INTERGOVERNMENTAL COMMITTEE ON SURVEYING & MAPPING

The Australasian Geodetic Infrastructure:

10 Years and Beyond

Discussion Paper

Version 2.2.1

Geodesy Technical Sub Committee
November 2000

Vision

A Geodetic infrastructure supporting instantaneous, 3-dimensional, sub-centimetre positioning, anywhere in Australia and New Zealand

This will underpin national, regional, and local economic and social development and decision making by providing an authoritative coordinate reference system and will be achieved through the provision and availability of:

- a modern spatial reference framework
- intellectual information including specifications and standards
- an accurate and accessible geodetic network
- high integrity data providing confidence and reliability in the system

1 Executive Summary

This paper has been prepared at the request of Intergovernmental Committee on Survey and Mapping (ICSM) as a discussion paper to define the form, structure and nature of Geodetic Infrastructure for Australia and New Zealand.

In the future the nature of the geodetic infrastructure will be expanded into a more comprehensive positioning infrastructure. The infrastructure consists of the reference framework, data, physical elements, intellectual component and institutional arrangements.

The positioning world is changing. Currently, there is an explosion in the use of positioning in a broad range of applications and there is consequently a rapidly expanding user base. No longer can the geodetic infrastructure focus on the needs of the survey community alone, it must now consider the requirement of a much broader group, whilst a number of other players are now able to contribute directly to the geodetic infrastructure. These players have expanded beyond the traditional government bodies and now also include purely commercial providers.

Technologies, notably satellite based positioning systems, have revolutionised the process of measuring and spatial data is increasingly position based. This technology makes positioning more accurate and more accessible than in the previous generation of geodetic infrastructure networks. Other new technologies are also set to play their role in the future as communication technologies converge and greater integration of previously separate technologies will improve the overall functionality and thereby further expand the use of positioning for greater utility.

New spatial information is being made available through wireless technology using reliable and accurate positions as the integrating tool for disparate databases. The technology already exists to have real time centimetre positioning for populated or areas of high economic activity areas. Cell phones can be expected to have positioning capabilities of several metres within ten years and remote areas already have similar position capability using DGPS and satellite communication devices. Global issues are becoming even more dominant, with the geodetic infrastructure part of a dynamic global solution, and playing a greater role in monitoring global climate changes.

It is clear that the future role, structure and nature of the infrastructure in Australia and New Zealand will be quite different to now. Initially there will be an increase in the number of ground marks as new useable 3-dimensional marks are established for greater user utility. In the long term however the need for ground marks across the countries will decline as the trend to real time positioning continues.

2 Introduction

The geodetic infrastructure is comprised of five key components:

- Reference framework - comprising definitions of the size and shape of the earth, geodetic and vertical datums, map projections, transformations between datums and projections, and the geoid model.
- Data - which is the survey data and associated information, including the results of computations or adjustments and delivery systems for data
    - Physical components - are the actual marks in the ground, or satellite receiver antennas.
    - Intellectual components - which is the network design and the knowledge base of professionals and users.
    - Institutional arrangements - being the institutional and administrative arrangements required to deliver the infrastructure.

The geodetic infrastructure has historically played a key role in the development of Australia and New Zealand. It provides the basic positional infrastructure on which society is based. A large amount of human activity is related to or dependent on geographic location and information about land resources. Accordingly, a geodetic infrastructure is designed to provide a reference system to enable people to acquire, manage, disseminate and exchange information about land and its resources.

2.1 ICSM

In May 1999, ICSM requested the Geodesy Technical Sub Committee (GTSC) to prepare a paper on the future role, structure and nature of the geodetic infrastructure for Australia (and New Zealand.) ICSM noted that this was in line with a need for all its activities to be published more widely and to help generate an understanding of the importance of geodesy in the wider communities of Australia and New Zealand.

The GTSC formed a reference group to carry out this task and a progress report was presented to ICSM in November 1999. A draft report was presented to ICSM in May 2000 and an updated version in

November 2000. ICSM members were encouraged to provide feedback via their Geodesy Technical Sub-Committee member.

The initial report placed emphasis on the provision of an adequate and appropriate geodetic network over:

- High population areas;
- Environmentally sensitive areas;
- Areas of high economic value; and
- Communication routes.

3 Current and Emerging Issues

Positioning is currently an area of intense activity. Many research themes are being actively pursued across the world and that in turn stimulates international conferences to consider the results. There are also several international organisations with direct or indirect interest in positioning.

Below are a number of issues relevant to the ICSM jurisdictions.

3.1 Government

Government roles and responsibilities have continued to change. Once core activities are now often considered peripheral. Those core activities remaining are often delivered differently.

However, these changes have not had a major impact on government responsibility in provision of geodetic infrastructure. The reason revolves around the need to maintain a coordinated approach from local to national and through to the international level. This will not change and it is expected that government will retain the responsibility for the provision of the geodetic infrastructure.

Whilst the responsibility will remain with government, many service delivery activities may not. Service delivery will use the full range of options including direct government service delivery, private sector contractors, and cooperative arrangements with public, academic and private sectors.

3.2 Expanding User Base

The geodetic infrastructure is used by a broad group of users. The infrastructure will need to continue to support existing users that have typically been in survey and mapping processes such as cadastral surveying, topographic mapping, hydrographic charting, engineering surveying, project surveying and GIS.

However, due to the growing utility of satellite positioning, the user base for the geodetic infrastructure has now expanded beyond the traditional survey and mapping areas. This expansion will continue as technology advances. Future users will come from land, water, environment, natural resource management, transport, fleet management, emergency response and navigational industries as well as the recreational sector.

All of these users will have varying accuracy and immediacy requirements and the future geodetic infrastructure needs to cater for all these needs.

3.3 The Role of Third Party Satellite Positioning Services

There are a number of agencies with strong interests in positioning objects such as ships, aeroplanes or vehicles. Many have their own positioning infrastructure. In the past these have often been specialised radio navigation systems such as Non Directional Beacons (NDB), Variable Omnidirectional Range (VOR), Instrument Landing System (ILS) for air, Loran and Shoran for ships.

However space based technologies such as global positioning system (GPS) are becoming the system of preference for all because of the ease of use, accuracy and low cost. The establishment of differential global positioning system (DGPS) base station networks is expanding rapidly.

Some of these new DGPS service providers offer free to air correction services. One example is the Australian Maritime Safety Authority (AMSA) network. Although the system was designed to assist shipping, many people are now using it on land. (It should be noted that AMSA do not encourage or guarantee it except for marine navigation.)

Other commercial providers (e.g. Fugro, Racal and Ausnav) cover all or part of Australia and New Zealand. These companies provide about 1 - 10 metre accuracy over large areas.

The commercial provider’s marketplace has been slow to develop on land and is confined to specialist use where high capital and/or operating costs reduce the impact of the providers fees. It is expected that they will continue to play a role, and that role will expand. However, price structure will continue to impact on the significance of their role in the future geodetic infrastructure.

There also will be continuing technical developments. For example, with GPS, the recent cessation of ‘Selective Availability’ is likely to expand the user base for the infrastructure as a whole and reduce the viability of differential services to those offering the most accurate solutions. The future introduction of a second civil frequency and then a third frequency will also have technical impacts.

Whatever the magnitude of these ongoing developments, these service providers will be significant players in the future geodetic infrastructure. While they will continue to rely on the fundamentals such as a common datum, this range of additional players will offer significant augmentations to the nation's geodetic infrastructure. The successful coordination of their activities could produce significant benefits and this is a major challenge for the infrastructure in the coming decade.

3.4 The Role of Satellite Positioning Base Stations in Surveying

A major trend in surveying using satellite positioning is to ‘real time’. Current technology allows real time centimetre accuracy surveying at ranges typically up to 10 km from a base station (some manufacturers state ranges up to 40 km).

This has a number of implications for the future role, structure and nature of geodetic infrastructure.

The first is the need for high quality 3-dimensional geodetic stations suitable for occupation as base stations for real time satellite surveying. Such stations also support other satellite surveying techniques such as quick static, which uses short occupation time but post processing.

The second is whether such base stations should be established on a survey by survey basis or whether, in the long run, a network of permanently running base stations would be more effective.

It should be noted that none of the third party DGPS networks described in the previous section support centimetre accuracy.

To support real time surveying, the currently required density for permanently running base stations would be very high (eg every 15 - 40 km). This may be viable in high value, highly populated areas but is unlikely to be so in rural and remote areas.

On the other hand, a current research could produce a breakthrough that increases the range and makes permanent base stations more viable in rural and remote areas.

Another issue is the ability to do accurate satellite surveying directly off a network of permanent tracking station such as AUSLIG’s Australian

Regional GPS Network (ARGN). Achieving centimetre accuracy over very long baselines requires specialised post processing and long occupation times (many hours to days). As such, it has limited application for commercial surveying activities that will continue to operate relative to nearby points with real time or short occupation periods and using turnkey processing packages. However, the technique has strong appeal for establishing, densifying and/or maintaining the datum in remote areas.

Given all this, a reasonable approach is to continue to build a three dimensional infrastructure. This will be the only viable infrastructure for centimetre accuracy surveys in rural and remote areas requiring short occupation times.

However, it is also necessary to keep a watching brief on developments that improve the viability of permanent base station techniques for some areas. Experience in running base stations for post processed applications, such as, with the ARGN, the network in Victoria or the International GLONASS Experiment (IGEX) site in Brisbane, provide useful infrastructure services in their own right while also building valuable experience to apply to real time base stations in the future.

All the issues outlined in this section will continue to influence the appropriate ways to develop and maintain the infrastructure in the future. To service urban, rural and remote areas the appropriate infrastructure for some time to come is likely to be a mix of several approaches. Those involved must continue to monitor developments and be ready to respond as appropriate.

3.5 Datum Issues

There has been a tendency to say that, because of the recent adoption of geocentric datums in both Australian and New Zealand, there are no further datum issues. This is not so. The following are datum issues still requiring attention:

3.5.1 Integration of Horizontal and Vertical

The horizontal and vertical datums have in the past been separate entities. The continually expanding role of 3-dimensional satellite positioning systems will continue to highlight the need for tighter integration of the two.

The inherently 3-dimensional nature of the new geocentric datum of Australia and New Zealand has made a significant contribution to setting the correct framework. This tighter 3-dimensional integration may lead to opportunities to reduce the amount of effort currently devoted to maintenance of separate horizontal and vertical networks.

Even so, it is important to realise that in a purely geometric 3-dimensional system the heights are ellipsoidal rather than orthometric.

3.5.2 Managing the Vertical

For many practical purposes there is still a need to maintain an orthometric height network.

The existence of two commonly used heights (ellipsoidal and orthometric) requires the geodetic infrastructure to better manage the origin, use, and manipulation of height data.

3.5.3 Geoid Model

Geoid models allow accurate conversion between orthometric and ellipsoidal heights and are an important component of this management regime.

The current geoid model, although an improvement on its predecessor, is still a restriction in relating ellipsoidal and orthometric heights. It, therefore, limits the contribution of satellites positioning to orthometric levelling. Under these circumstances, the infrastructure needs points at which ellipsoidal, orthometric and geoid heights are all available to allow meaningful examination of the issues.

Commitment to the development, testing and management of continually improving geoid models will be an ongoing feature of a modern geodetic infrastructure.

3.5.4 Integration into World Wide Datums

In both Australia and New Zealand the new geocentric datums are tied to the International Terrestrial Reference System (ITRS) and by default to each other, although each datum uses a different realisation of the ITRS. There is a move towards implementation of regional datums (eg Asia Pacific Regional Geodetic Project (APRGP)). There is also consideration of a global vertical datum. While adoption of geocentric datum in Australia and New Zealand means we are now well placed, the future infrastructure must continue to monitor trends in regional and global datums and act where appropriate.

3.5.5 Dynamic Datum

The ITRS can be considered a dynamic system through its annual realisation of International Reference Frames (ITRF) and consideration is currently being given to more frequent realisations.

New Zealand has already incorporated a velocity model into its new datum NZGD2000. Traditionally Australian geodesists have considered velocity modelling as less significant because Australia is one single plate. However, expectations are that single point positioning or positioning relative to IGS stations, directly in the latest ITRF, will improve to the stage where the Australian continental drift can be directly measured over short time interval and in routine operations.

3.5.6 WGS84/GDA94 relationship

Related to the above section 2.5.5 is the fact that in the past it has been assumed that WGS84 and GDA94 were practically the same. Given limits to the resolution of measurements and the current coincidence of the two datums, this has been a safe assumption. However, if measurement accuracy increases, or WGS84 moves away from GDA94 as it accounts for continental drift on a global basis, it may not remain a reasonable assumption.

Given these increasingly important accuracy and time dependency factors with both the ITRS and WGS84, there is a need to identify how the infrastructure can accommodate them in a way that minimises user inconvenience.

3.6 Existing Ground Mark Networks

3.6.1 Network Layout

The layout of current ground mark networks reflects past technical needs. For example, the requirements for intervisibility between ground marks and the need for a hierarchy of orders set key parameters for network design.

These no longer apply, thereby, providing much greater flexibly in network design.

An alternative approach using current technology would be to dramatically reduce the hierarchical nature of the present orders and site new marks where they are required for convenient access.

3.6.2 Ground Marks

3.6.2.1 Role

Historically, the placement of ground marks in both Australia and New Zealand has been in support of infrastructure development or mapping programs. To some extent they are a reflection of past needs. Their ability to support current or future activities is often a matter of good fortune rather than design.

The extent of the future need for ground marks versus satellite positioning networks is still being actively debated. There are a range of views about their long term future depending on characteristics and needs of individual jurisdictions. For example, in a country such as New Zealand, that is subject to crustal deformation, the physical mark in the ground will, for the foreseeable future, be an important component of the infrastructure to enable deformation at the local level to be monitored.

At the very least, a relatively smaller number of marks will always be required to define the datum, and as a basis for satellite positioning.

In addition, the ground marks will continue to play an important role in at least the short to medium term. However, in the future the nature of the ground mark may differ considerably. As the ability to give high accuracy coordinates to any object in the environment increases it may be possible that any physical feature may be used as geodetic control points, eg manhole covers etc. Cadastral surveying has the potential to add to the number of accurately coordinated ground marks as does almost any other type of surveying.

The adoption of this approach could lead to a rapid increase in the number of ground marks in jurisdictional databases.

3.6.2.2 Maintenance

Maintaining large a ground mark network has become expensive. With new technologies it may be more cost effective to replace destroyed marks as required rather than maintain them.

In addition, partnerships can be forged with industry to assist in the maintenance program through identifying areas of future interest, reporting the status of existing marks, or placing new marks.

3.7 All Measurements could be “Geodetic”

The concept that many routine measurements are now of geodetic quality is implied in the above discussion on ground marks. Whilst this is particularly true of satellite based positioning, it is also true of other types of measurement such as EDM.

It may be possible to treat all surveys as “Geodetic Surveys” and incorporate a broad range of additional measurements into the geodetic network. Adjustment software such as Dr Collier’s Dynamic Network Adjustment (DNA) software could facilitate this approach because it accommodates large data sets to which new measurements can be added.

3.8 Automation

As the last major data sets are being moved from paper to digital (eg titles registers), and as the power and speed of computers increases, there is a greater push for automation. In some jurisdictions the current activity attracting attention is automation of titles and survey processes. However, the potential for automation is far wider than that. It involves automating elements of transport systems, of vessel navigation and docking, of major construction such as road making, of container tracking, or simply of QA processes.

An increasing number of these automated systems use positioning of some sort.

3.9 Cadastre

A special case of automation is the cadastre as a data model as envisaged in “Cadastre 2014” (Kaufmann 1998).

Cadastre 2014 is an internationally acknowledged model for a multi-purpose cadastre, which has been endorsed by ICSM and the survey industry as potentially providing the basis for future cadastral reform in both Australia and New Zealand.

It is envisaged that such a multi-purpose cadastral system would be capable of automatically generating, upon request, a complete and authoritative statement as to the nature and extent of every one of the multiplicity of private and public interests which may currently impact on the use and occupation of any specified land parcel. The capacity of any such system to deliver legally defensible integrated cadastral information products, will however ultimately depend on the spatial accuracy with which each of the contributory data sets digitally replicates the true location of the relevant interests in the real world.

It follows that the functional viability of any such future multi-purpose cadastre, must inevitably remain highly dependent upon the continued maintenance of geodetic infrastructure capable of supporting absolute spatial positioning of cadastral and related geographic and thematic features, with unprecedented accuracy and precision.

3.10 Augmentation of Satellite Positioning

3.10.1 Pseudolites

Pseudolites are ground based "satellites". They transmit similar signals to the space satellite and similar satellite receivers can record their signals. Because their positions are fixed and known, they suffer fewer uncertainties than their space based cousins.

Pseudolites can cover areas where satellites are unable. They offer the opportunity for satellite type technology to be used in urban canyons or mines. Therefore, pseudolites have potential in augmenting space based satellite networks.

In the future, industry may commence using pseudolites as part of its normal operations.

The coordination of siting pseudolites and the access to data could provide benefits for the wider community.

3.10.2 Expansion of Satellite Systems

The role of GPS and, to a lesser extent, GLONASS are known. However new positioning systems are now planned. The European Galileo project is planning point-positioning accuracy of 1 to 4m, free to air and better for paying services. Supplementation is also likely through the use of geostationary satellites, such as the European geostationary navigation overlay service (EGNOS). All will add to the ability for more accurate and/or faster positioning.

3.10.3 Accurate Imaging Systems

One metre resolution remote sensing satellites can also provide a contribution to the geodetic infrastructure because they are able to locate objects. These satellites will be sufficient for many purposes where time is not critical. Series mapping is perhaps one example. In this sense remote sensing satellites are additional positioning systems.

However, for the remote sensing satellites to reach their maximum accuracy the images must be controlled. Therefore, whilst they can contribute to the geodetic infrastructure, they will also rely on it. In this sense, they are a new user who relies on the geodetic infrastructure.

3.10.4 Synthetic Aperture Radar

The ability to measure very accurately (centimetre level) from space using synthetic aperture radar is revolutionising the field of monitoring and recording crustal deformation. Results of this work can be fed back into upgrading spatial networks

3.11 Integration of Technologies

Integration of technologies is an area of active research. The object is to combine two or more technologies so that the weaknesses of one are compensated by the strengths of the other. Two examples show potential. They are the integration of Inertial Navigation Systems (INS) and GPS and the integration of total stations and GPS.

The INS/GPS combination is already in production in vehicle navigation and prototypes of the total station/GPS combination have been developed.

Both have the ability to impact on the way that we think of positioning, and the required type of supporting infrastructure.

3.12 Other Technologies

It is almost certain that other positioning technologies will emerge over the next ten years. The geodetic infrastructure developed today must be flexible enough to accommodate these currently unknown developments.

3.13 Mathematical Development

Ongoing development of the mathematical models associated with satellite positioning will continue to provide improvements in accuracy, reduction in observation time and the ability to use cheaper equipment. Examples of areas of development are knowledge of satellite orbits, atmospheric models and development of multi base station solutions.

Developments are also occurring in network adjustment with one example being the large readjustment software called DNA.

4 User Needs

If the geodetic infrastructure is to play an ongoing valuable role in the development of a nation, it must meet the needs of the user community.

Typically, users are interested in three main characteristics being accuracy, accessibility and timeliness.

4.1 Accuracy

The broad user base also has a broad range of accuracy requirements. For example, surveying, engineering construction and mining typically require centimetre accuracy. Many GIS operations and natural resource managers require one-metre accuracy. Reconnaissance and navigation requirements are typically in the tens of metres range.

Despite the large accuracy range, the highest accuracy is generally required in areas of densest population. Major exceptions include areas of environmental sensitivity, significant communication corridors and areas of high economic value.

It is expected that users will demand increased accuracy as time goes by. Therefore, the future geodetic infrastructure must deliver the highest accuracy infrastructure to populated areas, but be capable of supporting;

- Sub-centimetre accuracy anywhere, and
- increasing accuracy requirements over time.

4.2 Accessibility

Accessibility relates to three major areas as follows:

- access to the physical infrastructure
- access to the data; the survey mark data, satellite positioning data
- access to the intellectual component of the infrastructure

4.2.1 Physical Infrastructure

All users need convenient access to the physical realisation of the infrastructure; the ground marks, satellite base stations or other forms of realisation.

As a general rule, the tightest accessibility requirements also match the highest accuracy requirement.

4.2.2 Data

Users require easy access to geodetic data from their offices. In the future they may even require access from the field.

Pricing policies should not provide a barrier to data access.

4.2.3 Intellectual Infrastructure

The measurement process will become increasingly simple and available to a wider range of users.

This broader user base will require support in terms of standards, best practice guidelines, advice and education. New technologies together with changed user requirements will lead to adaptation of the infrastructure.

4.3 Timeliness

Users require, preferably, instant access to geodetic data.

Users will increasingly require results in real time. They are currently showing a clear preference for instant results. Examples include the surveyor's clear preference for RTK and the construction industries need for real time for machine guidance. In some cases there is pressure for real time from users in spite of the apparent lack of a business or technical need for it.

5 Geodetic Infrastructure 2010 and Beyond

The following describes the potential future role, structure and nature of the geodetic infrastructure in 2010 and beyond.

5.1 Role

- Positioning – The New Utility: The ability to position an object will be regarded as the new utility. The ability to accurately locate a position will be as easy as telling the time. The spatial infrastructure will support this capability in a way that is invisible to the majority of users.
- Information: Spatial data will be converted to information through the easy integration of previously disparate data sets. The ease of positioning will have unlocked the power of position as the integration tool.
- Part of a Global Solution: The Australian and New Zealand spatial infrastructures will be an intrinsic part of a global datum and spatial infrastructure that accommodates the effects of crustal deformation and global change.
- Global Change: Rising global temperatures and sea levels will see an unprecedented level of interest in monitoring and measuring global change with the spatial infrastructure playing a key role.

5.2 Structure and Nature of Infrastructure

5.2.1 Reference Frame

- Common National Datum: All positioning activity will be integrated into a common national framework. The artificial split of horizontal coordinates and elevations has largely disappeared through the development of adequate geoid models and the integration of the two vertical datums. However, more work is still required on the geoid model to meet the most precise requirements.

5.2.2 Data and Systems

- Satellite Based Positioning Systems: The major satellite system will be GPS. Three frequencies will be available and selective availability has been turned off. Galileo has made good progress and was declared fully operational on time in 2008. GLONASS is becoming an effective constellation again. Most high quality receivers now have the capability to integrate and collect data from all three systems. This data has been augmented through targeted use of pseudolites, the use of geostationary satellites, and integration with other technologies, notably INS and total stations.

  All but the most precise scientific work uses real time systems. Common user real time kinematic (RTK) broadcast systems have been installed in all towns with a population greater than 50,000 across Australian and New Zealand. They also cover areas of environmental sensitivity, key communications corridors and areas of high economic value.

Cheap satellite based positioning units are now integrated into many forms of technology, eg cell phones, watches, electronic maps, vehicle navigation, alarm systems and to monitor animal and human movement.

- Other Technologies: There will be an emergence of technologies used for accurate positioning. The spatial infrastructure will ensure that these new technologies are integrated in to what will now be considered as the main stream positioning technologies such as GPS.

5.2.3 Physical Components

While ground survey marks will remain an important component of the spatial infrastructure, the emphasis will be on the maintenance of a high precision satellite based network of base stations. It will be easier and cheaper to replace destroyed survey marks as required rather than maintaining those marks. Any visible, stable physical object can be a survey mark.

5.2.4 Intellectual & Institutional

Government Role: The government role is management and coordination of the geodetic infrastructure. They will have high level knowledge and skills and these will have achieved wide recognition.

Spatial Position Infrastructure Community: Will be much broader and involve both government and private contributors to the infrastructure. The community will work cooperatively and will maximise the benefits of individual actions by ensuring they fit into a coordinated approach through the creation of national standards, operating procedures and strategic plans.

Working with Users: The spatial position infrastructure community will have a detailed knowledge of its user base in all its breadth and complexity. The community will work with users to ensure their business and community service goals are facilitated through timely delivery of any changes, upgrades or refinements to the geodetic infrastructure.

6 Analysis

The fundamental basis of the geodetic infrastructure is the ground geodetic network. But current trends to provision of improved accuracy of positioning over long distances as described by Featherstone (2000) will have an impact on the need for these ground marks, such as:

- the AUSLIG on-line GPS processing service for post processing and
- the expansion of real time positioning capabilities such as the virtual Reference station technology (Bucherl et al, 2000) and
- the improvement in communication technology converging with GPS positioning such as in the USA E911 requirement for location on mobile phone (Butterline, 2000).
- The provision of data using wireless technology for spatial data

It is clear that in the short term an increased number of ground marks will be required to be established in more useable locations than at present. However in the long term there will be a gradual reduction in the number of ground marks required as real time positioning in urban areas becomes available through RTK and in rural areas through DGPS and more convenient marks replace the inaccessible marks.

The cessation of GPS Selective Availability in May 2000 and the go ahead for the GPS modernisation project involving a third frequency (Kaneshiro, 2000) in September 2000 now ensures that this technology will continue to be available in an enhanced manner until at least 2030. As a result it is likely that single point positioning on good GPS receivers will approach 5 metres (Shaw, 2000)

In Australia the establishment of the Australian GNSS coordination committee (AGCC) at the Federal level (www.agcc.gov.au) to coordinate space positioning across Australia can be expected to facilitate multi purpose base station and transmission standards for GPS, GLONASS (www.rssi.ru/SFCSIC/SFCSIC_main.html) and even Galileo (www.galileo-pgm.org). The real time use of the technology by radio transmissions is an issue in spectrum management and the AGCC can be expected to monitor adverse use of the spectrum for GPS frequencies and control the potential negative impact of expected ultra wide band transmission technology to GPS application.

Ten-metre accuracy is virtually already available at the one-sigma level on a global scale. Australia is likely to follow a US pattern of cooperative free to air GPS base stations across the country for safety of life DGPS transmissions at the 1 metre level of accuracy using aviation or marine frequencies (Snay, 2000) for distribution. In this US model private sector providers concentrate in the provision of more accurate (eg sub metre) DGPS transmissions. Centimetre accuracy positioning technology from RTK linked to wireless technology on mobile phone from local government or private sector providers is already available for use in population centres or rural activity such as agricultural. Pseudolite type transmissions for position by frequency resections within buildings and CBD area is emerging using existing technology to give a total positioning picture. All these applications need to be supported by a strong homogeneous geodetic infrastructure with quality verification. It is important to watch the positions determined in an absolute (i.e. global) sense as the GDA is now almost seven years old and is about 40 cm from where it was in 1994.

The ready availability of this increased accuracy positioning technology to all spatial industry users in many cases will impact on the current accuracy of maps and data bases, placing pressure on the need to tag all spatial information positions with uniform and meaningful accuracy standards. The full impact of the increased availability and accuracy of positions is considered to be outside the pure scope of the geodetic infrastructure as it involves all other aspects of spatial data management. Similarly this report does not address cost the future development of Geodesy in Australia or to provide educational or promotional material. These are considered out of scope of the discussion paper requested. For purely scientific developments in Geodesy beyond the infrastructure applications of the technology to the wider community, the Academy of Science Geodesy Sub committee is considered to be the appropriate body to best define developments in geodetic science in Australia.

In some jurisdictions (eg South Australia and New Zealand) the cadastral network (cadastral standard marks) has been connected to and coordinated in terms of the geodetic network. This provides an extension to the geodetic network (in the case of New Zealand 60,000 new marks will be added to the geodetic database during 1999-2002). Clearly the boundary between the geodetic and cadastral networks is blurring. In these juristictions the geodetic infrastructure and number of marks will expand rapidly in the short term.

The higher order geodetic infrastructure supporting the wider spatial infrastructure is changing from a ground mark basis towards a transmitted information situation. This requires an infrastructure of base stations either GPS or telecommunication, or combined. The high population areas and areas of high economic value can be serviced using real time RTK virtual station technology now available whilst the communication routes and rural community can be serviced by DGPS from multi purposed GPS or GLONASS base stations distributed from Aviation, marine or private sector providers. Development of such systems will allow marks (for cadastral and other purposes) to be replaced directly where they are required easily and cheaply. This will allow maintenance to be reduced for the existing geodetic framework that provides the breakdown from the high order to the lower order network. Coordination of an Australian countrywide approach to base stations and transmission of DGPS data is currently the responsibility of the AGCC. There is no similar body yet established for New Zealand.

7 Conclusions

In the short term geodetic marks will continue to be required, particularly in high-density urban areas, but they will be established in convenient locations, rather than on remote hills. The ready availability of accurate positioning will mean that these marks will be more densely located and the distinction between geodetic and subsidiary marks will be blurred.

In the long term fewer physical marks will be required, as accurate positioning, independent of nearby marks, will be readily available through the synergy of global positioning and communications technology. This will require vigilance with regard to standards for data storage, electronic dissemination and spectrum management.

8 References

Bucherl A., H. Landau, C. Pagels, U. Vollath, B. Wagner, “Positioning Using Virtual Reference Stations”, Spectra Precision, Terrasat GmbH, Germany, ION GPS 2000, Salt Lake City, USA, 19-22 September 2000.

Butterline, E. “Use of GPS to provide Emergency 911 caller location information”, Symmetricom, Civil GPS Service Interface Committee - 36th Meeting, 18 Sept 2000, Salt lake City, USA. (www.navcen.uscg.mil/cgsic/meetings/summaryrpts/36thmeeting/default.htm)

Featherstone, W.E., “The future of geodetic networks: a Western Australian perspective”, Report for the Western Australian Department of Land Administration, February, 2000.

Kaneshiro B., “GPS Modernisation”, GPS Joint Program Office, Civil GPS Service Interface Committee - 36th Meeting, 18 Sept 2000, Salt lake City, USA. (www.navcen.uscg.mil/cgsic/meetings/summaryrpts/36thmeeting/default.htm)

Shaw M.E., R.Hessin, “SPS Signal Specifications Update Status”, Civil GPS Service Interface Committee - 36th Meeting, 18 Sept 2000, Salt lake City, USA. (www.navcen.uscg.mil/cgsic/meetings/summaryrpts/36thmeeting/default.htm)

Snay R.A., “The National and Cooperative CORS Systems in 2000 and Beyond”, ION GPS 2000, Salt Lake City, USA, 19-22 September 2000. (www.ngs.noaa.gov./CORS/)

Kaufmann J., Steudler D., 1998. “Cadastre 2014 -A Vision For A Future Cadastral System” Working Group 1 of FIG Commission 7, July 1998 (http://www.swisstopo.ch/fig-wg71/cad2014/cad2014/index.htm)