 1945, in some of the largest amphibious assaults ever undertaken by Australian forces. The personal qualities, knowledge and practical abilities of wartime Corps personnel were widely acknowledged after the war with 13 wartime Survey Corps officers going on to head State and Commonwealth survey and mapping organisations. The Corps' war efforts were recognised in 1948 when King George VI approved granting the title 'Royal' on the Australian Survey Corps.

The question for the Army, and the Government, after the war was whether the Corps would simply revert to its peacetime work of producing strategic military mapping of Australia, would it only be concerned with organising, equipping, training and preparing for operational roles like other Army components, or would it do both of these things thereby contributing to the systematic mapping of Australia for both defence preparedness and national development and exercising in its wartime role ? Whatever it did, the next question was what size and shape should the Survey Corps be ?

This paper focuses on the Corps' work in the Australian topographic mapping programs after World War II, but that story would not be complete unless it was in the context of all of the other work for which the Corps was responsible. The paper explains the Corps' role, organisation, policies and doctrine, highlights key contributions, achievements and influences which the Corps had on topographic mapping of Australia after World War II and goes on to discuss the reasons and decisions in relation to shedding its responsibilities for strategic mapping work and finally the re-integration of the Corps with the Royal Australian Engineers on 1st July 1996 for the purpose of providing tactical survey and mapping support to the Australian Defence Force.

Australian topographic mapping at the end of World War II

The Army program of producing a military topographic mapping series of Australia before World War II was the only systematic mapping program funded by any Government of the Commonwealth at that time. Army had funded the program since 1910 and in seeking to share the financial burden at the end of the 1920s, and to improve the rate of map production, Army initiated a meeting in November 1929 between the Army General Staff and the state Surveyors-General who also published maps but mainly in relation to land ownership, land use and development (Report, 1929). A month earlier, national government had changed to the Australian Labour Party, the policy of compulsory military training changed to a voluntary militia and Australia followed the rest of the world into the Great Depression. At that meeting, it was agreed that there was a demand for a topographical map of Australia compiled to a standard size and type, showing contours and produced at a useful scale of 'one inch to one mile'. Essentially this was the standard military map produced by the Survey Section Royal Australian Engineers (Permanent), and later the Australian Survey Corps, since 1910 and popularly known as the military '1 mile' map. The Survey Corps made the maps available to government agencies and other approved organisations at no cost on a long term loan basis. Army acknowledged the public interest in military maps saying that they had been withdrawn from public sale in 1919 as they were 'bought up in large numbers by certain foreign nationals' (Report, 1929, notes p.1). The States believed that there was a ready civilian market for military type maps and were willing to provide any of their information suitable for compilation by the Survey Corps but were not willing, at that stage, to commit funds to a national systematic standard map program in a period of reduced public expenditure.

The Commonwealth Survey Committee, comprising the Commonwealth Surveyor-General and representatives of each of the armed Services, was established in 1935 as the principal advisory group to the Cabinet on matters of national survey, photography and mapping. But the lack of government commitment to a national approach continued to the beginning of the war, when a submission from the Minister for the Interior only 12 days before the outbreak of the war, was again deferred by Federal Cabinet. Soon after, the Commonwealth's focus was on mapping for the defence of Australia and the Committee did not meet again for more than four years.

Notwithstanding the lack of a whole-of-government commitment to national mapping, Army was concerned about the slow progress of the mapping program in the mid-1930s in the light of developing world events, and increased the strength of the Survey Corps from 14 to 35 in 1935, then to 60 in 1938 for the Long Range Mapping Program which aimed to improve map coverage over the next decade. There was approval to increase to 97 over three years, but by the outbreak of the war in September 1939 there were only 50 members of the Survey Corps.

Survey Corps and State map co-production during the war greatly improved coverage of the standard '1 mile' map of Australia from 80 at the beginning of the war to 440 in 1945, albeit

about 170 of these were classed as emergency editions (Tyson, 1965). Early in the war it was realised that even the Emergency Mapping Scheme, then underway in-conjunction with the States, would not provide the coverage needed for wartime planning and it was decided to produce a four mile to one inch ('4 mile') map, mainly of coastal and hinterland areas, by recompiling existing information, mainly from the States, into a standard format. Two hundred and twenty-four such '4 mile' maps, or about 40% of the nation, were produced with about one-third contoured and the remainder with spot heights and hachures to show approximate terrain shape (Fitzgerald, 1948)[1]. By 1944, the Survey Corps focus was on operations to Australia's north and as the need for a strategic program covering mainland Australia had diminished, the Emergency Mapping Scheme was suspended. That was not to say that strategic mapping of Australia was not important, but at that stage it was not the highest priority. Immediately after the war operational tasking was reduced to being mainly support to the British Commonwealth Occupation Forces in Japan and the return of Australian prisoners of war, but there remained a very significant military requirement for mapping of Australia and areas of strategic interest in the islands to the north and the South-West Pacific Area.

The decade after the war – mapping of Australia

The Australian Federal and State Governments started post-war reconstruction planning in early-1943 after Japanese forces were defeated, or their advances halted, in the Coral Sea, Milne Bay, Kokoda and north-Papua coast, Midway Island and Guadalcanal (Solomon Islands). In early-1943 a federal government department of Post-War Reconstruction was created including committees and commissions on rural reconstruction, national works, secondary industries decentralisation, demobilisation, housing, mineral resources development and transport development (Long, 1973, p.321). All of these activities were heavily dependent on current and reliable surveys, aerial photography and mapping. In May 1942, the federal government introduced new taxation measures meant to curb the public consumption of materials, but the most enduring new policy was uniform national income taxation (abolishing State income tax) which would assure funding for the war effort but would also assure funding for post-war reconstruction and national development (Long, 1973, p. 219). State governments also looked to post-war development and in 1943 the Government of Western Australia requested Commonwealth assistance seeking recent military aerial photography which would assist them in mapping projects of development areas.

In late-1943, the Commonwealth Survey Committee noted the post-war reconstruction intentions of the Government and reconvened in mid-1944 revisiting the pre-war recommendations of the committee noting that the strategic '1 mile' and '4 mile' military series of maps produced during the war would be suitable for both defence and development after the war. The Committee noted that the significant survey and mapping organisations that had been developed in the Services during the war were the only Commonwealth organisations at that stage capable of carrying out a large systematic mapping program and that they would be competent agencies to participate in national general purpose survey and mapping programs. Government acknowledged the Committee's recommendations that there was a considerable effort needed to achieve anything like a satisfactory coverage for post-war activities. The Committee recognised the role that the States should play in a national surveying and mapping program and in conjunction with the Surveyors-General recommended that a National Mapping Council be established to coordinate the national programs between the Commonwealth and the States, make recommendations on the

[1] An '8 mile' series (62 maps) was produced of remote areas, mainly by enlargement of the International Map of the World

programs and establish suitable technical standards. Cabinet duly approved the Council on 7th March 1945.

Implementation of government direction in relation to administrative authority and control over mapping of the nation soon became matters of dispute between the then emerging civilian Commonwealth mapping agency, the National Mapping Section of the Department of the Interior, and the Survey Corps. The administrative relationship between the two Commonwealth agencies has been discussed in other places and is not included here (Coulthard-Clark, 2000) (Lines, 1992). What is noteworthy is that the Director of National Mapping (from 1950 to 1977), the Director designate of National Mapping (1977), and the Directors of Survey – Army (to 1978) all served their country with distinction as officers of the Australian Survey Corps in World War II.

From the end of the war through to the early 1960s, Australia's defence policy centred on 'forward defence'. Asia was then unstable with Australian forces committed to an insurgency in Malaya, a confrontation in Borneo and full-scale wars in Korea and Indochina. In policy there was little mention specifically of the defence of Australia, but it would have been negligent of the Commonwealth government if it did not provide for mapping of continental Australia for defence purposes.

In World War II, Army had re-learnt the long established lesson that systematic standard topographic mapping was best done in times of peace, and was not prepared to diminish the Survey Corps' capability to the poor state of preparedness that existed before the war. Immediately after the war the Director of Survey and Chief of the General Staff both argued the "potentially dangerous lack of military maps, and for which it is estimated there is full-time work for at least 500 personnel for 20 years" (Coulthard-Clark, 2000, p.109). Director of Survey went on to argue that the post-war Survey Corps, which was based on a much reduced wartime organisation and would have a considerable core force to support the operational element of the Army, should be the authority for all Commonwealth strategic mapping. He strongly believed that the collective proficiencies and experience then in the Survey Corps would be diminished to the detriment of the nation if a significant permanent force was not maintained. Chief of the General Staff highlighted that more than 60 government organisations were understaffed in survey related positions and concentration in the current organisation was best for government as a whole. This view however was not shared by the Secretary of Department of Army, or the Minister, who were concerned about the Commonwealth budget allocation for Army in the context of the post-war emphasis on reconstruction and national development. The Secretary did however agree with Chief of the General Staff to maintain the Survey Corps at a reduced level until the future structure of the Corps was resolved.

With the return of most of the Second Australian Imperial Force to Australia from the Middle East in early-1942, the Survey Corps assumed responsibility for geodetic and topographic survey and mapping, and Corps units were added to the order of battle of the principal Australian war-fighting formations then mainly in Australia. The operational concept that was developed throughout the war, was retained after the war, and was essentially the same in Army doctrine until the Corps integrated with Engineers again in 1996. The Manual of Land Warfare, 1983 stated 'The role of the Royal Australian Survey Corps is to provide the maps, aeronautical charts, hydrographical charts and geodetic and control survey data required for land operations'. Functional responsibilities associated with this role were: geodetic survey for – theatre grid for control of artillery, naval gunfire and close air support, control for mapping and charting, navigation systems, communications system, surveillance systems; map production and printing for new maps and charts, plans, overprints, battle maps, air-

photo mosaics and photomaps, rapid map and chart revision; map holding and map distribution. The operational doctrine was that the combat force would ideally deploy into the area of operations with topographic maps adequate for planning, force insertion and initial conduct of tactical operations, that new maps and broad area update of the topographic base would be provided by the support and communication zone survey force and that the operational area survey force would update the base, add operational and intelligence information and provide the value-added products for the combat force.

The normal allocation of survey units to conventional operational forces to support the early post-war Army (after demobilisation) was based on the organisation developed during World War II. This allocation, with approximate authorised peacetime personnel numbers (full-time Regular Army) is in Figure 1. In general the elements in the operational area and communication zone were restricted in peacetime and would be manned initially from the support area.

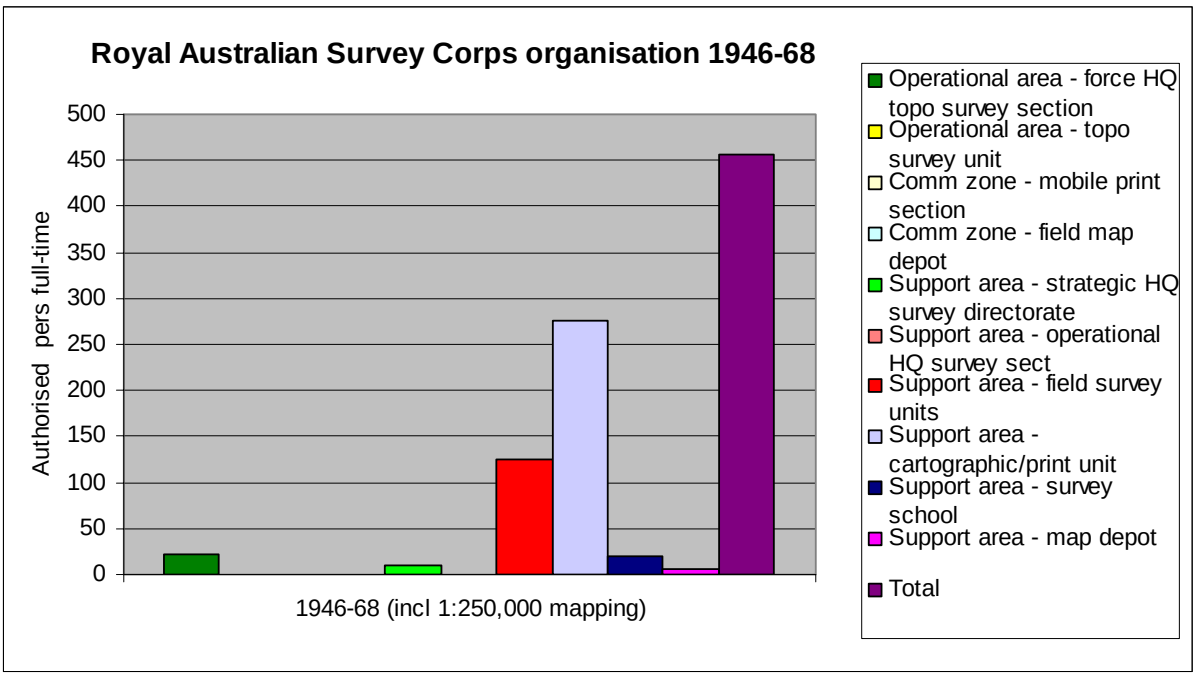

Figure 1. Survey Corps organisation 1946-68

This force structure, with some modification, expansion and restriction from time to time, was the basis of the Survey Corps organisation for the next 45 years, until the 1989 reorganisation. Shortly after the war, the combined support area capability (about 460 Regular Army personnel positions) was the core force being both the force-in-being to support the Army of the day and the main building-blocks for expansion during wartime, although there was some allocation of Citizens Military Force for wartime expansion with these elements being on longer readiness requirements. Although there had been some improvements in application of new technology (eg. aerial photography) between 1910 and 1946, the task of survey and mapping was still very labour intensive and time consuming, and the 1910 decision that systematic standard military mapping in peacetime was the work of permanent troops was still valid.

The total core force personnel positions in the support area was also about the same number (500) proposed by Chief of the General Staff and Director of Survey as needed to address the deficiency of military mapping in Australia immediately after the war. After post-war demobilisation, it was to be another 25 years before actual personnel numbers did reach 460.

This organisation meant that in peacetime there were survey units in the support area which could be tasked to work on higher defence priority parts of general purpose (defence and national development) survey and mapping programs when they were not required for solely military purposes. This had the dual benefit of progressing the national programs, which included higher priority defence requirements, and exercising the command, staff, operational and technical functions of the Survey Corps in their wartime role.

Post-war demobilisation plans, which commenced from late-1944, affected the Survey Corps like all Army elements. Weekly Routine Orders of survey units, including those units deployed on operations in New Guinea and beyond, published lists of Government agencies which were recruiting staff with survey related skills (Australian War Memorial). Not long after victory, the Corps was reduced to less than 25% of its wartime strength with about 430 personnel in late-1946. Discharge from the Army was relatively routine for all members except those in the pre-war Permanent Military Force. In 1945, Director of Survey reported that he was rejecting applications for discharge of those Corps members in the Permanent Military Force until the future of the Corps was resolved (Coulthard-Clark, 2000). After demobilisation, the disbandment of the Second Australian Imperial Force and the formation of the Interim Army in 1946, the fourteen wartime Survey Corps units and sections/staff on higher headquarters were reduced to the 3rd and 5th Field Survey Companies, Land Headquarters Cartographic Company at Bendigo, 11th Field Survey Depot at Bendigo and the Survey Directorate of Army Headquarters in Melbourne. In late 1945, 5th Field Survey Company moved from Brisbane to Chatswood in Sydney where in part it acted as a holding and training unit for the Interim Army. 3rd Field Survey Company, also based in Sydney, had field survey sections in Queensland, Victoria and Western Australia.

With the formation of the Regular Army in 1947, the two field survey companies were replaced by five field survey sections each of 25 personnel assigned to the regional commands – Northern Command Field Survey Section in Brisbane, Eastern Command Field Survey Section in Sydney, Southern Command Field Survey Section in Melbourne, Western Command Field Survey Section in Perth and Army Headquarters Field Survey Section (4th Military District) in Adelaide to serve South Australia and Northern Territory. This section was replaced by Central Command Field Survey Section in 1954. Some of the regional sections did not replace the 3rd Company Sections until 1949. The sections were tasked to provide survey and mapping support in each of the regional or geographic commands, mostly by extending the trigonometric networks and '1 mile' military mapping program in the defence priority areas. 11th Field Survey Depot was replaced by Army Headquarters Field Survey Depot located in Melbourne to provide map storage and distribution. Army Headquarters Field Survey Section (3rd Military District) in Melbourne was responsible for the air photo library and survey stores. Land Headquarters Cartographic Company resumed its name Army Headquarters Cartographic Company and was the largest Corps unit. This Corps organisation was generally consistent with the core force structure mentioned before.

From late-1946, improving civilian employment opportunities further reduced Corps numbers to less than 250 by late-1948 (Australian Survey Corps, 1948) and 210 by early-1950. Whilst this attrition was to be expected after the war, much needed experience was being lost and there was then a need to start a formal training program for Corps personnel, to replace the ad-hoc on-the-job training provided by experienced non-commissioned officers. In August 1947 approval was given to raise the School of Survey at Balcombe, Victoria and training commenced there in August 1948. The school was renamed School of Military Survey in 1960. Significantly, in 1950, command of the School and the Cartographic Company were brought to equivalence with similar Army units, with the rank of the Commanding Officers raised to Lieutenant-Colonel. This was an increase for the Corps from one to three senior

officers at that rank, significantly improving the officer structure and providing additional career opportunities.

Although Government wanted to move quickly to establish post-war reconstruction and national development projects, the much needed survey assistance was at that stage beyond the capacity of the civilian agencies. It was not until 1947 that the National Mapping Section was established in the Department of Interior. So, in addition to its military survey and mapping programs, the Survey Corps was tasked by Government to provide assistance to early post-war priority national development projects, such as:

- 1946-49. At the request of the Prime Minister to the Minister for Army, 5th Field Survey Company was directed to provide preliminary surveys and mapping (Kosciuszko and Berridale) for the Snowy Mountains Hydro-Electric Power Scheme. Work continued until 1949 when Snowy Mountains Hydro established their own survey section mainly through recruiting ex-Survey Corps members who had worked on the preliminary surveys.
- 1946. 3rd Field Survey Company completed a horizontal and vertical survey for a diversionary water channel between the Murray and Murrumbidgee Rivers in the area between Urana, Narranderra and Yarrawonga.
- 1946. 5th Field Survey Company completed high-order triangulation around Spencer Gulf, South Australia, for hydrographic surveys for industrial development of Whyalla, Port Augusta and Port Pirie.
- 1947. Army Headquarters Cartographic Company provided mapping for the Australian census.
- 1947. At the request of the Queensland Government in relation to development of the Burdekin Basin, the 3rd Field Survey Company completed surveys and mapping of Nogoa and Comet Rivers, a chain of triangulation from Rockhampton to Emerald, standard mapping of Emerald and Anakie areas and air photo mosaics of about 17,000 sq km.
- 1947. At the request of the Australian Bureau of Mineral Resources, Western Command Field Survey Section completed field surveys and mapping of the Fitzroy River in the Kimberly region, and ‘4 mile’ mapping of Noonkanbah.
- 1948-53. At the request of the Department of Supply, Army Headquarters Field Survey Section (4th Military District), assisted from 1949 by the Survey Corps Long Range Weapons Establishment Survey Section, completed surveys and mapping for the proposed Long Range Weapons Establishment at Woomera, South Australia, including baseline and triangulation surveys, ‘4 mile’ mapping of the 300 mile long range and ‘1 mile’ mapping of the range-head facility. In 1950 the Woomera triangulation was joined to the South Australian primary trigonometric network through the first order Koolymilka baseline (length - 7 miles). The baseline measurement was by the precise invar tape electrical resistance method developed by the Corps and University of Adelaide in the 1930s and acknowledged around the world as a significant technological advancement. The Section also surveyed and mapped the Maralinga atomic weapons test site west of Woomera.
- 1950s. Surveys for CSIRO Soils Mapping of Arnhem Land, Northern Territory

The early post-war Survey Corps remained much as it was until 1952 when there was approval to expand personnel numbers to about 320 (Coulthard-Clark, 2000, p142). In July 1951, with the introduction of the National Service scheme as the Government was concerned about the deterioration of the regional situation, two topographic survey companies (Citizens Military Force) were established in Sydney and Melbourne. These units were intended to support large war-fighting formations and they allowed the National Servicemen to complete their service obligations. The units contributed to military topographic mapping, mainly producing exercise and training area maps. Both units were disbanded by 1961 as the Army structure changed.

The high-level administrative arrangements for control and authority for Commonwealth mapping in Australia remained unresolved in the late-1940s and early-1950s. In 1948, the Minister for Army ordered a report on mapping matters, having received a recommendation initiated by an ex-Survey Corps senior officer to invite a senior officer of the British survey authorities to visit Australia to advise on the best program of work for the Survey Corps for defence purposes, and how the Corps and civilian mapping authorities might co-operate with each other and to provide advice on organisational and tasking matters. This idea was endorsed by the Chief of the General Staff and an invitation was made to the United Kingdom Director-General of Ordnance Survey, Major-General R.L. Brown who was visiting Australia in 1950. The consequent report (Brown, 1951) was interpreted differently by the agencies involved and in 1954 a submission to Cabinet sought to resolve the matters of dispute. Unfortunately the submission was poorly handled in the Department of Army, and the Minister, and therefore the Cabinet, was not aware of the opinions of the Chief of the General Staff who later objected to the decision based on the Cabinet not being fully informed[2]. Chief of the General Staff did not accept that "all responsibilities for geodetic and topographic surveys and mapping in the Department of Army be placed with the authority (Department of the Interior)". Taken literally this meant that Army would not have operational and administrative control over the survey and mapping work of the Survey Corps (Coulthard-Clark, 2000, p.128-133). This interpretation appeared to be contrary to the Defence Act 1903 in relation to command of the Army.

Chief of the General Staff did agree that the Survey Corps would be tasked to work on the defence priority parts of national survey and mapping programs, when the Corps was not needed for solely defence purposes. He also agreed that the National Mapping Council was the appropriate authority to coordinate cooperative activities between the Commonwealth and the States and to establish technical standards for those dual purpose surveys, aerial mapping photography and mapping. This model of 'agency support' for the national programs was the basis for the work of the Survey Corps in the national programs for more than 25 years. All funding for Survey Corps participation was from the Army budget and not from new lines of funding established for the national programs. It might be argued that because the Survey Corps bid for Defence resources from the normal operational, personnel, training and logistic parts of the Defence budget, and took advantage of opportunity tasking of other Defence assets, it meant that much of the work in the very remote areas of northern-Australia would have cost civilian agencies considerably more than it cost Defence. Indeed, some of the work might have taken many more years to complete or it might not have been done at all.

[2] Convention of the diarchy of the civilian and military streams in Defence, was that the Secretary provided Departmental administrative advice to the Minister and the Chief of the General Staff provided the Minister advice on operational and command matters.

Participation in the first national topographic mapping program – scale 1:250,000 maps

Arising from the 1954 Cabinet decision, the Advisory Committee on Commonwealth Mapping replaced the Commonwealth Survey Committee and set about coordinating the first systematic national mapping program which was to produce the 540 general purpose maps of the nation. Essentially this was to extend the '4 mile' series of topographic maps commenced as the wartime maps of the Emergency Mapping Scheme and continued after the war by the Corps. Some of the wartime and post-war maps were contoured, where existing information was available, but it was agreed by the Commonwealth agencies that for the initial national program full contouring was to be kept to a minimum except for those areas with a definite requirement for contours, and that relief would be portrayed by hill shading and spot heights (Lines, 1992). This led to the description of topographic and planimetric maps for those with contours and those without contours respectively. In 1960, the Committee estimated that the project would take another 9 years for completion of the initial phase of the minimal contouring series and 18 years for completion of the follow-on phase of full-contouring. In the end, the second phase was replaced by the 1:100,000 program with 1:250,000 maps largely being revised by derivation from the 1:100,000 program. The map series number, R502, for the initial 1:250,000 program is described with other map characteristics in a later section.

Change to metric scale mapping

In World War I the Australian Imperial Force fought on metric scale maps in all theatres of the war. In World War II the Survey Corps produced metric scale maps for operations with the British Army in the Middle East and with the US forces in the South-West Pacific theatre, but continued with imperial scale maps in Australia and New Guinea and metric scale training area special maps in Australia through the 1950s. In 1954, the Advisory Committee on Commonwealth Mapping noted comment by 'the Brown report' that it would be inevitable that standard map scales would move from imperial to metric and also noted that Australia's major military allies United Kingdom, United States and Canada were standardising on metric scales. From 1910 until early post-World War II, standards for Australian topographic mapping had generally followed those of the United Kingdom. But post-war, Australia was drawn into broader strategic collective security alliances and it was Australia's membership of the 1954 South East Asian Treaty Organisation (SEATO) for collective defence that was the immediate driver for standardisation with military allies, in particular the United States and United Kingdom (Fitzgerald, 1980, p.108). The system of military standards for interoperability is discussed in a later section.

In 1956-57, the Survey Corps produced the first metric scale 1:50,000 standard map in Australia, Mildura West, as a prototype to replace the standard '1 mile' map, and soon after produced other 1:50,000 maps including around Canberra, defence facilities and bases and areas used for training in most States and Territories (Royal Australian Survey Corps, 1985). In 1957, the Commonwealth agreed to migrate the national program from '4 mile' to scale 1:250,000 noting that both Commonwealth agencies had produced only about 15 maps each of the imperial scale. Two years later the National Mapping Council decided to transition all Australian mapping to metric scales. That was not to say that the metre would yet be adopted for the map grid, or for height information, which were yards (10,000 yard grid for 1:250,000 maps) and feet respectively. Nonetheless, towards the end of the 1:250,000 program, metric grid ticks were introduced to those maps produced after the adoption of the Australian Map Grid 1966. Metric heights were adopted in 1963, although this did not apply to the initial series of 1:250,000. From 1957, the Corps' focus on work in Australia turned to the concurrent national geodetic survey and mapping programs, discontinuing the military '1

mile' series in 1959. Nonetheless, a military requirement for this scale (content and accuracy) map was extant and a new military program commenced for this purpose, in the form of the 1:50,000 defence mapping program, about 20 years later.

Corps Structure and Organisation

The Survey Corps organisation continued to evolve, to address changes to Army structure but also in an attempt to get personnel numbers up to the authorised levels. In 1955, Army Headquarters Cartographic Company and Southern Command Field Survey Section amalgamated to form the Army Headquarters Survey Regiment, at Bendigo, including Topographic Squadron, formed from the Survey Section. Topographic Squadron then replaced the New Guinea Survey Unit which was raised in 1954 for special projects with United States forces in the New Guinea area, under the 1947 Australia/United States Cooperative Mapping Agreement. When the Melbourne based Citizens Military Force company was disbanded, a part-time increment of 22 personnel was added to the Regiment to form the second topographic survey squadron as the nucleus for future expansion for another deployable sub-unit. In 1962, the regional command field survey sections were redesignated command field survey units but with the same compliment and role. The main reason was to differentiate the word 'section' from the common Army understanding of an infantry section being about 10 men with a Corporal in command, whereas the survey unit had a personnel strength of 25 commanded by an officer, a Major.

In late-1962, in response to an Army restructure and for tactical survey support to operational forces at heightened readiness, a new survey structure was authorised, with 1st Topographic Survey Squadron (Detachment) of 20 formed from part of the Regiment's Topographic Squadron with personnel 'loaned back' to the Regiment. In 1965, this was changed to 1st Topographic Survey Troop and increased to 42 personnel. The troop, minus cartographic and lithographic elements which remained at Bendigo, was collocated with Eastern Command Field Survey Unit in Sydney with members working for that unit when not required for individual and collective operational training with the Troop. In May 1966, the Troop's 'A' Section of 17 personnel deployed with the Australian Task Force Vietnam to work directly for the headquarters of the force. Although individual Survey Corps members had deployed on active service since World War II, this was the first formed Survey Corps unit to have done so. 'B' Section remained in Sydney as an individual reinforcement section with members 'loaned back' to other survey units after completing pre-deployment training including attending an operational mapping course at School of Military Survey.

The Corps organisation over the period of the initial 1:250,000 national mapping program is included in Figure 1.

Personnel

The Corps personnel strength had gradually increased during the 1950s being about 400 by the end of the decade. The Command Field Survey Sections based in Perth, Adelaide and Brisbane were then deployed across Northern Australia in the dry season, employed on extending the geodetic networks and the 1:250,000 mapping program in the Kimberley, Arnhem Land, Gulf of Carpentaria and Cape York. When in barracks, for respite from long deployments of typically nine months, and by necessity from the constraints on operations in the wet season in northern-Australia, the sections compiled maps using multiplex and then later Wild B8 photogrammetric equipments. The operations in the northern-Australia high priority areas were supported by detachments from Eastern Command Field Survey Section in Sydney, which was also mapping in New South Wales and Victoria, and the Topographic Squadron in Bendigo which also worked in Victoria. The capabilities of Army Survey

Regiment were the full spectrum of mapping, with concentration on photogrammetric triangulation and compilation, cartography and printing.

Throughout the 1:250,000 program the School of Military Survey trained an averaged 32 basic mapping trade course students per year (Jensen, 2011). As the program came to an end in 1968, Corps personnel numbers had grown only marginally to 414.

Geodetic survey and topographic survey

Survey triangulation based mapping had been introduced into the colonies in 1834, and the need for a national geodetic survey network had been proposed as early as 1892 by the Surveyors Boards and Institutes of the colonies, but apparently it was not a high priority for the new nation at the turn of the century (Lines, 1992). It was however a recommendation of the Conference of Surveyors-General in 1912, although once again there appeared to be little interest to fund such a program of work in particular from the Department of Home Affairs that then had responsibility for such work. The matter of survey networks was indeed at the forefront of concerns of the Army General Staff when considering the matter as to whether military mapping should be based on geodetic survey networks or on parish maps and local cadastral surveys[3]. The General Staff decided, in late-1913, that standard military maps would be based on geodetic networks. It then fell to the Survey Corps to conduct the geodetic trigonometric surveys prior to its topographic mapping projects[4]. The need was again endorsed by the newly formed Commonwealth Survey Committee in 1936, but it was not until the post-war programs commenced that Commonwealth resources, other than from Defence, were applied to the national networks.

In 1957, as the 1:250,000 national mapping program got going, it was another nine years before the national geodetic survey was completed. So for the initial national topographic map coverage the horizontal spatial framework was survey networks based on State astronomic datums, the Clarke 1858 ellipsoid and grid coordinates on the Australian National Grid being a special case of the Transverse Mercator projection and the modified British Grid with Australian zones, this having been adopted by the Survey Corps in 1933 to replace the polyconic projection introduced by the Survey Section in 1910 for the '1 mile' military mapping program. In remote areas where there was no trigonometric survey networks, survey point coordinates were determined by astronomic observations many of which were made by the method of 'position line' fixes, an efficient technique first used by the Survey Corps in the Middle East in World War II (Fitzgerald, 1980). Other astronomic based longitudes were determined with assistance of time signals, broadcast from the Royal Australian Navy, Belconnen, ACT radio station, which originated in World War II for Survey Corps work in New Guinea (Fitzgerald, 1948).

Just as the Corps' work for the national mapping program and the national geodetic survey commenced, man-portable electromagnetic distance measurement systems were introduced into service, firstly the light-based Geodimeter then soon after the microwave-based Tellurometer, which significantly changed survey methods from triangulation to primarily traverse, allowing rapid extension of survey networks. In addition, the use of Bilby observation towers, up to 18 metres high, extended intervisibility lengths of traverse lines by up to 25 kilometers, further improving the efficiencies of the new survey method. By 1962,

[3] The argument by Intelligence officers for using existing parish maps and cadastral control surveys was a matter of expediency in producing maps for military exercises

[4] In 1930 the Corps identified inconsistencies between the trigonometric surveys of New South Wales and Victoria and in 1934 commenced connecting triangulation networks of the Eastern States adopting the Sydney Observatory as the astronomic datum point and using the Clarke 1858 ellipsoid as the computational surface

Survey Corps high order traverses in Australia had established 427 stations and covered more than 12,750 kilometers (Sargent, 1990). All of this work, including Laplace astronomic observations as part of the national geodetic survey, and surveys in Territory of Papua New Guinea, was provided to the National Mapping Council for the national survey network adjustments which became part of the Australian Geodetic Datum 1966 set of station coordinates.

The vertical datums for the maps were the State based sea levels determined from tide gauges. Height data was carried through the traverse networks by trigonometric heighting and barometric heighting linked to the trigonometric network and the rapidly expanding network of 'levelling control surveys' being established by National Mapping, the States and contractors to National Mapping.

A significant loss to the Survey Corps, in February 1954, was the resignation of Lieutenant-Colonel H.A. Johnson MBE, Commanding Officer and Chief Instructor of the School of Survey who went on to National Mapping as the Senior Geodetic Surveyor and who was a major driving force of the national geodetic survey program. He joined the Survey Corps (Permanent) in late-1935 as a Warrant Officer Topographer, being a licensed surveyor in South Australia (Coulthard-Clark, 2000, p55), and was the second-in-command of the 2/1st Corps Topographic Survey Company deployed in the Middle East in 1941.

Aerial Photography

Aerial photography had been introduced by the Survey Corps into standard mapping in Australia in the 1930s. Much of the photography for the initial national mapping program was acquired in the seven years early post-war by the Royal Australian Air Force (RAAF) No 87 Squadron (Photo Reconnaissance). By the time the unit was disbanded in 1953, due to lack of funding, it had provided systematic coverage of more than 3.3 million square kilometres (43% of the country) of overlapping near-vertical photography, of varying quality, and 520,000 square kilometres of tri-metrogon reconnaissance photography, totalling more than half the nation (Lines, 1992). This was before the national 1:250,000 mapping program got underway. Generally the photography was flown with Fairchild K-17 mapping cameras with focal length 152mm (6 inch), flown at 25,000 feet, giving a nominal scale of 1:50,000. This was the smallest scale possible with the mapping quality lens and the flying height which was the highest that the aircraft could fly economically for large-block photography normally covering a 1:250,000 map sheet area. The methods and techniques of the RAAF photography were the basis for the *Specifications for Vertical Aerial Photography* approved by the National Mapping Council in 1953. For the remainder of the 1950s and early-1960s, photography for the national mapping program was provided by National Mapping through contract services or State members of the National Mapping Council using in-house capability or commercial contracting. By 1963, the initial aerial photography national coverage for the 1:250,000 mapping program was complete although some of the earlier photography was less than the desired technical specifications. From the early-1960s, contract aerial photography, arranged by National Mapping, was acquired using their newly purchased Wild RC9 cameras with super-wide angle low distortion lenses (120 degree cone, f=88.5mm (3 ½ inch)) and with aircraft flying heights of 25,000 feet, provided a nominal scale of about 1:85 000. This smaller scale photography greatly improved efficiencies in flying photography, aerial triangulation, and map compilation as the number of photogrammetric models in a 1:250,000 area was reduced by about 60%. By the time this new photography capability was in-service, planning had commenced for the follow-on 1:100,000 national topographic mapping program, which would require national coverage of the new RC9 aerial photography. The new program was complete by 1975, except for 30 map areas at larger scale (Lines, 1992).

The Corps was equipped with Wild RC9 cameras, but these were used for spot, supplementary and reconnaissance photography in Army and charter aircraft, rather than large block mapping photography of Australia.

Major advances in technology and methods

The Corps was always supported and encouraged by Army to adopt new technologies, equipments and methods where they were appropriate for military tasking and where they demonstrated improved efficiencies. The Survey Corps did not receive a separate line of funding for equipments and each year had to bid for new equipment projects like all Army components, with successful bids based on competitive (across all of Army for new equipment) justified business cases. Significant new technologies, techniques and methods adopted by the Survey Corps throughout the initial 1:250,000 mapping program included:

- 1952 - anaglyph light projection Multiplex equipment introduced for densifying photogrammetric control and for plotting/compiling map detail and heights, replacing graphical perspective rectification methods, including slotted templates, introduced in the 1930s
- 1956 - metric scale mapping
- 1956 - cartographic scribing of map detail on stable coated plastic, replacing fair drawing with ink on linen and paper
- 1957 - electromagnetic distance measurement systems (light and microwave) introduced for rapid extension of survey control, mainly by theodolite traverse, replacing triangulation
- 1957 - use of the helicopter and light fixed-wing aircraft to revolutionise transport of survey parties in remote areas, for reconnaissance and for technical functions of barometric heighting and pre-compilation field annotation of aerial photographs
- 1961 - analogue hill shading by wax modelling and photography for relief portrayal
- 1962 - introduction of Wild A9, B9 and B8 photogrammetric plotting equipments to be compatible with Wild RC9 based mapping photography. Multiplex photogrammetric equipment was phased out, except for training, in 1968.
- 1962 - presensitised printing plates
- 1962 - two colour printing presses (modified to three colour presses in 1968)
- 1963 - computer controlled coordinatograph for grid production
- 1963 - analytic aerial triangulation using a Zeiss Jena stereo-comparitor, the Stecometer. The first 1:250,000 block area (Townsville-Ayr) was adjusted on a Victorian Country Road Board IBM 1620 digital computer in Melbourne (School of Military Survey, 1985).
- 1963 - the radar airborne profile recorder, employed immediately in Territory of Papua New Guinea to map the border with West Irian, which was then the highest priority mapping area
- 1964 - the airborne microwave electromagnetic distance measurement system (fixed-wing charter aircraft mounted Aerodist MRC2 based on the Tellurometer) to extend and densify survey control over large areas and long distances using the method of trilateration, employed immediately in Territory of Papua New Guinea

- 1964 - vehicle mounted Johnston Ground Elevation Meter

Achievements

Army had committed to produce about half of the initial national mapping series and by late-1968 had completed its work of 216 compilations (40% of total) and 300 published maps (56% of total - including 84 from State compilations) of the 540 maps in the series. The average number of maps published was 28 per year.

On completion of the R502 series, map maintenance by the Survey Corps was by replacement, by producing the military specification (originated from United States) scale 1:250,000 Joint Operation Graphic – Air (JOG-A), Series 1501A, and the companion Joint Operation Graphic – Ground (JOG-G), Series 1501[5], compiled by derivation from the new 1:100,000 maps of the national mapping program, from the equivalent National Topographic Map Series products and later from the maps of the 1:50,000 defence mapping program. JOGs were fully contoured with 165 foot contours, and hypsometric tints, on JOG-A and 50 metre contours on JOG-G. By 1992, the Corps had produced 285 JOG-A and 260 companion JOG-G to replace series R502 maps.

Notwithstanding that the first national map coverage was then complete, it was only the first phase of national endeavour as the maps were for general planning purposes only and did not contain the topographic detail needed for detailed planning and conduct of military operations and for other nation building purposes.

Corps direction

Direction of the Corps over the initial 1:250,000 program, was by three Directors of Survey on the General Staff, firstly Colonel Lawrence Fitzgerald OBE who retired in 1960 after 37 years Survey Corps service having been the Director for most of the war, secondly Colonel Donald MacDonald AM, who retired in 1967 after 32 years service and lastly Colonel Frank Buckland OBE, who went on to retire in 1972 after 35 years service. All had enlisted in the Permanent Military Force before World War II and were wartime officers of the Corps. In recognition of their service they were all retired with the rank Brigadier.

Participation in the second national mapping program – scale 1:100,000 maps

With still five years before the first national topographic map coverage was complete, planning started on the follow-on program which was developed by the National Mapping Council in April 1963 and endorsed by the Advisory Committee on Commonwealth Mapping in February 1965 with a Cabinet submission coordinated by Department of National Development (Division of National Mapping). The larger scale mapping requirements of the States and Territories were generally for 1:50,000 topographic line maps and larger scales of the large population centre and near regions, 1:100,000 topographic line maps in the agricultural and pastoral regions and 1:100,000 compilations for the remainder of central Australia (Lines, 1992, p190). Defence preferred 1:50,000 topographic line maps for the priority northern-Australia area, but in recognising the huge resources required for such a program that was proposed to be completed in 10 years, accepted the realistic compromise of the medium scale 1:100,000 topographic line maps of the priority northern areas and areas of economic activity, and compilations for the remainder, with provision for larger scale maps of special interest areas and training areas (Coulthard-Clark, 2000, p158). Cabinet endorsed the program in September 1965.

[5] There was also a Joint Operation Graphic (Combined) but only a few were produced

The so called 'red line map' (Lines, 1992), drawn on the index of 1:250,000 maps, showed those maps outside the line which would be published as full colour topographic line maps, and those inside the line which would be completed to compilation stage only. From time to time there were minor amendments to the line to accommodate areas of new economic development.

Army undertook to participate in the program through the 'agency support' model established for the 1:250,000 map program focusing on areas of higher defence priority, mainly northern-Australia north of 24 degrees south latitude, with some areas closer to the capital cities allowing operational respite for the members of the field survey units.

In 1961, the Survey Corps had produced a prototype 1:100,000 map, of Port Wakefield, South Australia, for its 1:100,000 mapping program of Territory of Papua New Guinea. Interestingly, this map and other 1:100,000 maps produced in the early-1960s before the national program was approved, included the note that the map was part of the 'national mapping program'. This statement was either an artefact from the 1:250,000 maps or it anticipated approval of the 1:100,000 program. The National Mapping Council, 1963 approved metric contours, but those early maps used a contour interval of 100 feet. In general the Corps adopted the Council's standard for contour interval of 20 metres for flat and medium terrain and 40 metres for hilly and mountainous terrain (National Mapping Council, 1965).

A task of the field survey squadrons for all mapping, standard or otherwise, was to liaise with the Military District Intelligence Sections which maintained the Key Points Register, to ensure that infrastructure as portrayed on the maps was consistent with the national security classification of the maps, which for the national mapping program and most of the defence mapping program was unclassified and releaseable to the public.

Corps structure and organisation

In 1968, at the same time as the Corps started work on the Australian 1:100,000 mapping program, the Strategic Basis 1968 paper identified for the first time the need for self-reliance against sporadic attacks and raids on Australia's mainland, mainly from small commando type forces in any of the northern areas (Dibb, 1986, p24). This was against the background of the 1967 decision of the United Kingdom to withdraw permanently based military forces from east of Suez and the 1969 United States President Nixon Guam doctrine which included that allies should be capable of defending themselves with the exception of major attacks against their sovereign territory.

The then tasking commitments prompted Army in 1967/68 to conduct the first major review of the Survey Corps, albeit an internal review, since the reorganisation in 1947, with the review report recommending significant growth and to re-balance elements of the capability. This was approved by Army but not fully implemented mainly because of Army restructure and budget reductions after the withdrawal of most troops from Vietnam in 1971. In 1970, the four field survey units were increased in personnel numbers from 25 to about 45 (not all the same) and redesignated field survey squadrons with the prefix numbers associated with the military districts, 1st for 1st Military District (Queensland), 2nd for New South Wales but also covered Victoria and Tasmania, 4th for South Australia and Northern Territory, 5th for Western Australia. The squadrons were organised, equipped and trained for geodetic and topographic survey, photograph annotation, photogrammetric plotting, map compilation, field verification and final cartography. Each field survey squadron was equipped with Wild B8 stereo-plotters which were operated on two shifts five days a week when soldiers were not deployed on field survey operations. The 1970 increment to Army Survey Regiment severely

stretched the facilities at Fortuna with the situation alleviated by establishing a cartographic detachment in the old military area at Bonegilla adjacent to the School of Military Survey. The Corps' cartographic completion capability was enhanced in 1968 with commencement of contract cartography for the 1:100,000 program.

1st Field Survey Squadron worked on Cape York and the Gulf of Carpentaria for the 1:100,000 mapping program but deployed to Territory of Papua New Guinea in 1969 and 1970. 2nd Field Survey Squadron deployed to Indonesia from 1970 to 1972 and from 1976 became the principal survey squadron for Defence Cooperation Program projects, being deployed as such on all forms of surveying, photography and mapping in Indonesia and the South-West Pacific every year of the next 15 years until the unit was disbanded in 1990. Although largely committed to overseas Defence tasks during this period, the squadron did continue to contribute to military mapping in New South Wales and Victoria and the broader Australian survey and national mapping programs. 4th Field Survey Squadron worked throughout South Australia and Northern Territory but were deployed to Territory of Papua New Guinea from 1972 to 1974 and took over the field survey work of the Defence Cooperation Program from 1990 to 1996 after 2nd Field Survey Squadron was disbanded. 5th Field Survey Squadron worked through north-west Western Australia and deployed to Indonesia from 1973 to 1975. In the late 1960s, survey work of the Corps was assisted by Royal Engineer Survey Troops, based in various countries, attached to Survey Corps units in the Kimberley region, New Guinea and Albury, for a few months of each of three years.

When 'A' Section 1st Topographic Survey Troop returned from Vietnam in 1971, B Section was disbanded with 'A' Section attached to 2nd Field Survey Squadron in Sydney. In 1975, 'A' Section moved to Brisbane and collocated with 1st Field Survey Squadron. It was then redesignated 1st Division Topographic Survey Troop in 1980, in direct support of 1st Division, and then Headquarters 1st Division Topographic Survey Troop in 1985 along with a staff officer appointed to the Division headquarters. In late-1972, 9th Topographic Survey Squadron (Citizen Military Force) was raised in Sydney as a 'communication area' unit and restructured and later redesignated as Divisional Topographic Survey Troop (Reserve) in support of 2nd Division (Reserve) and Headquarters Field Force Command in Sydney.

Not long after the Survey Section returned from Vietnam and the field survey squadrons were increased in strength, Army decided to raise 8th Field Survey Squadron in Territory of Papua New Guinea in late-1971, with a complement of 20 personnel, to provide a full-time in-country presence for mainly geodetic and topographic survey and field completion for the 1:100,000 mapping program which drew heavily on the resources of the Australian based survey units then also working on the Australian 1:100,000 program. This is further mentioned later in the section 'Papua New Guinea'.

After the 1973 Sir Arthur Tange review into defence administrative and command arrangements, the single service departments were abolished and amalgamated into the Defence Department, and Army reorganised along functional command lines of field force, training and logistic commands. In practical terms Army Survey Regiment (formerly AHQ Survey Regiment) and Army Field Survey Depot (formerly AHQ Field Survey Depot) came under command Army Office (the General Staff – command exercised through Director of Survey) and the field survey squadrons came under command Headquarters Field Force Command in Sydney. A survey section was established on that headquarters and a senior survey staff officer was appointed to assist the command function. Importantly for Army Survey Regiment, the Topographic Squadron was renamed Air Survey Squadron, more correctly representing the Squadron's role as it no longer had a field survey capability. The School of Military Survey came under command Headquarters Training Command. The

heightened individual readiness requirements for military skills proficiencies, combat fitness, basic physical fitness and medical fitness of soldiers in the field force field survey squadrons did decrease unit productivity, especially in the 1:100,000 national mapping program, but these personnel were soldiers first and surveyors second. The Corps organisation for the 20 years after the 1968 review, and a comparison with the earlier post-war period, is in Figure 2.

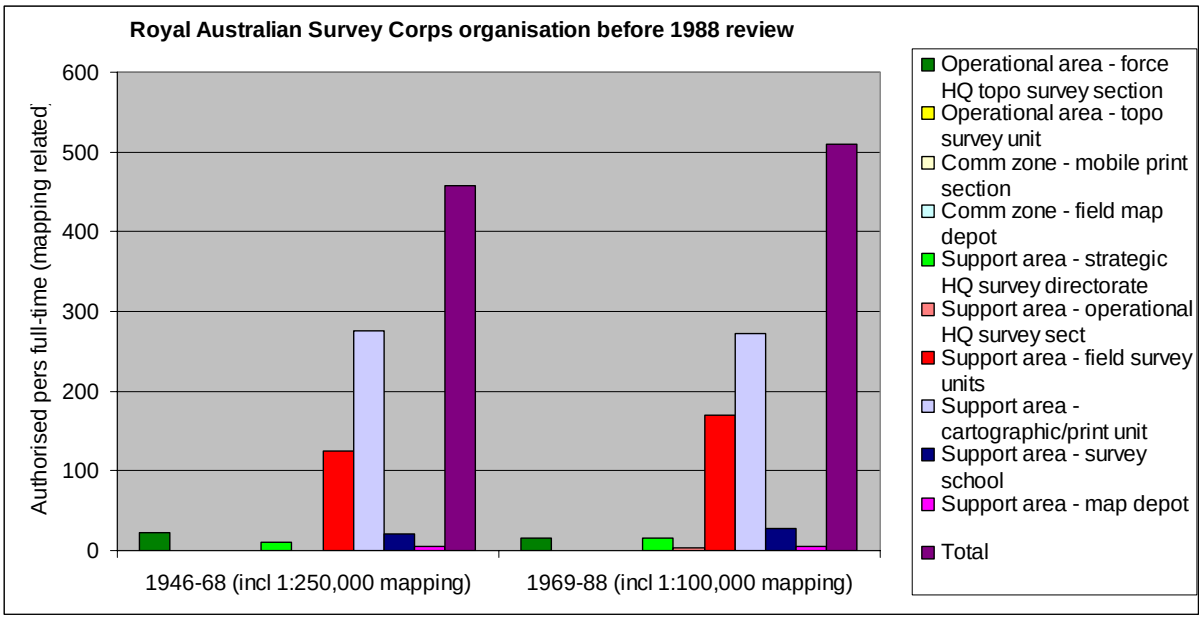

Figure 2. Survey Corps organisation 1946-1988

Personnel

The average Corps personnel strength throughout the era of the 1:100,000 program was about 510, with the year 1970 having a net increase (recruitment-discharges) of 103 being the largest for any post-war year (Jensen, 2011). School of Military Survey trained an average of 96 basic survey trade course students per year over the years of 1:100,000 mapping program. From time to time students from the Division of National Mapping attended courses at School of Military Survey.

In 1976, Corps soldier mapping related trades were rationalised with Topographic Surveyor and Topographic Draughtsman merging to become Technician Cartographic, with other trades merging to Technician Photographic and Technician Print. This was in recognition that the new era of computer assisted mapping systems required new skills with Automap 1 being delivered to the Regiment in that year.

Since the 1970s, selected Corps non-commissioned officers and warrant officers were appointed to non-Corps units in positions such as recruit instructors. At that time the Survey Corps administrative and logistics trades (clerk, storeman, driver), which had been essential positions to keep units operating since World War II, were rationalised across Army and concentrated in logistic Corps. This reduced Corps numbers by about 8%.

Geodetic and topographic survey

Within a year of Government approval of the scale 1:100,000 mapping program, the initial national geodetic survey was complete and the local astro-geodetic Australian Geodetic Datum 1966 (AGD66) was published by the National Mapping Council and gazetted. It included the datum station, Johnston Geodetic Station, with defined geodetic coordinates of latitude, longitude and spheroidal height and the size, shape and orientation of the Australian

National Spheroid. It provided nationally homogenous geodetic coordinates of hundreds of high-order stations, from a mathematical adjustment, and related projected map coordinates on the Australian Map Grid 1966 (AMG66) based on a Transverse Mercator projection equivalent to the military Universal Transverse Mercator (UTM) grid developed by the US Army Map Service in 1947 for a system of globally unique grid coordinates with the exception of polar regions. The US Army provided books of tables to assist with UTM computations.

The initial AGD66/AMG66 (extended into Papua New Guinea) was the high order geodetic network (fixed) for the more dense lower order topographic surveys conducted for the 1:100,000 national mapping program. Post-1966, topographic survey work of the Corps, of all era, was added to the national network of survey adjustments after survey observations were validated, then compiled into a computer readable form at the field survey units for geodetic adjustment conducted at Directorate of Survey, primarily using CSIRO computers and the method of 'least squares' and 'variation of coordinates'.

All heights were in 'metres' and initially with respect to State based sea level datums, but this changed to the nationally homogeneous sea level based Australian Height Datum when that system was introduced by the National Mapping Council in 1971 (AHD71).

Aerial Photography

The aerial photography used for the second phase of the national mapping program was the second national coverage, which was acquired though National Mapping from the early-1960s to 1975 with super-wide angle large format cameras (Wild RC9) providing a nominal scale 1:85,000. It is perhaps counter intuitive that scale 1:85,000 photography was used to produce the 1:100,000 mapping when the initial photography program of the larger scale 1:50,000 photography was used for the smaller scale 1:250,000 mapping program. The reason for this, as was mentioned earlier, was the limit of the aircraft to operate economically above 25,000 feet. The greater spatial accuracy required for the 1:100,000 mapping was partly achieved by the low distortion lenses and the application of optical plates to correct for the effects of earth curvature and refraction as photographs covered a ground distance of about 18km. Photogrammetric compilation scale was generally 1:50,000 and the sheets were photographically reduced to scale 1:100,000 for final cartography at map printing scale.

Major advances in technology and methods

Adoption by the Corps of new technologies, new methodologies and innovative ideas across all disciplines of map making continued throughout the era of the 1:100,000 topographic mapping program, supported by Army from the successes that the Corps had in implementing new technologies to improve efficiencies and operational effectiveness. Significant developments included:

- 1969 - the beginnings of the concept of a digital computer assisted cartographic system (later known as Automap)
- 1970 - digital coordinatograph plotter for grids, graticules and base compilation sheets with aerial triangulated model control
- 1970 - programmable calculators for field survey
- 1971 - second generation super wide-angle aerial survey cameras (Wild RC10) for supplementary, reconnaissance and spot photography (survey points) and later block mapping photography

- 1972 - second generation computer assisted airborne microwave electromagnetic distance measurement system - MRB3, deployed immediately in northern-Queensland and Territory of Papua New Guinea
- 1972 - orthophotomap production
- 1973 - RC10 mapping cameras mounted in 2 Squadron RAAF Canberra bombers for high-altitude photography (40,000 ft, nominal scale 1:135,000), deployed mainly Territory of Papua New Guinea and Indonesia
- 1974 - portable US Navy TRANSIT satellite Doppler geodetic receivers (Geoceivers - AN/PRR14) and computing system, deployed immediately to Indonesia and Territory of Papua New Guinea
- 1974 - airborne laser terrain profile recorder (WREMAPS II), deployed immediately to Territory of Papua New Guinea
- 1976 – delivery of the first computerised cartography and mapping system (Automap 1), first map published 1978 (Yampi Training Area, 1:50,000). It was with this system that the Survey Corps was a world leader in utilising new computer technology for map production.
- 1976 - four colour printing press
- 1978 - new cartographic specifications (SYMBAS Symbolisation All Scales) for map and air chart production by digital cartographic methods

Achievements

The 1:100,000 national topographic mapping program was not completed in the 10 years as expected when authorised in 1965, and commenced by the Corps in 1968, but by 1980 the Corps had completed most of its commitment to the program. It was not until 1988 that the last maps were published. The Survey Corps' contribution included compiling 629 of the 1635 maps outside the 'red line', publishing 862 maps (53% of total) outside the 'red line', including more than 200 maps compiled by the States and compiling 87 of the compilations inside the 'red line' (Coulthard-Clark, 2000) (Sargent, 1990) (Lines, 1992). The improvements in technology and the increase in Corps personnel numbers had improved the average number of maps published from 28 new maps per year for the 1:250,000 program to 72 new maps per year for the 1:100,000 program.

On completion of its parts of the 1:100,000 program the Royal Australian Survey Corps had completed its commitments to all of the Government approved national mapping programs. All topographic information produced by the Survey Corps as part of the national programs was available to government agencies, and the public, through National Mapping/Australian Surveying and Land Information Group. Later, all production materials for the 1:100,000 program were passed to Australian Surveying and Land Information Group as part of the national asset and for their use for map revision, maintenance and sales to the public, although Defence retained the right to revise the maps for its purposes, which it did by derivation from maps produced in the 1:50,000 defence mapping program. By mid-1992, 261 maps had been revised (Royal Australian Survey Corps, 1992).

Corps direction

Directors of Survey throughout the 1:100,000 national mapping program, and Army representative on the National Mapping Council, were Colonel Frank Buckland OBE who retired in 1972 after 35 years service, Colonel John Nolan who retired in 1975 after 37 years

service, Colonel Jim Stedman who retired in 1978 after 37 years service and Colonel John Hillier who retired in 1983 after 38 years service. Colonel Hillier was the first Director of Survey not to have served in World War II.

The 1:50,000 defence mapping program of Australia

Chief of the General Staff had directed the strategic standard mapping work of the Corps, and the Survey Section Engineers, since 1910. In 1965, the Defence Joint Mapping and Charting Committee [6] had stated its need for 1:50,000 topographic line maps for detailed planning and conduct of tactical level military operations. This need was confirmed in the 1976 Defence White Paper which included the concepts of low-level contingencies of small raids and attacks on Australian territory and escalated conflict involving lodgement of conventional ground forces on Australian territory. The associated demand on the survey and mapping capability was that of providing current, accurate, detailed topographic information, at short notice and over a number of widely dispersed areas concurrently. The paper stated that tactical joint forces might be required to deter, disrupt and defeat enemy forces at short notice. At that stage the 1:100,000 topographic map coverage was not yet complete and although the maps were adequate for advanced logistic and tactical planning they did not contain the detail for many of the types of operations envisaged. With the end of the national 1:100,000 program in sight, the Corps field survey elements turned their attention to surveys for 1:50,000 defence mapping of northern-Australia, commencing work in the Northern Territory Tactical Mapping Area in 1976.

In 1983, the Joint Mapping and Charting Group sought and gained Chief of Staff Committee[7] endorsement for an extensive defence mapping program in the form of 1:50,000 maps of the higher priority areas in northern and north-western Australia covering the coastal regions, offshore territories, major training areas and defence bases, remote population centres, major resource areas and the main land communication route from Adelaide to Darwin. The highest priority part of the program required production and publication of more than 2400 topographic line maps and 380 enhanced ortho-photo maps, of which the latter covered mainly the southern communication route. In 1985, the Chief of Staff Committee acknowledged that even the priority areas would not be covered within 15 years, but decided not to assign additional resources to the task, preferring to address the problem through more efficient utilisation of existing resources. The fact that Defence had embarked on a 1:50,000 defence mapping program was referred to a review of Australia's Topographic Mapping Facilities conducted by Professor J. Richardson in 1985/86 (Richardson, 1986). The effect this had on the program is mentioned later in the section 'Reviews of Commonwealth topographic mapping agencies'.

Scale 1:50,000 topographic maps were also a standard product of State Lands Departments and where there were coverage overlaps of Defence and State requirements, the Corps collaborated in activities with the States and shared materials for field survey, aerial photography, photogrammetric compilations, cartography and printing.

Since the mid-1970s the Survey Corps recognised the potential pervasiveness of digital topographic information in emerging military systems and designed Automap as not only computer assisted mapping systems but also to produce standard digital products and to

[6] The Joint Mapping and Charting Committee, founded in 1965, was replaced in 1972 by the Defence Joint Mapping and Charting Group to broaden the membership to include the Joint Staff and the Joint Intelligence Organisation

[7] Committee comprising Chief of the Defence Staff, Chief of Naval Staff, Chief of General Staff and Chief of Air Staff

archive digital data for future use. However, at that stage sponsors of those other military systems were slow to articulate their requirements for digital topographic data and unfortunately often left the matter to vendors with proprietary solutions. There appeared to be a reluctance to identify system requirements, perhaps thinking that their projects might be required to pay for the production of the data. It was not uncommon that maps and 'the like' was the last thing thought of but the first thing needed, and that they could get whatever they needed, whenever they needed it, from the local Survey Corps unit map store, just as they did for paper maps. This was a distraction for the Corps in its drive for all of Defence to adopt non-vendor specific formats to optimise inter-operability for exchange of digital topographic information, to assure data quality and to avoid duplication of effort. The Regiment's Automap 2 photogrammetric input sub-system had a capacity of stereo-plotting about 50 new maps (1:50,000) per year and the combined graphic photogrammetric plotting capability of the field survey squadrons was 100 new maps per year for conversion to digital data by scanning on Automap 2. Much of the photogrammetric plotting effort went into contouring, where the standard contour interval was 10 metres, although 5 metres was used in some areas to better portray the shape of the ground.

Although the 1:50,000 mapping was a military mapping program, the Corps provided for the release of the topographic data to other mapping agencies and the public. At the Inter-Governmental Committee on Surveying and Mapping annual meeting in July 1994, Director of Survey, Colonel Simon Lemon said that although Army was the only non-public interest mapping authority on the Committee, it would continue to contribute topographic data to the National Geospatial Data Infrastructure, through Australian Surveying and Land Information Group, with the principles of data supply being: transactions were to be cost neutral to Army, a levy may be charged based on value of intellectual property, the data was to be guaranteed and copyright was to be protected (Director of Survey, 1994).

Corps structure and organisation

The 1:50,000 defence mapping program attracted much attention and comment from the Commonwealth (see the section 'Reviews of Commonwealth topographic mapping agencies') but it was not until April 1987, that the Chief of the General Staff, Lieutenant-General L. O'Donnell, ordered an Army review of the Royal Australian Survey Corps in relation to future role, tasks, structure, organisation and personnel taking into account Government policy in the soon to be released 1987 Defence of Australia White Paper, Defence policies, strategic guidance, the recent Review of Australia's Topographic Mapping Facilities (Richardson, 1986) and the consequential decision by the four Ministers (Defence, Finance, Resources and Energy and Administrative Services) and the Auditor-General's Efficiency Audit Report on Army Mapping which by its very name had raised questions about efficiency of a number of aspects of the Corps' operation and organisation. Importantly, the terms of reference for the Army review included a requirement to identify manpower savings for redistribution within Army.

This was to be the first such review in 20 years, the last being in 1968. Brigadier J.S. Baker (later General, Chief of the Defence Force) was appointed but later succeeded by Brigadier J. Byrnes to complete the review in mid-1988 making 38 recommendations. The major thrust of the report was that the fundamental objective of the Survey Corps should be to develop a multi-product digital topographic database within a clearly defined military geographic information system, with map making being one of the essential outputs, and a heightened need for Survey Corps units, or elements, to deploy in the area of operations. It also found that the recent introduction of new technology survey systems reduced the requirement for most field survey squadrons. This all required reorganising and re-equipping the Corps.

The Chief of the General Staff agreed in principle to the future direction of the Survey Corps in the review report, and with some amendments accepted the recommendations. Consequently, in February 1989 instructions were given to (revised organisation included in Appendix 1):

- disband 1st, 2nd and 5th Field Survey Squadrons – being three of the five squadrons
- restrict Headquarters 1st Division Survey Section in peacetime
- raise 1st Topographical Survey Squadron in Brisbane under direct command Land Command including 2nd Topographical Survey Troop (Army Reserve) in Perth
- raise Military Geographic Information Sections in Perth and Darwin as a part of a pilot project
- increase Army Survey Regiment in Bendigo
- increase 4th Field Survey Squadron in Adelaide but move the Squadron under command of the Regiment and therefore the General Staff, exercised by Director of Survey, and after the introduction of Project Parare reduce the Squadron and concentrate it at Bendigo, and
- establish six map reference libraries co-located with major formation headquarters in Canberra, Sydney, Brisbane, Townsville, Darwin, Perth

The other Corps units then remaining were: School of Military Survey at Bonegilla, Army Map Depot (disbanded 1 May 1993) at Bandiana and 8th Field Survey Squadron at Port Moresby, Papua New Guinea (disbanded 1 December 1995) with staff on Army Headquarters (Directorate of Survey) and Land Headquarters. The Corps organisation after the 1987/88 review, and a comparison with the previous periods, is in Figure 3.

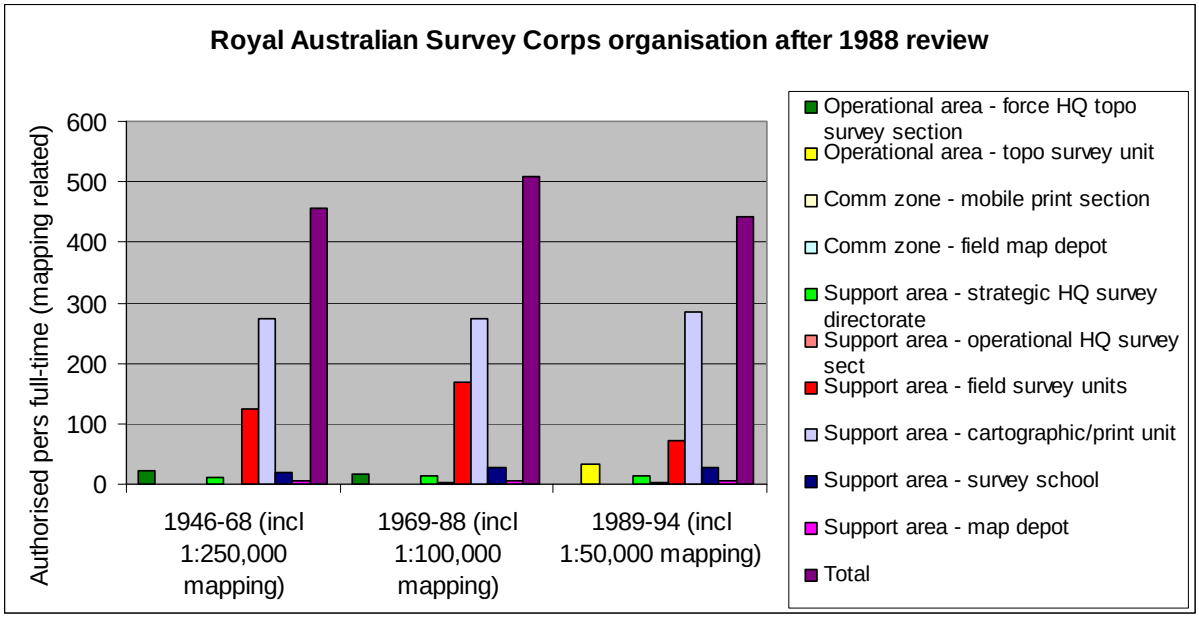

Figure 3. Survey Corps organisation 1989-1994

Actions in relation to this reorganisation were not complete before implementation was overtaken by the events leading to the May 1992 decision to commit the major part of the capability – Army Survey Regiment and 4th Field Survey Squadron - to testing under the Defence Commercial Support Program (see the later section 'Commercial Support Program –

digital topographic support to the Australian Defence Force') which was then the major efficiency reform program in the Department of Defence.

Personnel

The averaged Corps personnel strength (mapping related trades) throughout the era of the 1:50,000 program was about 490 with a significant shortfall of about 25% in 1990 mainly due to foreign companies target recruiting personnel with computer assisted cartography skills in particular operators of Automap. School of Military Survey trained an average of 45 basic mapping trade course students per year over the 1:50,000 mapping program (Jensen, 2011).

New technology and methods reduced numbers needed in the photo and print trades, and then with the changing skills associated with the introduction of military geographic information systems and later the impact of the reduced number of mapping related positions, the soldier 'survey' trades were once again rationalised, in the mid-1990s, with the three trades Technician Cartographic, Technician Photographic and Technician Print merged into the new trade Technician Geomatic with specialist streams. This restructure was largely complete before mid-1996, including a successful pay case that meant that senior soldiers of the trade who were selected for post-graduate tertiary education were the highest paid technicians in the Army.

In the early-1980s, the Corps assumed responsibility for personnel in the Army trades reprographic illustrator, still photographer and cinema projectionist, increasing Corps numbers by more than 80, although this did not add to the mapping capability.

A great collective strength of the Corps officers was that appointments were from a wide range of entry avenues including Royal Military College, Officer Cadet School, Direct Entry and In-Service Commissioning for selected warrant officers and non-commissioned officers. Directors of Survey argued the need for well educated officers to understand, develop and implement rapidly changing technologies, gaining places in the Army training schedules for 90 percent of officers to have under-graduate degrees in survey, mapping, geography and computing and 50 percent having post-graduate education in technical disciplines or from service staff officer courses in Australia and overseas[8]. This was well above the Army average. At any time, it was normal that more than 25% of officers (out of about 100 in the early-1990s) mostly in the rank of Major, were posted to non-corps command and staff appointments. Officers posted to a headquarters were often met by the chief-of-staff with 'not another bloody surveyor', to which a suitable reply was (normally a little later and perhaps another place) that General Washington, General Macarthur, General Monash and Field Marshall Kitchener all started as survey officers. More often than not, that chief-of-staff was on the telephone to Army Headquarters before the next posting cycle asking if there were any more surveyors.

Geodetic and topographic survey

Adoption of new technology survey equipments by the Corps to support the 1:50,000 military mapping program significantly improved the effectiveness and efficiency of providing geodetic and topographic survey. However, control surveys for the 1:50,000 mapping

[8] Including: International Training Centre - Delft (photogrammetry), Univ College London (photogrammetry), Oxford Univ (geodesy), Royal Military College of Science – UK (technical staff officer), Univ of Wisconsin (cartography), Univ of New Brunswick (photogrammetry), The Ohio State University (geodetic science), University of Melbourne, University of New South Wales, Univ of Queensland, Univ of Rochester (printing), Western Aust Inst of Tech

program started out with conventional traversing through the Northern Territory in 1976. In 1982, the TRANSIT Doppler Geoceiver equipments which were employed in point-position mode, were augmented with MX1502 receivers for point-positioning, and relative-positioning within a survey network, which improved productivity significantly by reducing the time spent on station. These systems were used very extensively for densifying topographic survey networks. A few years later, in 1987, the field survey capability was once again improved with delivery of Global Positioning System (GPS) Texas Instruments TI4100 receivers for relative positioning, and later point positioning, and the helicopter and vehicle mounted Ferranti Inertial Land Surveyor 3 (FILS3), which was based on the artillery Position and Azimuth Determination System for relative positioning. Both of these technologies provided a very rapid field survey capability. The GPS receivers were the only dual frequency/code capable receivers in Australia and there were many requests for assistance from not only Government mapping agencies but also scientific agencies and universities. FILS3 was a very precise and rapid survey system but its operational use was constrained by the need to stop every four or five minutes, for about a minute, for a 'zero-velocity update' to calibrate the system accelerometers. The system was more suited to the work of 1st Topographic Survey Squadron in providing operational support, than it was for control surveys for standard mapping.

Height determination for aerial triangulation by WREMAPS II laser airborne profile recorder, replaced barometric heighting by helicopter early in the program in the mid-1970s, to ensure that the specification accuracies were achieved for 10 metre contour interval, and to improve productivity.

The design rate of effort of horizontal and vertical control acquisition, along with aerial photography and field completion, was matched with the capacity of Automap 2 at the time, to produce six 1:250,000 areas of 144 new 1:50,000 maps a year.

Aerial Photography

This program required new aerial photography for currency of information as well as additional survey control to achieve the greater spatial accuracies required. The photography program commenced in 1977 and by mid-1992, photography had been flown for 1896 map areas, that is 79 x 1:250,000 blocks (Royal Australian Survey Corps, 1992). In the earlier part of the program, photography was flown by charter aircraft using a Wild RC10 camera, then later contracted to the Australian Surveying and Land Information Group. In 1991, the Corps formed the Aerial Photography Team in 4th Field Survey Squadron for overseas operations, using a charter Lear Jet and Titan aircraft with GPS navigation, Wild RC10 camera and statoscope. When not used for that purpose the team was assigned to aerial photography in Australia mainly for the defence mapping program. In some project areas the Corps used State Lands Department photography in collaborative bi-lateral arrangements. The initial nominal photo scale was 1:65,000, but this was changed to 1:80,000 after a review of the efficiency of the program in the context of the spatial accuracies required for digital topographic data to support existing and planned digital command and control, intelligence, weapons, navigation, mission planning and simulation systems. In the early-1990s, research and development focussed on using differential-GPS to determine the precise position of the exposure point of each photograph, and later the camera orientation, to reduce reliance on ground control. This developed into a capability requirement for an advanced aerial imagery acquisition system for 4th Field Survey Squadron/1st Topographic Survey Squadron.

Major advances in technology and methods

Just as it had done with earlier mapping programs, the Corps continued to take advantage of new technologies and methods, where appropriate, throughout the era of the 1:50,000 defence mapping program. Significant advances included:

- 1982 - Schut 'Bundle' analytic adjustment to augment 'polynominal strip' adjustment of large area block air photography
- 1984 - second generation computerised cartography and mapping system (Automap 2) and a preliminary archive of digital topographic information for creation of a multi-product database for military geographic information related systems
- 1987 - global positioning system receivers (Texas Instruments 4100)
- 1987 - helicopter and vehicle mounted inertial positioning system (Ferranti Inertial Land Surveyor 3)
- 1988-92 - adoption of World Geodetic System 1984 for all new products with existing products being transformed on revision
- 1990 - a geographic information system for the pilot project to inform requirements for development of Project Parare
- 1990 - Automap 2 upgrades including capability for exploitation of commercial satellite imagery
- 1990 - colour processor and plate processor
- 1991 - GPS precise point positioning software (from US Defense Mapping Agency)
- 1991 - five-colour printing press
- 1992 - research and development for aerial camera precise positioning and orientation
- 1992 - rationalisation and centralisation of all Survey Corps survey records and cartographic/lithographic materials at Army Survey Regiment
- 1992 - Weipa and Cape Weymouth 1:250,000 areas identified as terrain representative areas for evaluation of new products and new production techniques and methodologies
- 1992 - development of a portable digital topographic data demonstration system to support all Australian Defence Force units and sponsors of new military systems
- 1993 - adoption of the Digital Geographic Information Exchange Standards – DIGEST
- 1995 - large format printing press enabling just-in-time printing

Two of these warrant further explanation because of their influence on the future of surveying and mapping in Australia – adoption of World Geodetic System 1984 and adoption of digital geographic information exchange standards. They are both dealt with later in this paper under ‘influences of collaboration with major allies’.

Achievements

The initial computer assisted mapping system, Automap 1, was in-service by 1978, and by June 1982, 144 topographic line maps had been published and data stored as part of the

fledgling digital topographic data base. By mid-1988, and after the introduction of Automap 2 in 1984, there were 826 published maps or maps awaiting printing. The first large block priority area of 379 maps of the Pilbara Region with paper maps but more importantly a digital topographic database of digital elevation models and vector data of culture, drainage, relief and vegetation was completed in 1992 (Royal Australian Survey Corps, 1992). The digital data was 1.9 gigabytes and stored on magnetic tape and optical disc at considerable cost – it would now fit on one USB memory stick costing a few dollars. By 1996, when the Survey Corps transferred its responsibilities for the scale 1:50,000 defence mapping program to the Army Topographic Support Establishment, the Corps had produced 1530 topographic line maps and 380 enhanced ortho-photomaps, totalling 74% of the 1:50,000 higher priority defence program.

Averaged personnel numbers over the 1:50,000 program were a little less than those over the 1:100,000 program, but productivity had improved from an average 72 new maps per year for the 1:100,000 program to an average 110 new maps per year for the 1:50,000 program. This production rate was less than initial expectations of Automap 2, mainly due to inadequately described and understood performance specifications which led to technique and system modifications, and to some extent Corps under-manning in the late-1980s mainly because of civilian work opportunities in computer assisted mapping.

Corps direction

Directors of Survey throughout the scale 1:50,000 defence mapping program, and Army representative on the National Mapping Council and Inter-Governmental Committee on Surveying and Mapping were: Colonel John Hillier who retired in 1983 after 38 years service, Colonel Alex Laing who retired in 1989 after 32 years service, Colonel Don Swiney MBE who retired in 1991 after 32 years service and Colonel Simon Lemon who retired in 1997 after 27 years service.

Other defence topographic mapping programs

Support to military operations – other than survey operations

Mapping for Australian forces involved in the Malayan Emergency (1950-60) and the Indonesian Confrontation (1963-66) including Borneo was mainly provided by the British Army Royal Engineers and for the Korean War (1950-53) by the United States Army Map Service. The Survey Corps' contributions to military operations post-World War II was a mix of staff positions on headquarters and direct mapping support. The most significant of these, not including the Vietnam War which was mentioned before, included: staff posted to British Commonwealth Occupation Force, Japan (1946); staff posted to Malaya Campaign Force Headquarters (1955-60); staff posted to United Kingdom General Headquarters Far East Land Forces – Singapore (1951-70); Detachment Army Headquarters Field Survey Depot assumed responsibility, from United Kingdom, for storage and distribution of maps in Singapore, in 1970 the unit was renamed 16th Field Survey Depot and in 1971 renamed again to ANZUK Survey Map Depot (1969-75); rapid response mapping of Darwin after Cyclone Tracey – survey controlled rectified photomaps from Air Force photography in the few days immediately after the cyclone (1974); rapid response contingency mapping of Fiji (Operation Morrisdance 1987); rapid response contingency mapping of Vanuatu (Operation Sailcloth 1988); staff posted to United States and United Kingdom forces during Operations Desert Shield and Desert Storm in Kuwait and Iraq (1990-91); staff posted to United Nations Transitional Authority in Cambodia (1993); staff posted with British Army Geographic Staff to United Nations Protection Force Headquarters in Bosnia-Herzegovina (1995); and general

mapping for the many UN, multi-national and Australian peacekeeping and humanitarian operations 1947-1995.

Special military products

Apart from the systematic standard topographic mapping and tactical support to planning and operations, the Survey Corps produced topographic maps for military exercises and maintained a range of Defence special products mainly of scales from 1:10,000 to 1:50,000 such as: training area maps; naval, army and air force live-fire weapons ranges safety traces; vital asset protection maps; maps for safe storage of munitions; and digital terrain models for applications such as direct fire weapons fans and weapons locating radar for counter battery fire, communications planning and electronic warfare, radar planning, mission planning, low level flight routes, training simulators, war-game simulations. This does not include the ad-hoc diverse survey and mapping support provided by all survey units to all defence elements[9] or the tactical survey and mapping support being the daily bread-and-butter work of the 1st Topographic Survey Squadron and its predecessors.

Papua New Guinea

It was only five years after the end of World War II that the Survey Corps returned to the Territory of Papua New Guinea to begin a cooperative and collaborative relationship with firstly the territory, then the nation since 1975, that lasted 45 years and which was of great value to both nations (Laing, 1995). This topic is part of another paper at this conference, but it would be neglectful not to at least mention here that the Corps' work in New Guinea, in particular all that went towards producing all of the 278 of the 1:100,000 topographic line maps of the nation, the derived 1:250,000 Joint Operations Graphics and the military city ortho-photo maps, highlighted the abilities and commitment of the Corps to produce quality surveys and maps under difficult conditions. In 1980, when the 1:100,000 mapping program was completed, Papua New Guinea was more completely mapped than Australia. Six units of the Corps were involved in these projects, including 8th Field Survey Squadron raised in Papua New Guinea in 1971 with a strength of 20 personnel, and disbanded there in 1995, although most of the field survey capability ceased in 1980. In the 1970s, up to 50% of the Corps' assets were assigned to the survey and mapping of Papua New Guinea (Laing, 1995). Obviously these were assets then not available for tasking for the concurrent Australian 1:100,000 national mapping program, but this reflected the high defence mapping priority at the time.

The Defence Cooperation Program

Although the primary focus of defence planning from the mid-1970s was the defence of Australia and its offshore territories, survey and mapping was also required for areas of strategic interest outside Australia and Papua New Guinea. Presumably the Corps' successes of surveying and mapping in remote and difficult terrain, recently evident through the progress of mapping of Papua New Guinea, were examples applied to requests for assistance through the Defence Cooperation Program, from 1970 to 1995, by Indonesia, Malaysia, Solomon Islands, Vanuatu, Fiji, Western Samoa, Tuvalu, Kiribati and Nauru. In general, projects of mutual interest, including; geodetic and topographic surveys, geodetic adjustments and datum definition, aerial photography, aerial triangulation, mapping, printing, training both

[9] For example – mapping for F111C terrain following radar flight training, trials of Leopard and M60 tanks before the Government acquisition decision, astro-navigation training to Special Forces, specialist lecturers at Australian Defence Force Academy, Defence Force Assistance to Civil Community – navigation on nationally significant historical exploration activities

in-country and in Australia, transfer of technology, map exchange arrangements and military survey advisers, ultimately assisted the countries for defence, to define their Exclusive Economic Zones under the United Nations Law of the Sea convention, to map their natural resources and to respond to natural disasters.

These projects were not a force-determinant for the size or shape of the Survey Corps. Units that would otherwise be tasked to meet the survey and mapping needs for the defence of Australia, were those applied to the Defence Cooperation Program. The field survey squadrons and the topographic survey squadron were involved in field survey, air photography and photogrammetric plotting tasks, along with: the Regiment for airborne profile recorder network adjustments, aerial triangulation, photogrammetric plotting, cartography and printing; the School for training foreign students in Australia and overseas; and the Survey Directorate which developed and authorised survey and aerial photography plans, provided aerial mapping photography quality assurance and advisory teams to Air Force, computed survey station coordinates from TRANSIT Doppler data and GPS data and conducted geodetic survey adjustments integrating surveys of many nations, many techniques and over many era[10]. Most field work was done by 2nd Field Survey Squadron and then 4th Field Survey Squadron after 1990. From the mid-1970s to early-1990s more than 40 overseas survey operations were the main overseas joint (Navy, Army and Air Force) operations of the Australian Defence Force and were used to develop and test the doctrine and command functions for Field Force Command, later redesignated Land Command, to mount joint force operations overseas.

The official Corps history noted that after the withdrawal from Vietnam in 1971, "indeed for much of the period until the 1990s, the Corps was the most visible element of the Army outside Australia" (Coulthard-Clark, 2000, p.160).

Aeronautic charts

After World War II, the driving requirement for global military aeronautic charts was from long range strategic weapons systems, in particular those of the United Kingdom and United States, who divided the world amongst themselves for aeronautic chart production. The United Kingdom sought assistance from its major allies and from this came the series of families of aeronautic charts covering 5% of the earth for which Australia became responsible for. The area of responsibility covered nine Jet Navigation Charts (1:2,000,000), 27 Operational Navigation Charts (1:1,000,000) and 94 Tactical Pilotage Charts (1:500,000) from Malaysia south-and-east to Tasmania and east to Vanuatu, not including New Zealand. Army Survey Regiment maintained the topographic base, integrated the Air Force Aeronautic Information Service information and printed the charts on behalf of Chief of Air Staff. Typically about 10 charts were produced or revised annually. The 1:500,000 Tactical Pilotage Charts were all digitised to be maintained on the Automap 2 system. The Regiment also printed Air Force enroute and plotting charts and terminal amendments.

Hydrographic charts

Collaborative and cooperative survey support with Hydrographer, Royal Australian Navy commenced soon after World War II and continued in many forms for the next 50 years including: geodetic survey, beach survey, training, transport, Automap/Autochart and printing.

[10] Including Dutch, Japanese, French, Indonesian, British, Australian and American triangulation, traverse, trilateration, astronomy, trigonometric heighting, TRANSIT Doppler and GPS

Using its map printing capability, the Army Survey Regiment printed hydrographic charts of all types and sizes for Hydrographer to fulfill his responsibilities to both the Defence and the civilian maritime community. About 300 charts were printed each year.

Influences of collaboration with major military allies

The major influence that military standards had on topographic mapping of Australia since 1910 continued after World War II. That Australia was then a part of the new world order and the reality of new collective defence alliances, other than being a member of the British Empire, drove a need for new military interoperability and exchange of much needed topographic information. Australia did not lead interoperability developments, but embraced the advantages of associations with major defence allies who always sought and valued the Corps' comments and opinions.

Military mapping standards and specifications

To achieve military interoperability with allies it is necessary to have standards and specifications for that point of interface and for exchange of information in a meaningful and reliable way. The 1952 ANZUS Treaty is Australia's most important defence alliance, but it is the world's largest collective defence alliance, the North Atlantic Treaty Organisation (NATO), which drives western military interoperability standards. Although Australia is not a member of NATO, it was soon drawn into that interoperability arena through its relationships with major allies, the United States, the United Kingdom and Canada who are all members of NATO and who had formed the group of America Britain Canada (ABC) Armies in 1947. From 1954 to 1977, Australia, United States and United Kingdom were all members of South East Asia Treaty Organisation (SEATO) whose interoperability standards, known as SEASTAG, generally flowed from the NATO standards, known as STANAG. This influence in relation to metric scale mapping was discussed earlier. In 1963, the Australian Army became a member of ABC, to form ABCA, which since 2006 includes New Zealand, using the Five Nations Mapping, Charting and Geodesy Conference, of map production agencies, as its advisory forum on those matters. STANAG are considered by ABCA nations for ratification as standardisation agreements known as QSTAG (Quadripartite). As the United States, United Kingdom and Canada have normally already ratified the STANAG it is generally an easy process for ABCA ratification. QSTAGs were the basis of military standards and specifications adopted by the Survey Corps and it was through the Corps' membership of the National Mapping Council that content in some QSTAGs was considered for adoption as standards in the national survey and mapping programs.

The Five Nations Mapping, Charting and Geodesy Conference was the key multi-lateral forum for not only military mapping programs and interoperability, but for sharing information and technical developments in all aspects of geodesy, topographic mapping, aeronautic charting and hydrographic charting. Bi-lateral arrangements between members of Five Nations Conference were also of great mutual benefit for exchange of topographic information in Australia's area of strategic interest and information sharing for survey/mapping/charting system development.

World geodetic systems

The drive for a global geodetic system commenced soon after World War II with the introduction of long range strategic weapons systems of the United States and United Kingdom. Spatial accuracies required were initially satisfied by the globally disparate local geodetic systems, but from the late 1950s greater accuracies required a coherent global system. Under a 1961 arrangement between Australia and the United States, Survey Corps

units participated in global optical and electronic geodetic projects including: lunar occultations, astro-triangulation using Wild BC4 ballistic camera observations of ECHO and PAGEOS satellites, Australia-New Guinea connections to the global equatorial US Air Force High Range Navigation by Radar (HIRAN) network, radio frequency observations of SECOR, ANNA and TRANSIT satellites. Under this umbrella arrangement the TRANET station was established at Smithfield, South Australia, for geodetic research and later provision to Australia of precise ephemerides of TRANSIT Doppler satellites and provision of computer programs for computation of survey station coordinates by point-positioning. Much of the geodetic observation data was included in the determination of the World Geodetic System (WGS) 1972 and then WGS84. In the early-1960s, acquisition of aerial photography was also a combined effort, when the Corps supported a US Navy Southpaw aerial photography detachment based at Townsville. The Australia – United States relationship was strengthened in 1973 when a memorandum of mapping, charting and geodesy arrangements was signed between the Corps and the newly created US Defense Mapping Agency. This arrangement also supported the establishment of the Global Positioning System (GPS) station at Smithfield, in 1981, for testing of GPS systems, development of orbit determination capabilities, production of precise ephemerides, development and maintenance of WGS84 and provision of precise satellite ephemerides to approved users, including members of National Mapping Council/Inter Governmental Committee on Surveying and Mapping and Universities, and provision of GPS post-processing computer software. 4th Field Survey Squadron remained a part of this project until 1994, in collaboration with the Defence Science and Technology Organisation, when the Smithfield Station was moved to Salisbury and which still operates there as part of a global network to maintain WGS84 for GPS precise orbit generation and for geodetic research and development.

WGS72 had been introduced into AGD66 based national mapping of Australia, firstly with the 1:100,000 maps, in the form of grid ticks and datum conversion notes in the margin. For the offshore territories it had been adopted as the primary datum and spheroid after surveys which used TRANSIT satellite Doppler receivers.

Adoption of WGS84. With the release of the World Geodetic System 1984 (WGS84), the United States Defense Mapping Agency believed that that system had achieved an accuracy at the earth's centre of mass to within 1-2 metres. In 1984, the National Mapping Council adopted a new geodetic adjustment of Australia, known as AGD84, including survey observations of improved quality, but retaining the same datum coordinates, ellipsoid size and shape and ellipsoid orientation as AGD66. The average difference between AGD66 coordinates and AGD84 coordinates was about 2 metres. At the same time, the National Mapping Council recognised the potential of GPS in Australia and acknowledged that a geocentric datum, which would provide coordinates about 220 metres different to AGD66, would be adopted in the future. The Survey Corps then played a major leadership role towards a geocentric datum through participation in a Council GPS Working Party and then a Working Party to revise Standards and Practice for Control Surveys – Special Publication 1. The key issue was how to deal with outputs of modern survey systems, which would become widely available to all surveyors, and whose internal precision was greater than the quality of some of AGD66/84. At the 1988 meeting of the Inter-Governmental Committee on Surveying and Mapping (ICSM), being the successor to the National Mapping Council, Director of Survey, Colonel Alex Laing advised the Committee that Defence was committed to adopting WGS84 for all military geospatial purposes. The Committee resolved that for the community to maximise the benefits in applications of the Global Positioning System, Australia should adopt a geocentric datum by 1st January 2000 and appointed a Survey Corps

led Working Party to advise the Committee. The Survey Corps was confident that any Australian determined geocentric system would be consistent, for most practical purposes, with WGS84 which is maintained by the US Defense Mapping Agency (now US National Geospatial-Intelligence Agency) as the US datum for military geospatial products and the GPS datum for both broadcast and post-orbit precise ephemerides (Malys, 1994). Survey Corps transition to WGS84, for survey and mapping, commenced with secondary WGS84 grid ticks (replacing WGS72) on AGD66 based products in production, and from 1st July 1992 as the primary horizontal system for all geospatial products with appropriate warnings placed on all products. The first new maps produced reference WGS84 were in the Weipa and Cape Weymouth areas, in addition to Shoalwater Bay maps for major training exercises.

In 1994, the Government adopted the Geodetic Datum Australia 1994 (GDA94) which for practical purposes provides coordinates equivalent to WGS84 which was retained by Defence. The map grids for both WGS84 and GDA94 (known as Map Grid Australia 1994 (MGA94) remain based on the Transverse Mercator projection and the Universal Transverse Mercator grid.

Digital geographic information exchange standards

By the late-1980s requirements for mapping systems and other emerging digital military systems showed a need for easy and reliable exchange of digital geographic information between military allies just as there were map exchange arrangements. In 1987, the US Defense Mapping Agency proposed a collaborative research and development project with its major allies Australia, Canada and United Kingdom. The Senator Sam Nunn Amendment to the 1987 US Military Appropriations Bill provided for funding of US agencies research and development projects with NATO and certain non-NATO countries. To secure participation, Australia signed the Digital Chart of the World agreement in June 1990 involving both the Survey Corps and the Defence Science and Technology Organisation. In general, the project developed a family of standards for the exchange of digital geographic products, created a global database from the standards, using the Operational Navigation Chart (scale 1:1,000,000) as the source material, and provided computer software to exploit the database. The standards which provided for the exchange of matrix, raster and vector data between producers and users, became known as Digital Geographic Exchange Standards (DIGEST), sponsored since 1992 by the Digital Geographic Information Working Group (DGIWG) of NATO nations, now including nations beyond NATO including Australia. DIGEST became a NATO and ABCA standard for Defence and is being prepared by DGIWG to migrate to more flexible standards for military applications under the suite of standards ISO TC 211 19100. Australia's participation, including that of the Survey Corps, in the Digital Chart of the World project was a very significant contribution to the development of digital geographic information exchange standards both military and civilian.

Personnel exchanges

Personnel exchange programs with the United States, United Kingdom and Canada were of great benefit to the Corps through providing operational experience with allied forces in peace and war, but also day-to-day involvement in development of future systems, giving an insight which Australia would not otherwise have, into technology which later would be available more widely. While on exchange with the US Defense Mapping Agency in 1983/84, then-Major Simon Lemon (later-Colonel and the last Director of Survey) learnt that future systems would mean "….that map-making was no longer a highly technical science. It was something available to the man on the street, and there wasn't a need for large manpower resources. I realised then that the Corps' days were numbered"(Coulthard-Clark, 2000, p195).

Map specifications – the military and international influence

The influence of mapping by Australia's military allies on map scales in Australia was dealt with earlier in relation to the initial 1:250,000 national mapping program. It was only logical that other map characteristics such as series numbering, map/sheet numbering, sheet lines, conventional signs (symbols), accuracy standards, map sheet printing size and edition numbering, would generally follow the earlier military series of topographic maps. For the national programs these standards were 'Australianised' by the National Mapping Council, but there were accepted departures especially for military requirements.

Series numbering followed the military convention, probably initiated by the United Kingdom but adopted by the United States, to provide a unique global series identifier for all series topographic mapping. For the initial Australian 1:250,000 program the unique global series number was R502. The letter represents the large regional area (Australia), the first digit identifies the scale (eg. 5 = 1:250,000, 6 = 1:100,000, 7 = 1:50,000, 8 = 1:25,000), the next digit indicates the sub-area (0 = national area), and the final digit the number of series of like maps (2 - as the earlier '4 mile' was similar) (United States Department of Army, 1956). JOG followed another military convention where 1:1,000,000 were series 1301 and JOG 1:250,000 were 1501 and 1501A for the ground and air versions respectively.

The standard sheet lines for all of the standard series were geographic latitude and longitude originating from the 1909 International Map Committee for the scale 1:1,000,000 International Map of the World and the alpha-numeric numbering system 'S' for southern hemisphere 'N' for northern hemisphere, progressing 'A', 'B' etc being 4 degrees of latitude from the equator towards the poles and numbers from '1' to '60' in zones of 6 degrees of longitude easterly from the 180 degree meridian eg. SI55 Canberra (Geoscience Australia, 2010). For the 1:250,000 series, this rectangle was then subdivided into a four-by-four matrix each of 1 degree of latitude and 1 degree 30 minutes of longitude being numbered 1 to 16 from the top left and progressing left to right and top to bottom eg. SI55-16 Canberra. The 1:100,000 series sheetlines were 30 minutes of latitude and longitude making six map rectangles in each scale 1:250,000 area and the scale 1:50,000 sheetlines being 15 minutes of latitude and longitude being four rectangles in each scale 1:100,000 map area. Map sheet numbering for the scale 1:100,000 series was a military system (United States Department of Army, 1956) covering the series area, of four digits with an origin (0000) to the extreme south-west and the first two digits advancing east by each sheet and the next two digits advancing north by each sheet eg 8727 (Canberra). The 1:50,000 sheet numbers were then a subdivision of the 1:100,000 sheet number being 1, 2, 3, 4 clockwise from the north-east rectangle eg 8727-1. This was a departure from the earlier '1 mile' sheet numbering which used the scale 1:250,000 number as the base. Military special maps had standard series sheetlines, or special geographic sheetlines for optimal area coverage. The edition notation adopted by the Survey Corps, for all mapping, to indicate the production authority, was the suffix AAS (Australian Army Survey) attached to the edition number. Although all Australian maps were identified by firstly the sheet number, then the edition, then the series, they also had names which were approved by the State/Territory Nomenclature Committees.

Map symbology for series R502 was agreed by the National Mapping Council in 1958, being similar to the '4 mile' series which had been first adopted by the Council in 1948 and published as the Standard Topographic Map Symbols in 1953. Essentially the symbols derived from symbology in the *British Army Manual of Map Reading and Field Sketching of 1906* (Lines, 1992) and many Australian symbols had survived since the '1 mile' maps commenced in 1910. Specifications for the 1:100,000 maps were the Council *Specifications for Topographic Map Series Volume 1 Australia 1:100,000 Scale.* Later in the 1:100,000

program and then in the 1:50,000 program, the Survey Corps developed, produced and used Symbolisation All Scales (SYMBAS), which was developed for use by Automap. It was also used by other National Mapping Council members for development of other symbology sets. Compliance with the Council specifications was not 100% with notable departures including the military requirements for roads to be portrayed by 'surface material' (since 1910) and 'number of lanes', enlarged internal grid number 'type' as this was a key military feature in low light, printing in red-brown ink instead of red, and later change of hydrographic feature names from blue to black, to be compatible with military night vision environments which also drove changes of 'type' such as map name and 1:100,000 grid square identifier from open-face to sans serif and medium weight. From time-to-time SYMBAS was modified to accommodate continuity of the vector digital data such as contours on cliffs and coastlines and also the need to generate new stipples. Information for the 'road classification' requirement became a routine task of field surveys of all types over the years of all the mapping programs.

The placement of World Geodetic System (WGS) 1972, and later WGS84, grid ticks and warnings inside the neat-line were added to both 1:100,000 national maps and 1:50,000 military maps to accommodate the military habit of cutting the map at the neatline as most wars occur on the join of four maps.

Military specifications required that the maps be printed on high wet strength paper so that they were less likely to turn to pulp when they were wet. This also had been a military requirement since 1910, when the original '1 mile' series was printed on linen backed paper.

Map accuracies for the national series, horizontal and vertical, were consistent with the *Standards of Map Accuracy* published by the National Mapping Council in 1953, revised in December 1975 as second edition and published as Special Publication 3. For the 1:250,000 Joint Operation Graphic, revision of the 1:100,000 topographic line maps and the 1:50,000 maps of the defence mapping program, the ABCA military standard for map accuracy, QSTAG 546, was adopted. The stated reliability of the information portrayed was in relation to the age of photography and date of field verification.

Reviews of Commonwealth topographic mapping agencies

The Advisory Committee on Commonwealth Mapping did not meet after 1972, and in seeking wider efficiencies in the late 1970s, the Public Service Board established an inter-departmental committee to review the matter, the outcome of which (known as the Moran, 1981, report) was another inter-departmental committee to coordinate Commonwealth activity where appropriate. This group had no directive powers and did not meet after end-1983 (Richardson, 1986, p.48).

The 1983 Defence decision to embark on a large 1:50,000 defence mapping program once again exposed the long-unresolved matters between Army and National Mapping about 'authority' for topographic mapping. This led to a 1984 Cabinet directive for an independent review of Australia's topographic mapping resources, appointing Professor J. Richardson to the task. In considering the review report in 1987, the responsible Ministers (Resources and Energy, Defence, Treasury, Administrative Services) decided to resolve major outstanding matters, one decision being that Defence would retain prime responsibility for the scale 1:50,000 series topographic mapping program in Defence priority areas in Australia.

Paul Dibb's 1986 report of the Review of Australia's Defence Capabilities recognised specifically the fundamental importance of mapping of the natural and man-made terrain for planning and conduct of military operations and noted with some concern the timeframe to achieve a satisfactory map coverage of Australia (Dibb, 1986, p64). Dibb mentioned the

Professor Richardson review would soon be available to Government, but noted the need for effective coordination with civil authorities, and believed that where a mapping effort was undertaken to meet a defence requirement (such as large scale maps of the north and north-west) it should be funded and managed by Defence. He suggested a modest increase in Defence resources for mapping, subject to investigation of the most cost effective means of addressing the requirement including greater use of civil contractors. He also commented that Australia had a defence need for military mapping unlike Canada, United Kingdom and the United States "as we must contemplate seriously the conduct of ground force operations on our own territory".

The subsequent 1987 Defence White Paper went on to identify priority areas for military preparedness as the area of direct military interest as Australia and its Territories, Indonesia, Papua New Guinea, New Zealand and the South West Pacific and the wider area of primary strategic interest as South East Asia and the South Pacific. The paper developed the concept of credible contingencies whose characteristics included: the wide geographic dispersion of potential activities, the emphasis on small unit operations, the requirement for comprehensive surveillance and highly detailed intelligence, the need for normal civil activities to proceed with least disruption, the need for high level cooperation between services and with civil authorities and the need to be able to move forces rapidly over large distances then commit quickly to tactical operations (Defence, 1987). In relation to the survey force, the White Paper noted that the availability of comprehensive and up to date military geographic information of Australia and our area of direct military interest was fundamental to the effective conduct of military operations, and that although new technologies improve productivity the mapping of priority areas of the north will still take many years. Although the primary focus of defence planning was on the defence of continental Australia and its offshore territories, map coverage would be required for other than Australian territory.

This was a busy time for reviews and comments about Army mapping, and the next was an efficiency audit conducted by the Auditor-General, taking into account the Richardson Report 1986 and the Defence White Paper 1987. The Auditor's report, in mid-1987, focussed on efficiency issues in relation to map compilation output of the field survey squadrons, photography technical standards and arrangements for aerial photography, the requirement for replacement of Automap 2, printing presses and map and chart stockholdings. These matters were all considered in the Army Baker/Byrnes review then underway and which led to the 1989 reorganisation discussed earlier.

Commercial Support Program – digital topographic support to the Australian Defence Force

This section draws on notes by the author (Jensen, 1996) who was the Directorate of Survey senior staff officer appointed as the Commercial Support Program Management Review Team Leader.

In 1990, the government directed review *The Defence Force and the Community* by Mr A. Wrigley, included an examination of Defence Geographic Information Systems. In regard to the Survey Corps, Wrigley 1990, concluded that "Defence could and should withdraw from the operational and production sides 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 within the framework of a national program…". An Inter-Departmental Committee (IDC) was established to consider the Wrigley recommendations and a Working Group of officers drawn from the Departments of Defence, Finance and Industrial Relations was formed to examine survey, mapping and charting within the Australian Defence Force to determine: what level of commercialisation

was possible, over what time frame should commercialisation occur, any constraints to commercialisation and the affects of commercialisation on economy, operational needs and expansion capacity. A key issue in the report of the IDC was that the Army Survey Regiment could be civilianised but commercialised at some risk, as transfer of the complete function to either the private or other public sector organisations would expose Defence to a monopoly. The Army response to the IDC report included: acceptance that greater use should be made of the commercial sector for the Australian Defence Force mapping requirements where opportunities exist, and agreement that there was scope for civilianisation of Army Survey Regiment, but not before Army's manpower needs to support the topographic element of the combat force and future digital technology in the proposed Project Parare could be determined. The IDC broadly accepted Wrigley's findings (Wrigley, 1990, p7) that civilians were about 23% cheaper than military members, if account was taken of service related costs of service allowance, housing, removals on posting, medical, training etc, and there were additional savings of another 27% if use was made of contractors. Similar savings had been achieved in the UK and US where both of these nations had also found savings of 10-20% in activities that were reviewed but not contracted out.

At about this time other major Defence reviews were in play. The Defence Force Structure Review 1991 combined the Defence of Australia 1987 priorities for self-reliance with the priority Defence roles identified in Australia's Strategic Planning 1990 and outlined a long term restructuring program including maximisation of combat capabilities by reducing the numbers of Service personnel involved in headquarters and base support functions by using commercial and civilian support and maintenance where operationally feasible, practicable and cost effective. Force Structure Review, 1991 said that a detailed knowledge of Australia's environment is essential, and planned investment in mapping and charting effort would continue as a high priority.

So, by early-1992 and after many high level reviews there was unquestionable support for the need for land surveys and mapping for military planning and operations, but the argument was how to provide this much needed information in the most efficient manner. There was no argument about the effectiveness of the existing arrangements but there was broad comment that activities at Army Survey Regiment could be civilianised and perhaps commercialised although the latter at a higher risk.

Proposals for the replacement of Automap 2 commenced in the late 1980s with a variety of project names and identifiers, but all with the suffix 3, following on from Automap 2. The project, which became known as Parare[11], was initially endorsed by Army in November 1990 and taken over by the then new Defence capability development process. Parare was to address deficiencies in Automap 2, and provide for a multi-product digital topographic data base which would not only produce maps and charts, but digital products for other military systems and provide the topographic base for military geographic information. Unfortunately the Parare project business case was developed pre-Wrigley and it did not argue the critical issues of core and non-core[12] capability, note the relevance to the Wrigley recommendations nor the principal outcome of the Wrigley review being the Commercial Support Program (CSP) then being implemented across the Department. This was a critical omission at the time. It was another 12 months before Army decided what parts of the survey capability were core and non-core.

[11] From the Corps' latin motto Videre Parare Est – to see is to prepare

[12] Definition by Wrigley Inter-Departmental Committee (IDC) - non-core those activities which would not affect operational readiness – should be subject to competitive tendering

The capability submission was considered by the Defence Force Structure Policy and Programming Committee (FSPPC) in May 1992 seeking a financial commitment in financial year 1992/93. The requirement for effective topographic support in the planning and conduct of military operations was acknowledged by the Committee but the need for a CSP review of Army mapping activities was clearly on the agenda. Army resisted this approach, said that if it was agreed that a CSP review was required the scope of the review should be limited to the activities directly associated with Parare and that the complex nature of the review may take considerably longer than the 12 months suggested. Army argued that the appropriate level of civilianisation would be reviewed once the new equipment entered service. The CSP was only a new program and the review methodologies and the relationships between CSP and capability development were apparently not well understood. It is possible that the Committee meant only to test commercialisation through normal purchasing practices, or by using a consultant, rather than committing to the rigid CSP process which once started would be very difficult to stop. In conclusion the Committee agreed, *inter alia*, that a CSP review of Army survey activities be undertaken by Army before further consideration of Project Parare. The decision confused the relationship between force development and what was effectively an administrative management tool to achieve efficiencies. It led to defining and developing a non-core activity before the core activity. This decision also committed FSPPC to a seemingly philosophically difficult position of potentially providing capital funds to resource a non-core activity – this is what occurred later. It was planned to have the CSP review completed and the outcome back before the FSPPC in May 1993 for project financial commitment in 1993/94. The completion date was soon seen to be unrealistic and a six month extension to November 1993 was approved. This meant a delay of perhaps two years for the capital equipment funding decision.

Army was left with no choice but to conduct the CSP review and Director of Survey was tasked to take the 'lead' with advice from the General Staff and Defence CSP Branch. The procedural guidance for the review was the CSP Manual (then Edition 3 November 1992) and an early deliberate decision was to follow the endorsed process by the letter of the manual. That was the only way to maintain internal and external transparency, integrity and accountability. A consultant was appointed through competitive tendering to provide business and management expertise during the evaluation of Invitations to Register Interest (ITR) and the Request for Tender (RFT).

The draft Statement of Requirement (SOR) for the activity was written in simple terms of functional and performance requirements so as not to restrict innovative solutions and to be equally fair to commercial and in-house tenderers. It said what was required not how it was to be done. In broad terms it included work performed by Army Survey Regiment, Bendigo and 4th Field Survey Squadron, Adelaide but it did not include Defence Cooperation Program projects as these could not be used as force determinants. In terms of personnel numbers, the review would test about two-thirds of the military positions of the Survey Corps. At that stage the SOR contained activity elements which were later defined by Army as core and were removed before issuing the RFT.

The ITR phase was over one month in May 1993, and included an industry brief and full disclosure of status-quo operating costs, existing operations and the government furnished equipment and facilities which were offered to do the work. The summary of the evaluation of the ITR phase was that seven respondents indicated a capability, and two the potential capability, of performing as prime contractor for all activities in the SOR. Obviously this was potentially a non-monopoly situation and showed that there would be no requirement to include part-offers in the RFT. Moreover, the review had no option but to progress to the next CSP stage.

The CSP allowed the Commonwealth to submit an in-house bid like any other tenderer. This originated as an agreement between Defence and the trade unions. It was also used, as it was in this review, as a measure to ensure that the Commonwealth gained best value for money. Four years later the Defence Efficiency Review 1997 went on to say that "Defence should seek more flexibility within current CSP processes, particularly in assessing on a case-by-case basis the need to run in-house options" (Defence, 1997, p363).

At that point, in June 1993, Deputy Chief of the General Staff, Major-General G.D. Carter AO DSM, decided on the following three major principles which would not only guide the CSP review but affect the future of all elements of the Defence and Army land survey and mapping capability and ultimately the existence of the Survey Corps:

- That systematic standard topographic mapping of Australia was non-core and therefore was subject to the CSP.
- That, with concurrence by Army Land Commander, operational tactical mapping for land combat forces was a core activity and would be retained by Army in the combat force. Land Command believed that the future non-core capability would not provide the required level of readiness nor the extant flexibility and responsiveness and requested transfer of 4th Field Survey Squadron from under command the General Staff to Land Command. Deputy Chief of the General Staff approved this augmentation of combat force topographic assets, but did not transfer the functions of 4th Field Survey Squadron which were part of the CSP review.
- That, with concurrence by Director Defence Intelligence Organisation, strategic mapping to support military operations outside Australia was a core Defence Intelligence responsibility, but would be retained by Army to support contingencies until Defence assumed responsibility for this function. Army would achieve this through extant map exchange arrangements with allies and nations in Australia's region and by maintaining a minimum capability at Bendigo throughout any transition that would result from CSP decisions. By definition, this core activity was then not included in the CSP. This transfer of responsibility was completed, in two phases, by November 2000 when the Defence Imagery and Geospatial Organisation was established.

In terms of the CSP the Deputy Chief of the General Staff agreed to the industry requests that the Commonwealth establish the CSP contract period as five years with the option to extend for a further two years, in 12 month increments, to encourage appropriate investment in capital equipment and personnel.

At the end of the RFT phase, which was open for 10 weeks to mid-October 1993, there were four tenders submitted including the in-house option.

With the concurrence of Director-General CSP, the standard tender evaluation process was amended to account for the requests of the commercial tenderers that the in-house option be tested against all other tenders. The three week tender evaluation assumed no prior knowledge of any bid and simply assessed each bid against all elements of the request for tender, to determine qualitative and quantitative ratings, and associated risk descriptions of both the business/management and technical proposals. In summary, the in-house option provided the highest business/management and technical worth and said that all work would be done by Defence civilians in a new organisation, the Army Topographic Support Establishment (ATSE) at Bendigo. The tender evaluation team recognised probable implementation delays and therefore risk in transitioning to an Australian Public Service staffed organisation and purchasing new capital equipment, and recommended that the in-

house option be accepted as the tender most likely to satisfy the RFT, but that the in-house option and the preferred commercial option be referred to detailed financial evaluation, including the affects of delayed implementation of the in-house option, to determine best value for money. The detailed financial evaluation was completed by end-November 1993 after which the Chief of the General Staff ordered an independent audit of the evaluation to be conducted by a major civilian accounting and audit company. This external audit confirmed the Army evaluation in late-January 1994. Estimated savings over the 10 year period of the evaluation, in comparison with the status-quo, were about $110m, or averaged savings over the five year period of the contract of about $55m. This was considerably more than the average savings of $34m across all CSP contracts reported in the Defence Efficiency Review, 1997. Some questioned how could it be that an in-house option could win? An Australian National Audit Office 1998 audit of the CSP program found that historically 30% of tested activities were awarded to in-house options. This was comparable with similar programs in the US and UK. The report went on to say that the more specialised the activity was, the more likely it was that the in-house option won. This was simply because of the high level of training and expertise in the existing workforce that was part of in-house options.

As a Tier 2 CSP review the savings were allocated on the basis of 20% of the status-quo costs to Defence and the balance of savings to Army. The review tested 373 establishment positions comprising 80 military positions being the whole of 4th Field Survey Squadron and 293 (286 military and 7 civilian) positions, being the whole of Army Survey Regiment. In terms of savings, 150 civilian positions were required to staff the in-house option, leaving 223 positions as savings of which Army removed all from the establishment. After delay caused by having to gain acceptance on the description of savings, and a price validity extension, the Minister noted Army's decision which was then publicly announced on 29th April 1994. The Commonwealth Gazette (Purchasing and Disposal) published the value of the contract as $53,606,876 over five years. This did not include the costs of Project Parare although it was included in the audited financial evaluation.

Defence chose not to quarantine any positions for the strategic core capability which had been excised from the CSP and which would be developed later in the Defence Imagery and Geospatial Organisation.

The contract effective date was 1st July 1994 but Army could not establish ATSE until all resources in the in-house option had been identified. At that stage it was believed that the standard materiel acquisition cycle could be by-passed and equipment could be purchased quickly, using CSP savings, as it was a commercial-off-the-shelf buy. This was not to be. Implementation difficulties were underestimated and it was soon clear that management practices in Defence would not accommodate the flexibility needed for such a CSP related change. Had it not been for the considerable cost comfort zone between the in-house option and the preferred commercial option the decision would soon have been reconsidered. Whilst the cost of the capital equipment had been included in the financial evaluation, the source of funding had not yet been identified. A number of options, including leasing and loans from Defence to Army with repayment from CSP activity savings were considered. In the end it was viewed that as the Force Structure Policy and Planning Committee had committed Army to the CSP review, Defence and not Army should be responsible for funding the equipment. After the de-briefings to the tenderers, and an independent inquiry into one formal complaint about the review process and outcome, Force Structure Policy and Planning Committee were able to again consider Project Parare in December 1994. The Committee recognised the imbroglio of force structure development and the CSP process and agreed to fund the equipment for ATSE, then known as Project Parare Phase 1. The Committee did not at that

stage support the still poorly presented core strategic capability but noted that Army was to remove all 223 positions to fully realise the CSP savings.

Chief of the General Staff was then able to approve raising the ATSE with effect 1st July 1995 with all action to be complete by 1st December 1996. As the ATSE was a CSP activity, Army was obliged under the Defence (Restructuring) Agreement 1994 to consult with appropriate unions. Most of the ATSE workforce, as submitted in the in-house option, was to transition from military members of the Survey Corps to the Australian Public Service (APS) by a seldom used mechanism in the Public Service Act 1922 Section 81B, which allowed for the transfer of activity functions and personnel performing the functions from the ADF to the APS. There was no precedence in the use of Section 81B for the numbers proposed in the in-house option. Director of Survey recommended that the use of Section 81B be restricted to 110 positions relevant to technicians and general service officers performing technical functions. The remaining 40 positions mainly in the administrative, supervisory and management classifications would be recruited by open advertising and transfer within the APS. It was believed that these recruiting methods would assist the ATSE in the desired outcome of the best possible workforce by broadening the recruitment base, albeit cognisant of the constraints that the APS classification structure and recruiting procedures placed on this aim. That the program was about commercial support meant that it was desirable that there was commercial experience amongst the senior managers. The intention was to recruit from the top down to effect the transfer of day-to-day implementation to the ATSE as soon as practicable and the General Manager, Mr Brian McLachlan, was appointed in January 1996 through open advertising of the position. In late July 1995 the Public Service Commission, Department of Industrial Relations, Defence and Army agreed that the provisions for Section 81B transfer could be broadened to include other ranks and officers who under previous interpretations of the Public Service Act were not eligible. This allowed for qualified personnel not directly affected by the CSP decision to volunteer for Section 81B transfer.

Planning for the transition of the Survey Corps workforce progressed on the assumption that Project Parare Phase 1 would be delivered to the ATSE with accelerated acquisition. A briefing package was provided to all Survey Corps soldiers (mapping trades) and officers, addressing personnel aspects which would assist individuals in electing future employment options. The options were: remain Survey Corps albeit with reduced Corps employment opportunities, transfer to other Army employments, or transfer to the APS and ATSE. There were no redundancies offered as part of this process, as Army believed that Survey Corps officers and soldiers were very suitable for non-corps appointments and other Army employments. Personnel elections were completed mid-August 1995 and after a process managed by Director-General Personnel Management, 87% of personnel were allocated their first choice from the election process. Given that more than 75% of the mapping related personnel positions had been removed from the Corps this was a reasonable outcome in the circumstances. Project Parare was still delayed (finally delivered in 1998) but it was decided to transition to the CSP contract in two phases with completion by 29th April 1996, by which date all 79 Section 81B transferees had transferred from the Army to the Australian Public Service. ATSE was then operational and capable of satisfying the contingency requirements which had been directed by the Chief of the General Staff as the minimum transition capability using the Automap 2 system provided as interim Government Furnished Equipment.

The Survey Corps organisation remaining after the CSP is in Figure 4 which summarises the organisation over the 50 years since World War II.

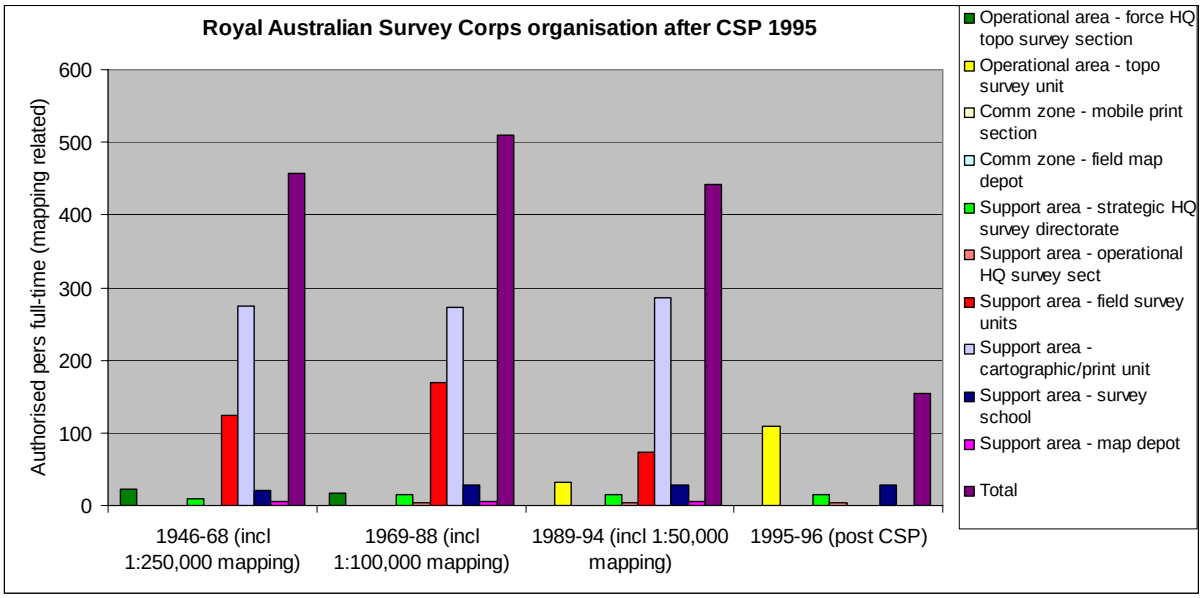

Figure 4. Survey Corps organisation 1946-1996

The end of the Royal Australian Survey Corps

Army was committed to its tactical survey force and bought back from its CSP savings, 77 full-time military positions to augment 1st Topographic Survey Squadron with a peacetime establishment of 109 full-time and 27 part-time troops. This was the classic example of transferring CSP savings from 'tail-to-teeth'. 1st Topographic Survey Squadron was then organised to provide direct support to one deployed joint force headquarters and three deployed task forces concurrently in dispersed geographic areas consistent with the Government guidance of low-level and escalated levels of conflict. In addition, topographic staff and advisers were posted to Army formations at brigade and higher levels.

Coincident with these major changes to the Survey Corps structure and operations there were major changes in the Army structure, especially outsourcing base support functions. Reduction in the Regular Army strength in the 1990s, across all of Army, was 22%. By 1st December 1995, seven Corps schools were to be grouped into the Army Logistic Training Centre, including the School of Army Health then at Portsea, Victoria. The Portsea facility was to be disposed of, and in early-September 1995, Chief of the General Staff, Lieutenant-General J.M. Sanderson AC, visited Portsea and then Latchford Barracks, Bonegilla, Victoria, which was the home of the School of Military Survey and the Army Apprentice School which was a key Logistic School. General Sanderson, an Engineer officer, was well aware of the affect of the CSP on the Survey Corps, but importantly he noted the facility of the Survey School as being a suitable facility for the Army School of Health[13] [14]. On 15th September 1995, Chief of the General Staff issued a directive that the Royal Australian Survey Corps would integrate into the Royal Australian Engineers and that the School of Military Survey

[13] The Army School of Health occupied the facility of School of Military Survey after that school moved to School of Military Engineering at Moorebank, NSW
[14] Discussion Lieutenant-Colonel P. Jensen and Directorate of Plans Staff Officer Grade Two Force Structure, September 1995

would move to Steele Barracks, Moorebank, NSW and integrate into the School of Military Engineering.

On 14th December 1995, Chief of the General Staff advised Defence Minister Robert Ray, through the Chief of the Defence Force General J. Baker AC DSM, of his decision to integrate the two Corps and sought the Minister's agreement. General Baker, an Engineer officer, was familiar with the Corps from his part in the 1987/88 review of the Corps, and more importantly broad knowledge of the digital future of mapping systems from his position as Director Joint Intelligence Organisation 1990-1992, in particular from a visit to the United States Defense Mapping Agency, in March 1990, escorted by the author. Chief of the General Staff advised that the Survey Corps personnel numbers had reduced to 239 including more than 80 in non-mapping related trades, but did not elaborate reasons for his decision except for efficiency. The Minister accepted the advice of his senior military advisers without question. 'Efficiency' was not further explained, but in a book review written by General Sanderson in 2010, the General said "The reviewer was personally involved in many of the reform programs of the 1990s and can attest that improving Australian Defence Force capability was always the principal aim. The target was not efficiency at all costs, but efficient effectiveness. It is surely not unreasonable to recognize that, while strategic circumstances may set the objective, some account must be taken of economic reality..……" (Sanderson, 2010). The indisputable fact was that the Corps then had only one survey directorate on Army headquarters, survey staff on operational level headquarters, one tactical level topographic survey unit, one survey school, a military geographic information pilot project and a few map libraries. The nearly coincidental timelines of this decision and the career decisions which individuals had to make only a few weeks earlier in relation to the effects of the CSP outcome on their individual future, was accidental, and was not intended to mislead Survey Corps members.

Director of Survey Colonel S.W. Lemon said that the Australian Intelligence Corps had also shown an interest in assuming responsibility for personnel and the tactical survey function (Coulthard-Clark, 2000, p196), as it had done pre-1910 as a staff and militia organisation. But Engineer Corps was the best option for three reasons:

- Engineer Corps offered the best career opportunities[15]
- Engineer Corps was responsible for advising battlefield commanders on the effects of terrain on operations, and the enemy, and it was only logical that they would also be responsible for providing, maintaining and assuring integrity of battlefield terrain/topographical information as part of the broader military geographic information system
- there were many elements of commonality in the selection, training and employment of military engineer and survey officers and soldiers

Moreover, Director of Engineers and Commander Land Command Engineers said at the time that the ability to collect, analyse and use terrain information to great advantage was an essential element of Engineer tasks in the Army of the 21st Century (Booklet, 1996).

Integration occurred on 1st July 1996, formally marked with a parade at the School of Military Engineering reviewed by Chief of the General Staff, 81 years after the Australian Survey

[15] Recent Chiefs of the Defence Force Generals J. Baker and P. Gration and Chiefs of the General Staff/Army Lieutenants-General J. Sanderson, F. Hickling and K. Gillespie, the current Chief of Army, were all Engineer officers

Corps was raised and when the Corps assumed responsibility for military mapping from the Survey Section Royal Australian Engineers (Permanent) which had begun its work in 1910.

Although the 'head of Corps' functions of Director of Survey, such as personnel, training, equipment, doctrine, ceremony, history, transferred to Director of Engineers on 1 July 1996, the strategic mapping core functions of managing the ATSE contract, foreign liaison and map exchange agreements remained with Army until such time as these responsibilities were transferred to Defence. To accommodate a smooth transition of these responsibilities, the Directorate of Survey was redesignated Directorate of Military Geographic Information – Army on 6th May 1996 with Colonel Simon Lemon, Director of Survey, appointed as the Director.

Then a few months later the Defence Efficiency Review, 1997 recommended rationalisation of seven of the geographic organisations across Defence, but this was only partially implemented. On 1st September 1997, the strategic mapping responsibilities of Army transferred to Defence and the newly raised Directorate of Strategic Military Geographic Information under command Headquarters Australian Defence Force.

But reform did not stop there. Importantly for topographic mapping, the Australian Imagery Organisation, which had emerged from the Defence Intelligence Organisation – Imagery Exploitation Centre, merged with Directorate of Strategic Military Geographic Information and the Defence Topographic Agency (redesignated from ATSE), by Cabinet Directive in November 2000, to form the Defence Imagery and Geospatial Organisation as a Defence Intelligence agency.

At that point the decisions made by Deputy Chief of the General Staff in 1993, about Army's responsibilities for topographic mapping and the concepts of the broader structure for Defence topographic mapping, had been fully implemented. Indeed, the Defence White Paper, 2009, p.102, included "Defence Intelligence provides….mapping, charting and other forms of geospatial support to ADF operations and national security operations and planning….". Defence Imagery and Geospatial Organisation – Geospatial Analysis Centre at Bendigo assumed responsibility for Defence core strategic mapping.

Since then, most of the non-core work, which had been the ATSE CSP work, has been out-sourced through Defence Imagery and Geospatial Organisation in-conjunction with Geoscience Australia.

Conclusion

The Survey Corps approached and completed its commitments to the national survey and mapping programs, the defence survey and mapping programs, the Defence Cooperation Program and other international programs post-World War II with all of the enthusiasm and professionalism which were the hallmarks of its people and its work since 1915. The Corps was a prominent and influential leader of topographic mapping in Australia and the envy of many organisations in Australia and around the world. The standards of its work set national and international benchmarks in much of what it did. The work of the Royal Australian Survey Corps will be evident to the Australian public for many years to come, through the Corps badge printed on more than 5000 maps, of which nearly 4000 were produced after World War II, which are available widely in map shops and in library archives around the world. Perhaps to a lesser extent the thousands of brass survey marks set in concrete in the ground in Australia and the region, many of them in very remote places, will remain as evidence that surveyor's of the Royal Australian Survey Corps had lived and worked there as part of something bigger.

On the occasion of the 75th anniversary of the formation of the Survey Corps in 1990, a notice of motion in the Australian Senate on 31st May, by Senator MacGibbon, noted the vital role that military surveying and mapping had played in the development of Australia since the time of explorer Sir Thomas Mitchell, acknowledged the high level of professionalism of the Survey Corps and its contributions during war and peace to not only Australia but also Papua New Guinea, Indonesia and countries of the South West Pacific, and congratulated the Corps on its meritorious achievements through the 75 years of existence.

In 2000, the author of the official Survey Corps history (Coulthard-Clark, 2000) concluded his work with "Australians as a whole might still be blissfully unaware and hence unappreciative of the debt of gratitude owed to the generations of surveyors who have helped make possible the enviable standard of living generally enjoyed today across the country. Should that situation ever change, and the story receive the wider recognition that it deserves, then the part within that tale occupied by military map-makers is worthy of special acclaim by a grateful nation."

Nearly a decade later on the occasion of the unveiling of a memorial plaque at the Australian War Memorial on 9th July 2007, commemorating the Royal Australian Survey Corps units that served in war, His Excellency Major-General Michael Jeffery AC CVO MC, Governor-General of the Commonwealth of Australia, quoted the Chief of the General Staff Lieutenant-General J. Sanderson at the Corps integration parade in 1996, "Since 1915 the Survey Corps has not just been a major contributor to the tactical success of the Australian Army in two World Wars and other conflicts, it has played an outstanding role in the building of this nation – the Commonwealth of Australia – and the building of other nations such as Papua New Guinea." As commander of Moem Barracks, Wewak, Papua New Guinea when 8th Field Survey Squadron was the only Australian Army unit based there in 1975, then-Lieutenant-Colonel Jeffery MC, Commanding Officer 2nd Pacific Island Regiment of the Papua New Guinea Defence Force, was very familiar with the personnel, operations, capabilities, standards and achievements of the Royal Australian Survey Corps. The Governor-General went on to say "Although the Corps is no longer, its legacy provides the ethos, the distinguished history and the enduring sense of high professionalism of our military surveyors of today."

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