PROJECTIONS REPORT

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EXECUTIVE SUMMARY

A number of major developments shaping the spatial infrastructure in New Zealand have resulted in this country considering a new projection for mapping. Because of the impact of modern positioning technology and related developments, it is now timely to assess the best approach to meet the modern needs for an accurate datum and convenient associated projections. Preliminary discussions have revealed strong contrary views about the most suitable future projection for this country. Small-scale map users generally support retaining the New Zealand Map Grid (NZMG), whereas the opinions of GIS users range from support for NZMG to strong support for the introduction of a standard projection.

This report reviews the relative merits of retaining the NZMG or of changing to another projection.

Background issues which have a bearing on current deliberations include:
- the introduction of a new geodetic datum
- major advances in database development
- New Zealand Defence Force military requirements, and
- national and offshore requirements and obligations for land, sea and air mapping.

Because of the unique nature of the NZMG, no overseas situation is directly comparable. The literature contains little that focuses directly on the central issue of the merits of retaining a specialist projection versus those of re-introducing a standard projection. The issue of a specialist country projection is unique to New Zealand.

International literature does, however, provide much useful supporting information. It indicates that the new global geocentric datum, the International Terrestrial Reference Frame (ITRF) has already precipitated new national geocentric datum in place of national traditional datum in many countries around the world. In most cases the consequential changes to mapping systems have been accommodated incrementally, although one example of an immediate revision of a national map series is that of Ireland. There the new geocentric datum has led to replacing the Transverse Mercator projection on the old datum with an adapted Transverse Mercator on the new projection. In the United Kingdom the same approach is planned, although the cost of conversion raised opposition, which led to the adoption of a staged approach. In the United States, Federal agencies have for some time been required to hold their co-ordinates in a geographic form, although this has not precluded the use of projections.

Major issues complicating resolution of the task include:
- the concept of a single projection
- the role of projections in a digital environment
- escalating user needs
- conversion of existing databases
- digital geospatial development

- legal implications
- mapping on demand
- mapping series policy
- interoperability within New Zealand, and
- international obligations.

The two major considerations are:
- what national projection should be developed for New Zealand, and
- how the range of other projections in use should be regarded.

In assessing the best approach for New Zealand it becomes clear that no single projection can serve the various user needs, nor ever has been able to. Reluctance to accept a range of projections is less tenable in today's electronic environment than it was in the traditional surveying and mapping environment. The case for a common projection is now countered by our technical capacity to enable specific applications to take advantage of the projection best suited to the end use.

New Zealand needs to accommodate a range of projections, and in doing so, it is quite reasonable to continue NZMG in relation to the existing Topomap 260 series (1:50,000), until the series needs to be replaced. The difference arising from the introduction of New Zealand Geodetic Datum 2000 is of little significance at the scale of this map, and a shift of the latitude and longitude graticule would provide a simple correction without necessitating changes of co-ordinates. Retaining NZMG for this specific purpose would not prevent the introduction of a new standard projection for other purposes.

The issue of a common projection remains significant in relation to large-scale urban mapping and local authority GIS databases. Without a clear direction on a common projection, these databases could become steadily less consistent. This would seriously inhibit national and regional use of this data, and interoperability across extensive tracts of New Zealand.

The choice of a national projection should balance the benefits of retaining an existing system against long-term costs and risks. The NZMG does offer advantages in terms of minimisation of scale. Its disadvantages are that it does not get automatic support (to the same extent as a standard projection) from all software developers; it is not readily visualised by non-specialist users; many users do not understand it as well as they do a standard projection, and it lacks national and international interoperability.

A distinct advantage can be determined for introducing a national Transverse Mercator projection for aligning urban mapping and GIS databases throughout New Zealand. Failing to adopt a standard projection now will increase the long-term costs of later conversion to a new projection. The costs of converting existing databases are inevitable, because all existing databases will eventually need to convert to NZGD2000. Introducing a national Transverse Mercator projection instead of a new version of NZMG offers significant long-term advantages of continuous software support and national and international interoperability.

It is recommended that a new national Transverse Mercator projection be introduced forthwith, supported by a targeted communication strategy and programme. The programme should provide consultation, brochures and workshops. It should aim to:

- develop an improved level of knowledge and understanding of the significance of datums and projections for GIS and associated databases
- obtain commitment to the common use of a national Transverse Mercator projection for large-scale urban mapping, and
- recognise the role of a suite of projections for other purposes.

INTRODUCTION

The current consideration of the best approach to take in establishing an appropriate projection for New Zealand follows several major developments in the evolution of the country's spatial infrastructure.

The Geodetic Datum of 1949 (NZGD49) was achieved through traditional surveying technology over a 36-year period of triangulation measurement and calculation of the geodetic network. In the early 1970s New Zealand introduced metrication for all measurement in the interests of global standardisation. At the same time the replacement of the colour plan system with black and white plans allowed the use of the technology of the time to effect improvements in recording and accessing spatial information.

The change to metrication coincided with the decision to produce a second national series of small-scale topographic mapping, New Zealand Mapping Series 260 (NZMS260). This provided a valuable opportunity to develop a new mapping projection for New Zealand reducing the scale distortion that existed in the previous mapping projections. The New Zealand Map Grid (NZMG) projection was developed with an initial aim of unifying the mapping and survey projections previously used in New Zealand.

That aim of a single survey and mapping projection did not prove practical, and the NZMG did not replace the 28 meridional circuits based on individual Transverse Mercator projections used for cadastral surveying. The NZMG did provide a single specially New Zealand-oriented projection for mapping. It replaced the separate North and South Island Transverse Mercator projections used for the previous inch to the mile, NZMS1 mapping.

The NZMG was designed for an era of paper maps and to meet a requirement for the minimisation of scale factor. It proved a very successful projection for New Zealand mapping. Because the projection parameters align closely to the geographical extent and dimensions of New Zealand, a remarkably small scale factor applies to the NZMG linear measurements.

As the NZMG was developed at about the same time that New Zealand was converting to metric measurement, the new metric small-scale topographic mapping series was able to utilise it and provide a national base for a wide range of thematic mapping.

Since then, even greater change in spatial information processing and measurement has taken place. A major element of this change has been the evolution of geocentric geodetic measurement through Global Positioning Systems (GPS) and the digital storage of geographical information. This has brought about an entirely new electronic and digital environment for surveying and mapping measurement, referencing and depiction.

Although the development of a global reference system e.g. World Geodetic Datum 1984 (WGS84) was initially driven by military requirements, a huge number of civilian applications have followed, including the development of the International Terrestrial Reference Frame (ITRF).

The formal establishment of NZGD2000, based on ITRF, was a major step in the development of New Zealand's modern spatial infrastructure. This new datum:

- is three-dimensional
- is fully compatible with international geodetic systems
- can support modern survey technology and techniques.

In the wake of these developments, New Zealand now needs to review its projection requirements in a modern geo-spatial electronic environment.

FEATURES OF THE CURRENT SITUATION

Current interest in the projection requirements for New Zealand was stimulated by a discussion paper compiled and circulated by LINZ. This led to the production of thoughtful responses and commentaries, and to continuing interaction. It has been successful in heightening the level of consideration of and interest in the topic.

The discussion has had a tendency to polarise opinions between traditional users of small-scale paper maps and GIS, and other users of geographic information. The debate has tended to focus on the retention of the status quo. As almost all the relevant points have been well canvassed, a consensus should now be established which balances immediate needs with long-term requirements and strategies, and accommodates the possibility of further change.

A number of aspects of the current situation need to be accommodated in determining the most appropriate infrastructure to support future user needs for co-ordinate grids and map projections. The factors to be considered are listed below.

The New Geodetic Datum

The introduction of NZGD2000 has set in train a number of implications and consequences.

- No longer must high-quality measurement be downgraded to fit the traditionally established and measured NZGD49 framework. Recent improvements to the global referencing system enable sub-centimetre levels of accuracy, and with NZGD2000 these may immediately be fully incorporated in intermediate positioning and geodetic frameworks.
- New Zealand geodetic measurement is now fully compatible with geodetic measurement undertaken elsewhere around the globe. This international commonality has enabled participation in a number of global or hemisphere based geodetic programmes - especially valuable in interrelating and monitoring crustal deformation related to the movements of various tectonic plates.

There are plans to adapt the NZGD2000 to accommodate future movement of the datum, possibly to accommodate significant movements arising from crustal deformation. New Zealand's location on the boundary of two major crustal plates results in different movements across the country of about 5cm per year due to plate tectonics. NZGD2000 provides New Zealand with a sound basis for modelling future long-term crustal movement.

The formal introduction of NZGD2000 raises the consideration of the merits of existing projections in New Zealand and possible alternatives to these. Although projections may have seemed a lower-order issue at the time NZGD2000 was planned, its consequential impact on projections of a new geocentric datum now needs to be accommodated.

The NZGD2000 geodetic framework highlighted the discrepancies that exist in NZGD49 and the co-ordinates, grids and projections developed in relation to it. As to be expected, modern global surveying technology has improved the accuracy and consistency of the geocentric datum in comparison to that determined through traditional surveying methods. Although the discrepancies in NZGD49 are remarkably confined, their presence will downgrade subsequent incorporation of high-precision measurement. The introduction of the new datum does not reflect adversely on the NZMG per se, but it does impact on the future of NZMG based on NZGD49.

New Zealand Map Grid (NZMG)

The introduction of the NZMG was driven by the requirement to minimise scale factor for a national topographical series. The design of NZMG is directly related to the geographical characteristics of New Zealand. It provides a reduction in scale distortion much superior to that available from standard projections including the less widely used oblique Mercator (Rectified Skew Orthomorphic). The NZMG successfully unified all mapping projections in New Zealand, replacing the previous Transverse Mercator mapping projections for the North and South Islands.

For cadastral mapping, the Digital Cadastral Data Base (DCDB) was provided in NZMG. Throughout New Zealand most local authorities and other organisations have used NZMG as their projection of choice in relation to the development of their spatial databases. Currently most Geographic Information Systems (GIS) and mapping systems in New Zealand generally use NZMG based on NZGD49 (NZMG is not used for cadastral surveying grids and plans).

Current Stage of Spatial Data Base Development

The advent of digital computer mapping and the proliferation of satellite positioning capability has introduced a new dimension and flexibility in geographic information management and mapping. Major geographic information systems are able to hold digital information in neutral systems (unprojected co-ordinates)[1] such as latitude and longitude. Modern computer spatial databases and mapping are not dependent on projections for representing geographic information in the way that traditional mapping has been. A projection is still needed for paper maps or where there is a requirement for a grid reference system. However, more and more primary data sources are utilising unprojected co-ordinates. For example, the DCDB was provided in terms of NZMG, but the new cadastral co-ordinates provided by the LINZ Land*online* system are in terms of NZGD2000 and expressed as latitude and longitude values.

NZMG is well established in New Zealand and provides a national consistency in the relationship of major digital databases throughout the country. The back capture of graphic data to populate spatial databases is well advanced but not yet complete. Some local authorities are almost completed, whereas others still have significant back capture to undertake. There is also an increasing demand for the capture of new spatial digital data to enhance existing and develop new spatial databases.

New Zealand Defence Force Requirements

The Universal Transverse Mercator (UTM) projection is well established for military use throughout the world. The New Zealand Defence Force needs the capability to readily use this projection for military purposes in New Zealand in the Asia/Pacific Region and elsewhere around the globe. The United States military is developing a wide portfolio of topographic products with global coverage, and access to these, together with the facility for interoperability with other nations' military forces, demands a close familiarity with UTM by the NZ Defence Force.

Although overlays of UTM grids serve military needs for local areas, full UTM coverage of New Zealand presents some difficulties because New Zealand extends through three UTM zones. The representation of the grids for each zone presents complications along zonal boundaries, encouraging the extension of one of the zones. Such an extension of a UTM

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[1] The term unprojected co-ordinates is used in this paper to describe neutral co-ordinates such as latitude and longitude. It is acknowledged that technically latitudes can be projected on to different conceptions of the spheroid but the term unprojected is used here to apply to co-ordinates which have not been projected on to a plane.

zone in effect becomes a Transverse Mercator projection. Thus, it is reasonable to anticipate that the NZ Defence Force will use Transverse Mercator as a projection for their own purposes to supplement the use of UTM.

As well as these military applications, the NZ Defence Force will be required to work with the chosen civilian projection. In any combined civil and military exercise or mission it is necessary for all parties to work off common maps, grids and projections. Since the UTM is not suitable for civil use, this precludes its use as a common projection for joint military and civil purposes. A practical alternative is to enable ready compatibility and accessibility between military and civil projections.

As the NZ Defence Force regularly uses existing civilian mapping, lack of international compatibility is a major handicap. NZMG is not supported in a number of military applications. For example,it is not included in the Arc Standard Raster Product (ASRP) list of supported projection codes. Attempts to have NZMG included in supporting applications involve cost and time. This is not feasible while NZMG is on NZGD49 as ASRP operates on WGS84. The result is that New Zealand coverage is not able to be included in current United Kingdom navigation charts for the Pacific region, because of incompatibility. This illustrates the reality of the difficulties in international exchange faced by the NZ Defence Force in managing their international relationships.

National and Offshore Responsibilities for Air, Sea and Land Mapping

Neither the NZMG nor a land-based Transverse Mercator projection is suitable for extension from the New Zealand land area over large offshore areas of the current Exclusive Economic Zone or the proposed territorial sea. Other projections such as Mercator, conical or stereographic projections do not serve the total offshore area well either. All of these projections, nevertheless, are used for specific offshore areas depending on the shape of the area to be represented and whether these areas have major north/south or east/west extensions. The Mercator projection is standard for sea and ocean areas around the world and is used exclusively for hydrographic charting. Aeronautical charts use a Lambert projection for small-scale charts.

The need for a common projection for offshore areas is not a central issue, as extensive paper mapping or surface demarcation is not required in these areas.

Antarctica

New Zealand maintains a significant mapping programme in the Ross Dependency. This work is often collaborative, undertaken jointly with the United States Geological Service or other national agencies, and the resultant mapping is used by a variety of international users.

It is not necessary or feasible for the projection used for mapping in the Ross Dependency to be in common or linked to that used in New Zealand. It will be necessary to take into account the international and scientific character of Antarctic mapping use in the selection or confirmation of the projections used for New Zealand Antarctic mapping. Stereographic projections are generally used for polar regions. The use of both types of projections will be suitable for New Zealand's future Antarctic mapping.

TERMS OF REFERENCE

Arising from these various developments, LINZ has sought to determine the merits of introducing a new mapping projection. LINZ recognises the need to undertake a detailed analysis to consider the economic and social impact of a move from any version of NZMG projection. The analysis is expected to provide recommendations and comments on:

- the merits of moving to a new projection
- whether the new projection be a variant of the NZMG or a standard projection, and
- whether more than one projection should be supported.

If time permits, the analysis should also:

- provide recommendations and comments on the transition and implementation.

SOME RELEVANT INTERNATIONAL EXPERIENCE

General

Although the role of projections in the modern electronic mapping environment is recognised as an important issue world wide, not much has been written about it in the international literature. Because New Zealand has developed a country-specific projection (the NZMG), overseas experience is not directly transferable. However, the experience gained from the conversion of projections and datum undertaken in other countries is relevant to New Zealand.

The introduction of a new civilian geocentric datum in the form of ITRF has led many countries around the world to introduce a geocentric datum to replace their traditional datum. These countries faced similar issues to New Zealand. Most other countries have introduced a geocentric datum without precipitating a revision of their national map series. In the main, the application of the new datum and the consequential adjustment of the projection are being carried out on an incremental basis, with gradual update of maps as they are produced. South Korea, however, has republished all its maps on the new datum and revised projection in a period of little over a year.

United Kingdom

The United Kingdom faced a major problem in the conversion of data because of the well-established production and use of digital data led by Ordnance Survey of Great Britain (OS). OS would like to introduce a new projection and grid directly related to their geocentric datum, ITRF89. This is practicable and desirable, because all mapping is held in digital form and there are significant inconsistencies between the old and the new datum.

The costs of conversion are an obstacle as no government funding is available. There has been much opposition from utilities and local government because of heavy investment in geographically referenced databases based on the earlier British National Grid (BNG). The opposition is exacerbated by the current requirement that OS makes such changes self funding.

The current objective is to introduce the new datum and related projection and grid over time in an incremental manner. For a start, it is proposed that OS redefines BNG to be an application of ITRF89 co-ordinates rather than a projection of Ordinance Survey of Great Britain 1936 (OSGB36) co-ordinates. Once users are familiar with the new version databases, these can be converted to geographical co-ordinates and a new grid can be introduced.

The projection used in the United Kingdom is a Transverse Mercator with a meridian offset from Greenwich. The projection related to the new datum will also be a Transverse Mercator. This projection extends through some 10 degrees of longitude, being two degrees less than the extent of longitude in New Zealand.

Ireland

Ireland has its own Transverse Mercator projection extending through some six degrees of latitude. The Irish Grid was developed through triangulation and electronic distance measurement. All observations for the whole of Ireland were combined into one mathematical calculation known as the Ireland 1975 (Mapping) Adjustment.

More recently the introduction of IRENET95 has produced a new geocentric datum with positions expressed in a different reference system. The positions on the new datum were computed in terms of the European Terrestrial Reference System, 1989 (ETRF89) which is the adopted reference system for Europe and is a subset of ITRF. Because of the precision of modern instruments, movements of stations have been detected between sets of observations taken at different times and may result in inconsistency of positions observed at different times over a few years' duration. Thus different co-ordinate systems are established within the defining reference frame of the European Terrestrial Reference Framework (ETRF). These different co-ordinate systems are linked to defined epochs for groups of observations.

The positions of points between the IRENET95 and the Ireland 1975(Mapping) Adjustment reference systems appear to have shifted an average of 54.3 metres to the north west. This was accepted without too much difficulty from users. Northern Ireland had progressed much further with re-triangulation and urban mapping than Eire. Consequently the projection was made to fit to 12 zero-based stations in the north with a free adjustment to relate to previous work.

There is a negative scale adjustment on the meridian. The existing control was transformed in terms of new GPS measurements which retained the shape of GPS figures. The parameters used were designed to allow the retention of the previous mapping sheet lines. Three different transformations of different precision were used in the adaptation. The transformation formulae enable converting co-ordinates back and forward without deterioration of the co-ordinates. Unlike the United Kingdom, the costs of conversion were not of great issue and the changeover to a new datum and related projection did not generate significant opposition.

Australia

In Australia AUSLIG has traditionally used UTM up to a scale of 1:250,000, Lambert conformal conic at 1:1m, and simple conic for smaller-scale mapping. AUSLIG GEODATA TOPO-250K is typically available in geographical form. The exception to this is for a projected format where low-end CAD systems require such data. The general use in geographical form eliminates joins in UTM zone boundaries in the provision of base data to users. Hard copy 250K maps are in Mapping Grid of Australia (MGA), which is a localised UTM projection. MGA allows producers to get cartographic properties correct, including maintaining topology between layers, and the coincidence of features, i.e. points always remain in their correct polygon relationship in different projections.

Other Countries

Reilly (2000) reports that the Swiss have re-affirmed a datum and projection based on the traditional one for cadastral surveys. A geocentric datum is also available for relating geocentric measurement, but this has not replaced the earlier datum.

SOME MAJOR CONSIDERATIONS

A number of considerations will influence the direction to be taken in selecting a national projection most appropriate for the modern digital and mapping environment.
These include:

- the practicality of an all-purpose projection
- the influence of new technology
- escalating user needs
- the impact on existing databases
- new mapping demands
- national and international operability, and
- legal implications.

These all represent changes to the situation since the development of NZMG. They introduce complicating factors, but also present opportunities for aligning New Zealand's spatial infrastructure to future needs.

The Concept of a Single Common Projection

The concept of a single projection serving all mapping and survey needs has been strongly recommended since at least 1970, most notably by L.P. Lee (1974) *(The computation of conformal projections: Survey Review 22: 245-256)*, but also by other experts. Although an elegant concept, it has not been implemented either in conjunction with the introduction of the NZMG or with NZGD2000. Twenty-eight separate Transverse Mercator projections continue today to serve the specific needs of cadastral and related users.

The current Surveyor General, Tony Bevin, says the retention of meridional circuits for cadastral survey is:

> "partly because of the large bearing differences, and also because of the labour of computing projection corrections. meridional circuits are now well entrenched in cadastral survey practice and for other large-scale mapping, and LINZ has decided to continue their use with NZGD2000 for cadastral surveys."

(1998 commentary to an article by I. Reilly. A Background to Change. Survey Quarterly, Issue 16.14-17)

Thus, although the theoretical convenience of a single projection has been promoted, the practical reality of cadastral survey requirements for local relativity has meant the retention of meridional circuits throughout the history of New Zealand surveying.

Although separate surveying and mapping projections have remained in use in New Zealand, national mapping has led to a commonality of projection for most New Zealand mapping. Significant examples still exist, however, of the use of alternative projections to depict special representation needs. In a modern computer environment there is less need for complete conformity to a common projection.

Major software systems now accommodate the storage of co-ordinates in neutral systems such as latitude and longitude. This has the benefit of flexibility: references are available in their initial form, yet can be directly converted to the user-selected projection. It is of interest that the United States National Spatial Infrastructure Committee has for some time required all federal agencies to hold databases in an unprojected form. This approach indicates that conversion on the fly will become increasingly routine, removing the need for databases to be dedicated to a particular projection. Some agencies already recommend receiving and archiving all data in a geographical form.

However, there are limits to the use of neutral co-ordinates and practical reasons for many operational systems needing to store co-ordinates in projected form. Neither is it efficient to hold raster data such as aerial photographic imagery in an unprojected form. This also applies to data used in conjunction with low-end CAD systems. Not all computer systems have the capacity to fully provide for all projections or to hold spatial information in a neutral system such as geographical co-ordinates. For these reasons databases which need to link to similar databases for wider coverage will also need to have a projection of choice for regular operations to limit the overheads associated with repetitious conversion. In association with these requirements, the alignment of a common projection throughout the country is desirable to facilitate interchange of information and a lowering of conversion overheads where such data contributes to wider coverage of an area or region.

Digital Geo-spatial Development

The average small-scale topographical map user has been able to ignore the realities that the world is round and that distortions are inherent in paper maps. For most such users, this will tend to remain the case, although as high-precision GPS develops for multiple use the problems arising from the curvature of the earth will become increasingly evident. For example, in-car or Internet digital vehicle tracking maps with interactive GPS input for positioning will need a good mapping capability to ensure accurate relationships between GPS positions and road centre lines and street building lines and furniture. Significant discrepancies may lead to serious user error.

Increased emphasis on computers will not merely make it easier to prepare a map: in many applications it will entirely remove the need for printed maps. People's perception that a map is a printed product will change as the electronic transition of cartography steadily progresses.

As the widespread multiple use of computerised databases develops, mapping will take on a much more flexible form, with users selecting the extent, format and content appropriate to their needs. Computers will rapidly plot a map on a different projection. A series of maps will soon be able to appear rapidly on the screen with varying properties for a given set of requirements. Deficiencies in one projection can be readily offset by another view with different properties. Distances can be calculated and displayed on a terminal, removing the effect of scale distortions.

In this form of mapping, standard sheet lines will often be of little consequence to the user, and user-selected meridians and origins will be sought for dedicated applications. Computerisation will not completely replace paper maps, but will impact significantly on the demand for the traditional map product. The trend towards mapping on demand will increase greatly, and it will be important to retain an underlying consistency while still permitting the flexibility that this new approach will evolve. This mapping will still need to be compatible with the existing hard copy mapping system, as many applications could involve the use of both products.

As systems develop, it will become the norm to hold positions in an unprojected form with conversion to the selected projection being undertaken on the fly, on demand. Major systems now have most of the capacity to rapidly convert or interrelate various projection systems on the fly. At this stage of GIS development most of the lowest-cost, bottom-end systems have difficulty doing projection transformations on the fly. They can support standard conformal projections but use approximations for more complex projections such as NZMG. There can be problems of registration where systems use approximations, and also problems in the overlap of systems, particularly due to the different characteristics of each particular projection. It is important to keep data sets consistent from one projection to another and to see they do not become out of terms because of generalisations.

Bundock (2000)[2] reports that to enable the production of projection co-ordinates on the fly, at a minimum systems should be capable of:

- at time of database implementation, being able to select the projection system used to manage the co-ordinates within the database, including the ability to select a neutral co-ordinate system such as latitude and longitude
- selecting/defining new projection specifications
- utilising a user-selected projection to transform from database co-ordinates to the user selected projection
- displaying the graphics in terms of the user-selected projection
- displaying and manipulating the co-ordinates in terms of the user-selected projection, and
- overlaying multiple databases, each potentially with its own database co-ordinate system, but where each is projected appropriately into the user-selected projection.

Through the last-listed capability a series of maps will soon be able to appear rapidly on the screen with varying properties for a set of requirements, and the deficiencies in one projection can be shortly offset with a projection possessing different advantages and shortcomings. Most of the major products support the first five capabilities with only one or two supporting the last-listed capability.

As large resolution satellite imagery becomes increasingly available, this will become a significant source of temporal data and update information. GIS use and the display of this data in hard copy or in relation to GIS databases will need to be congruent with other spatial information to which it is being related. The common requirement will be for this information to be provided in terms of the co-ordinate systems used in the user's GIS or databases.

Escalating User Needs

There is no optimal projection for all users. Because projections contain consistent distortions to achieve their particular representation, the choice of projection has always related to the individual needs of the user. This has involved a trade-off of properties required against other properties that can be dispensed with. This difficulty has encouraged the production of data and the development of databases holding co-ordinates in neutral systems. Customers of these databases have either the ready capability to convert projections of choice on demand, or use an intermediate data provider to do this.

[2] E-mail communication June 2000.

The digital development of databases has encouraged the escalation of a wide array of individual databases for an increasing variety of applications. Although the NZMG was initially used for 1:50,000 basic mapping, it is currently used in databases which have incorporated large-scale urban mapping data and large-scale cadastral survey data of high accuracy. In future, flexibility in the structure and storage of data will become a prerequisite for the effective use of such databases for a wide range of uses.

An emerging use of spatial databases is their interaction with GPS, and increasingly in real time applications. The recent removal of Selective Availability from GPS signals opens the way to highly accurate single reading positioning. The development of this application is likely to require greater rigour in the underlying datum and databases used for reference. Already a service is being developed in New Zealand which uses the Internet to make available to an organisation displays of the current position of vehicle fleets. The spatial reference for this is provided by an existing GIS or a derived data layer. We can anticipate increasing demand for multiple use of databases initially developed for more specific purposes.

Multiple use of spatial databases raises numerous issues, including:
- flexibility
- international standards
- ensuring systems and data are GPS and GIS user friendly, and
- ready integration between topographic, thematic and cadastral data.

Many users have joint and collaborative applications and need commonality of systems of co-ordinates and reference. Multi-use of databases raises the ante, and more users are finding accuracy and consistency increasingly important. High levels of positional accuracy will be the common currency of all spatial data users. Multiple use will precipitate expectations of commonality and simplicity of use of datum and projections for such uses as image registration, utility mapping, accurate overlays with cadastral boundaries and points of survey accuracy, and data exchange.

The last decade has seen accelerated uptake of digital applications for mapping and geographical information. The use of paper maps is still significant, and a percentage of such traditional users will remain for many years. However, the increasing numbers of users of GIS and digital databases have been developing innovative applications of spatial data and mapping not possible with traditional techniques.

Scale factor has commonly been a preoccupation with surveyors, engineers and any specialists who take measurements for representation in a grid or on paper maps or use measurements from maps or plans to relate to ground truth. These requirements are becoming increasingly less relevant for users of digital data.

Conversion of Existing Data Bases

Converting existing databases to a new projection based on NZGD2000 involves significant cost. On the other hand, an increasing amount of the data being collected will be referenced initially on the NZGD2000. This information includes Land*online* cadastral data, global positioning information, and a wide range of large-resolution remote sensing data spanning several spectrums.

As noted, the majority of spatial databases in New Zealand already use NZMG. The conversion of this data to any other projection will be an expensive exercise, aggravated by the reality that very evident costs will be experienced at the front end in the conversion process. The benefits, such as greatly improved interoperability, better accuracy and lowered overheads, will by contrast be much less tangible and only evident in savings over the long term.

However, maintaining the status quo where the NZMG is concerned will result in a steady erosion over the long term of the benefits and the comprehensiveness and consistency of all databases related to it. The hidden - but very real - overhead arising from long-term use of NZMG on NZGD49 is of great concern, in that it will result in steadily mounting costs as the use of the projection becomes ever more difficult to change.

The re-conversion of NZGD2000 information into NZMG on NZGD49 becomes a commitment that requires all jurisdictions to work in terms of a legacy system as the new geocentric and neutral projection systems become the norm. The cost of conversion becomes the lever for locking systems into the status quo.

Major systems are capable of holding unprojected co-ordinates, and the question will quickly arise as to whether NZGD2000 information should be retained in this form as well as in an NZMG-converted form. The danger is that the total cost of conversion may blind system owners to the merits of planning a strategy which prevents them from being unduly reliant on NZMG on NZGD49 over the long term.

The significance for the existing NZMG databases of the adoption of NZGD2000 is that errors inherent in NZGD49 and subsumed into the NZMG co-ordinates are now immediately apparent. Conversions from modern NZGD2000 co-ordinates, GPS-derived positioning and the like will all need to be converted back into traditionally derived parameters for the NZMG. This is quite practical, and many would argue that the errors referred to are of no consequence to the large majority of projection users. Insignificant to small-scale map users, the perceptible discrepancy contained in NZMG is significant for users working to larger resolutions.

Land*online* is planned to be available in the Otago Land District in late 2000 and it will roll out throughout the country during 2001. If the current NZMG continues without conversion to NZGD2000, the requirement to convert accurate survey information from geographical co-ordinates on NZGD2000 back to NZMG will continue to highlight the differences between the old and new datum. Updating of cadastral databases is of particular importance. Some GIS administration systems derive changes from succeeding versions of DCDB. Existing processes may not cope with the new format of Land*online*, and new processes may be needed to obtain the update information from Land*online* for NZMG databases on NZGD49.

Mapping Series Policy

Hard copy maps are likely to have a role for some considerable time. Not only are they portable for field applications, but they meet the need for a physical product to handle and annotate and instantly refer to.

The New Zealand paper map series serves a wide range of military, emergency service, statistical, recreational and other uses. The future of the current mapping, the Topomap 260 1:50,000 series, should be reviewed to determine its long-term relevance to users' future needs, and the desirability of a replacement series. At the 1:50,000 scale the datum differences are not of great consequence and the current NZMG can be retained in relation to this existing mapping product. There is no need to convert the current NZMS260 maps. The increasing accuracy of GPS technology and updating material will emphasise discrepancies in existing small-scale topographic maps. Some users may need to incorporate a small shift in the latitude and longitude graticule.

Some real benefits in functionality may be derived through enabling direct application of modern positioning technology in conjunction with maps. The current Topomap 260 maps will become increasingly inadequate for many uses as time passes, and be unable to fully capitalise on the updating capability available from large-scale urban databases. Taken with a range of other considerations, this raises the need for an early review of longer-term small-scale topographic mapping needs and determination of a appropriate replacement for this series.

Interoperability in New Zealand

There is an important requirement to harmonise geographic reference systems and databases throughout jurisdictions in New Zealand. Local and ad hoc authorities need to be able to operate in adjacent areas, and on a regional basis for regional planning and administration. It is also important for national administration that public sector agencies such as police, civil defence, and fire and emergency services have consistent database coverage throughout New Zealand.

International Obligations

New Zealand has a number of obligations to relate to international standards and operations. These include hydrographic, aeronautical charting, defence mapping, and Antarctic Treaty and Pacific regional commitments. New Zealand has developed a commonality of approach with Australia in spatial standards and this relationship will favour the use of a standard projection. International standardisation and interoperability and consistency with GPS measurements are essential for the long-term utility of co-ordinate systems supporting international services or products.

Legal Implications

Potential legal issues arise surrounding the retention of the old datum and co-ordinate systems. The legal requirement will initially be based on the old system. As it is established that the legal system is less accurate and up to date than the modern geocentric systems, questions about the probity of this approach may lead to legal liability.

Addressing the legal requirements may require more than simply labelling traditional reference systems and datum. Legal ramifications may oblige some recognition to accommodate what becomes established as a new datum of superior accuracy. Court cases concerning mapping discrepancies in the United States have emphasised the duty of care of information providers, and stressed the need for depiction of information in terms clearly understandable to the ordinary user. Where user expectations are reasonably held, labelling of differences has not proved sufficient protection to avoid legal liability.

THE PRIME CONSIDERATION

At this stage of geodetic and digital database development, the spatial data community in New Zealand is faced with deciding on the best way of preparing for the future electronic environment and determining the most appropriate national projection for common use.

The discussion to date has not provided any consensus on whether to retain the NZMG or introduce a new projection. Two strong contrary points of view have been well articulated. Although this approach has identified the important elements and greatly improved understanding of the current circumstances of New Zealand’s spatial infrastructure and the future possibilities, it has not identified a line of action.

The advent of digital databases, together with the formal introduction of NZGD2000, demands that the question be decisively addressed now. Should New Zealand continue with its custom-designed NZMG projection as the long-term means of providing a spatial reference system, or should we introduce a new standard projection to serve future national and international needs in the new digital environment?

COMMENTARY

A number of significant issues help move the debate towards a practical conclusion.

Limitations of a single projection

It is clear that the wide application of high-precision positioning technology and the introduction of NZGD2000 will precipitate an immediate or eventual conversion to the new geocentric datum of all databases. Attempts to maintain the NZGD49 and to convert all new data back to this datum will ‘concrete in’ discrepancies of the past, limiting the full utility of modern data generation. Remaining on the NZGD49 will lock digital databases into a pre-geocentric datum and reference system, and making geocentric measurement fit a traditional reference system will perpetuate problems and complications. Lack of ability to retain commonality of projections for large-scale urban mapping, and lack of incorporation of NZGD2000 are of such significance that they make the retention of NZGD49 untenable.

Once the validity of moving to the new datum is accepted, the issue of conversion becomes a common cost, applicable both to the retention of a new version of NZMG on NZGD2000 or to the introduction of a new standard projection on NZGD2000. The decision on which projection to proceed with depends on the judgement of less tangible benefits and risks.

The need to resolve this issue is urgent. Many major databases have already been established in digital form, and there is currently a raft of activity to complete the population of databases and the conversion of data. Without any indication of an alternative national mapping projection, various authorities and organisations have little option but to continue to use the NZMG, a standard conformal projection or meridional circuits depending on local preferences.

Looked at in the short term, the question of whether to retain NZMG or introduce a new national standard projection is a closely balanced judgement. In reality, no single projection will serve all New Zealand’s needs. This has never been the case and will not be the case in the future. The facility of modern computing systems to readily convert to projections supports a flexible approach to the role of projections in New Zealand. There will still be a need to accommodate a suite of projections if all New Zealand mapping and GIS and database requirements are to be adequately satisfied.

Interoperability: national

Because of the rapidly developing capability of computing systems to hold unprojected co-ordinates and to convert to user selected projections on the fly, it may well be asked whether a national projection is necessary at all. However, a compelling case can be made for a national projection to align all local large-scale urban, peri-urban and adjoining rural databases. This arises from the need for national and regional use of urban topographical data by police, civil defence, emergency and military purposes right across the country. As it is not practicable to hold all data in a geographical form, a common projection is required.

Interoperability: international

There is growing recognition that geographical references and databases in New Zealand are increasingly interrelated to geographical reference systems in the wider region and around the globe. There is also appreciation that it is of long-term benefit to New Zealand to achieve harmonisation and user friendliness to a community of users in this country interacting with information from external sources, or facilitating international users. In these circumstances the transparency and simplicity of systems and their ready availability to serve all users is a desirable quality. With the democratisation of mapping through digital technology, the facility for pervasive access by ordinary users will need to be planned into systems so that data is available in its most flexible form and that all users can experience interoperability on demand.

International connections have significant relevance to the long-term relationship of New Zealand's digital database development in both civilian and military applications. The relevance does not necessarily concern the need to conform to rigid standardisation, but accommodating interoperability, both within New Zealand and in New Zealand's activities with other countries. If New Zealand uses a unique projection, it will constrain the efficiency of data exchange and add an overhead to global and national interoperability. New Zealand GIS systems should be progressively aligned with international data formats, and interoperability in New Zealand and globally should now be maximised.

Costs

Changing to the NZGD2000 is inevitable, and delays will only increase the financial and opportunity costs. Conversion costs are inevitable because of the introduction of NZGD2000 and the severity of the risks and costs of not moving to this new datum. Converting to the NZGD2000 will involve significant conversion costs, whichever projection is chosen. Selecting a new version of NZMG on NZGD2000 or introducing a new standard projection on NZGD2000 will both incur costs of a similar order.

Although existing users are familiar with NZMG, a vast number of new users can be anticipated in the future. The cost of induction for future users for NZMG would be similar to those for induction into a new standard projection.

Software support

There is a significant risk that retaining the NZMG will incur inadequate or delayed software support and impose some level of incompatibility with international reference or recording systems. A standard projection, because of its wide global application, does not incur this risk. Nor does it risk confusion in the use of two similar co-ordinate systems, as does the use of two different versions of NZMG.

Software support provided by software vendors for NZMG has been to a less than satisfactory level. NZMG, being specialised, relates to a small group of customers in global terms and will always be a lower priority for support in relation to the international mainstream. Two examples of this disadvantage are those of ESRI Arcinfo and ERDAS. ESRI Arcinfo users have been aware for some time of the efforts needed to obtain software support for NZMG, sometimes having to wait for later versions. A recent free software release from ERDAS, intended for viewing images and allowing re-projection of images from existing images, has no provision for NZMG.

Other issues

Comparing the benefits of a new version of NZMG with a New Zealand-wide standard projection reveals that the latter has a significant advantage. A standard projection would provide long-term benefits of full compatibility with all present equipment and reference systems around the world, and those still under development. The risk of incompatibility and non-operability is minimal. The historic advantage of the NZMG in greatly reducing the quantum of the scale factor is now limited by the lack of significance of this characteristic in the modern digital environment. The benefit of NZMG as a legacy system is significant for current knowledgeable users, but induction will be required for the vast number of users in the future just as it will be for future users of new standard projection.

Moving to a new standard projection will still allow NZMG to be retained specifically for the 1:50,000 topographical maps series. The expense of converting basic topographical data is not cost-effective in relation to the current Topomap 260 series mapping product, and not warranted because the differences are not significant at this small scale. The merits of providing a national topographical map series on the new datum is one of the issues needing to be addressed when a decision is taken in due course on what replaces the current series.

NEXT STEPS

Consultation already undertaken reveals the need for a decision on a national projection to be made early and communicated widely. The interviews required to provide information for this report revealed a wide disparity in the knowledge of some database administrators and users. There was nevertheless a good fundamental grasp of the issues and great interest in seeing a satisfactory resolution. All those directly involved need to be familiar with the requirements and degrees of impact of changing to the new datum and of the application of projections. At least one person involved with each geographical database must have a basic knowledge and serve as a resource for other local users in each agency. There is a corresponding need for national leadership to ensure that all large-scale digital mapping information held in projection co-ordinates is in a common projection throughout the country.

This indicates that as LINZ determines its position and follow-up action on a projection, a suitable communications strategy and programme should be developed to provide a clear direction. This could begin with a brief outline about the datum and projection issues in New Zealand, and advice of the vision and strategy of LINZ.

It will be most timely, when deciding on the direction to be taken concerning projections, for a clear vision and evidence of facilitative leadership to be made visible. LINZ is the only authority with the capability and responsibility of doing this. Currently NZMG is not generally well understood, and whatever direction is decided upon, effective communication will be vital.

It will also be essential to explain the role of the other different projections used in New Zealand, and to build understanding and acceptance of the broad and flexible approach being taken for the future. Such a programme would involve the preparation of a simple and clear publication on the basis and implications of the new projection which can serve as a resource document for all spatial database administrators and major users. A series of halfday regional workshops is also recommended, to introduce and explain this resource document and the future strategy and directions being taken by LINZ.

From the outset LINZ has planned a wide consultative approach before deciding on the form of a new projection. This participative attitude is to be commended, and should continue. A second stage of consultation and promotion will now be necessary to facilitate the implementation and evolution of each organisation's long-term strategy. This will also provide an opportunity to deliver advice on ways database administrators can obtain assurance about the impact of the new datum and projections on their databases.

Good groundwork at this time will prove to be highly effective in developing learning and knowledge about the relevance of the new datum and associated projection to the operations and development of the various databases in New Zealand. It will provide individual agencies with the confidence to plan to move immediately or incrementally to the new projection.

CONCLUSION

Deliberations so far indicate that there is considerable user insight into the merits of two main approaches to selecting a projection to accompany NZGD2000. New Zealand needs a national projection to be selected, with its promulgation and implementation carefully planned and implemented. Assessing the risks and benefits over the longer term provides a sound basis for making an orderly decision about the merits of introducing a new projection.

The evidence points clearly to the need to move to a standard conformal projection for New Zealand. The benefits provided by the NZMG of a small-scale factor are of marginal advantage, and carry with them a serious risk of inadequate software support and a lack of national and particularly international interoperability. The evidence is clear that for the long-term future, a standard national projection should be chosen for New Zealand.

It is also apparent that a move to NZGD2000 is necessary as soon as possible for all measurement and databases where the discrepancies with NZGD49 are material. Without this recognition all modern data will be constrained to fit the conventional data, introducing unnecessary distortions and the dilemma of whether two sets of data need to be used in spatial reference systems. The case for the move to the NZGD2000 is becoming more and more evident and this advice needs to be given to all spatial database administrators and users. My interviews have indicated that already some spatial data users, who previously saw no need to move from the traditional datum, have more recently found that the discrepancies now arising convince them that a early move to NZGD2000 is necessary.

In recognising that all spatial data referencing should be in terms of NZGD2000 we also recognise that conversion costs are inevitable whichever projection is used. We must recognise, too, that although conceptually the development of a single projection for multipurpose use has been advanced for some time, it has not been achieved because of the different practical requirements of major users. In New Zealand a range of projections are currently sanctioned for a variety of differing map and database uses. An increasing capability to deliver and store unprojected co-ordinates with projection conversion on the fly is providing for even greater flexibility. It is evident that we need to continue to be able to recognise a suite of projections or reference systems which are in use for particular purposes or environments.

There is, nevertheless, a critical requirement to introduce a common projection for large-scale urban, peri-urban and related rural mapping and GIS databases for the whole of New Zealand. Local authorities are well advanced on the development of these databases, and it is essential they remain aligned to a common projection across the country. There are already examples of some local authorities wishing to move to NZGD2000 and, without an alternative standard, considering the local meridional circuit on the Transverse Mercator projection.

Without leadership and promotion of an organised pathway forward, there is a danger that the unity now achieved in local authority spatial databases through the use of NZMG could be eroded, as inadequacies in NZGD49 become more apparent to users and ad hoc moves to NZGD2000 occur. A national projection can provide a medium for initial comparison and operations in spatial databases at national and regional levels. For these reasons it is necessary to endorse a national projection for large-scale urban and peri-urban mapping.

A change to NZGD2000 introduces factors that favour a change to a standard projection. Conversion costs will have to be met on any projection, including a revision of NZMG. The issue of software support becomes critical, as any new version of NZMG will require reworking existing software packages and there is a risk that this will not occur automatically. The danger is that if the NZMG is retained, in the future such servicing and interoperability issues will have to be revisited and overheads and costs endured continually.

The issues of future software support and interoperability are paramount. Past lack of responsiveness of software developers to a unique New Zealand projection cannot be dismissed, even though there are suppliers who have committed to fully supporting NZMG. There is strong evidence that in some quarters significant delays and lack of support have occurred, and that because NZMG is not supported in some overseas referencing systems, interchange of information is being constrained.

Globalisation is a loose term, and its significance has not been accepted by those supporting the retention of NZMG. Yet the reality is that across the globe there is increasing interaction in relation to datum and projections. New Zealand is involved in this through military, civil aviation, maritime and a range of yet-to-be-exploited civilian applications. This is not to suggest that NZMG would prevent such interactions, but it is evident that in comparison with a standard projection it would introduce an overhead and risks and difficulties with non-specialist users.

International interoperability introduces long-term less tangible benefits and issues, as such commitments and international interactions are likely to become increasingly relevant.

User-friendliness is a term that can be used to denote the facility for ready use of a projection co-ordinate system by non-specialist users and by those who may not have all the necessary conceptual or definition information available. Standard projections provide a higher level of user-friendliness than does a specialist projection. The complexity of NZMG to other than the specialist and informed user is a serious limitation. Internationally, local variations will increasingly become the exception. Moving to a standard projection will remove future problems and risks from this source.

In the final analysis, it is clear that the traditional scale factor advantage of NZMG is of much less significance for future digital mapping in New Zealand. Issues of international interoperability, immediately responsive support and non-specialist user facility all point to the benefits of using the change to NZGD2000 to also change to a standard conformal projection.

In taking the long-term view and recognising the need for simplicity in global interoperability, the option of introducing a new standard projection, namely a New Zealand Transverse Mercator (NZTM), is recommended.

Reasons for adopting the Transverse Mercator projection include:

- The Transverse Mercator is considered the most suitable in terms of coverage and its relationship to other projections.
- It keeps the national large-scale mapping projection in a conceptual relationship to the meridional circuit projections and the UTM.
- In the case of the UTM it offers a practical alternative for managing the depiction of areas common two zones through the use of the national projection.
- It will provide a basis for automatic software support by all software providers.
- It will facilitate international harmonisation and national and international interoperability.

It is now timely for LINZ to provide leadership to the large-scale mapping and GIS community. There is an urgent need to make the decision to move to a national New Zealand Transverse Mercator projection. Even though an early decision is called for, the implementation can be staged to suit the planning and voluntary initiatives of each organisation.

RECOMMENDATIONS

Recommendation 1
That LINZ authorise the establishment of a new national projection for large-scale urban, peri-urban and related rural mapping in New Zealand, based on the new NZGD2000.
Commentary
Although there are significant costs in converting existing co-ordinates, the merits of using the superior accuracy and convenience of the new geocentric datum will inevitably require the eventual conversion of all databases.

Recommendation 2
That a Transverse Mercator projection be selected to provide consistent national large-scale mapping coverage of New Zealand.
Commentary
A Transverse Mercator projection is recommended because of the merits of having a standard projection which will automatically be supported by all new software developments, and be in terms of international referencing systems. It is particularly important to provide a common projection for large-scale mapping databases for urban and peri-urban areas throughout New Zealand. Although other standard projections are suitable there is a significant advantage in having the same basis for a projection as that used for cadastral and military purposes.

Recommendation 3
That more than one projection be recognised and supported to the degree necessary.
Commentary
The fact that no single projection suits all needs and that there is a ready capability in modern computer systems to convert from one projection to another means that the continuance of other projections for practical or user needs reasons should be accepted. This recommendation accepts the merits of continuing the Meridional Circuit Transverse Projections for cadastral purposes and the continuation of the NZMG to support the existing Topomap 260 series mapping product, and the special-purpose use of several other projections. It also accepts the merits of the provision of geographical co-ordinates from primary databases.

Recommendation 4
That LINZ formally authorise and announce the selection of a New Zealand Transverse Mercator projection for use in conjunction with NZGD2000 as soon as possible.
Commentary
Some local authorities still have yet to complete the conversion of data for inclusion in their databases and most have not yet determined their long-term database strategies. The roll out of Land*online* in 2000 and 2001 will also raise issues about the format of data storage. A clear and early indication is needed of the long-term projection aims. Such direction is appropriate by LINZ as its leadership will be accepted as authoritative, and it is necessary to achieve harmonisation of large-scale spatial urban databases throughout the country to enable national interoperability.

Recommendation 5
That the technical details of the true and false origins, sheetlines and the configuration of scale error be determined as a follow-up exercise.
Commentary
Considerable technical evaluation has already been undertaken which indicates the technical characteristics that can be achieved for a New Zealand Transverse Mercator projection. These can now be finalised and established as definitions for a new projection. From the point of view of user friendliness to the low-level user it would be preferable to have a scale factor of 1.0000 if this can be achieved without trading off significant increases in scale

factor. Otherwise a central meridian with a factor of 0.9996 will suffice. An early design action will be to select and confirm the final technical details.

Recommendation 6
That LINZ initiate a communications strategy and programme to ensure that there is good understanding of the projection and datum issues and of the merits of a common approach to the new New Zealand Transverse Mercator projection.
Commentary
Although there are very well informed GIS administrators across New Zealand, there is insufficient general understanding among GIS users of the significance of datum and projections and the implications of these for various users. A consultative initiative is needed to adequately inform all database and GIS managers and strategic users. The compilation of a clearly written leaflet together with the initiation of regional workshops, followed by continuing Internet-sourced information, would ensure that the process of aligning large-resolution database infrastructures throughout New Zealand is effected and maintained. Much of the material has already been developed.

Such a communications strategy and programme would open the way for local authority databases to be harmonised to enable national and regional alignment for wider administrative, emergency, civil defence and police use. This programme through its learning and networking role would also enhance the capability of all database managers involved and provide a communications network for continuous learning as new technology and applications arise.

Recommendation 7
That LINZ investigate the merits of introducing a new mapping series to follow on from the current Topomap 260 topographic mapping.
Commentary
There is a need to develop a mapping policy which provides a basis for the form of mapping to follow on from the present NZMS260 mapping. This existing product can continue in its present form as the differences arising from the introduction of NZGD2000 are not currently of significance to the majority of users of this small-scale mapping. Over time, however, GPS and other database comparisons will indicate discrepancies arising from the different datum or mapping quality that will become of increasing significance to the user. Military users are likely to find the Topomap 260 maps less and less convenient to interrelate. The pending electronic mapping environment will also herald new requirements and characteristics for mapping. All of these need consideration when developing a policy on the mapping system to replace the current Topomap 260 series.

Recommendation 8
That the current Topomap 260 small-scale topographic mapping product be retained in terms of NZMG and NZGD49 until such time as a replacement series is introduced.
Commentary
The differences arising from the NZGD2000 are not sufficiently material to significantly affect the use of these small-scale maps. The retention of NZMG for this series as long as it is produced is justified as the costs of conversion and the disruption are of major

proportions and would not be offset by the marginal benefits. Any change to Topomap 260 mapping requires a complete review of a number of significant issues which need to be determined so that complete changes are effected through the subsequent series.

ABBREVIATIONS USED IN THIS TEXT

ASRP	Arc Standard Raster Product
AUSLIG	Australian Land Information Group
CAD	Computer Aided Draughting
BNG	British National Grid
DCDB	Digital Cadastral Database
ESRI	Environmental Systems Research Institute
ETRF	European Terrestrial Reference System
ETRF89	European Terrestrial Reference System 1989
GIS	Geographic Information System
GPS	Global Positioning System
IRENET95	Ireland Control Network 1995
ITRF	International Terrestrial Reference System
ITRF89	International Terrestrial Reference System 1989
LINZ	Land Information New Zealand
MGA	Mapping Grid of Australia
NZGD49	New Zealand Geodetic Datum 1949
NZMG	New Zealand Map Grid
NZMS	New Zealand Mapping Service
NZTM	New Zealand Transverse Mercator
OS	Ordinance Survey
OSGB36	Ordinance Survey of Great Britain 1936
UTM	Universal Transverse Mercator
WGS84	World Geodetic System 1984

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