A New Geodetic Datum for the Northern Territory

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SUMMARY

The geospatial reference system (GRS) or geodetic framework of the Northern Territory comprises of passive and active survey control that are mathematically defined on a global reference system. The GRS underpins most land related information through position, both horizontally and vertically. The geodetic infrastructure in the Territory which facilitates GRS activities has recently undergone a major upgrade through numerous national and local initiatives. Upon completion, it is estimated the capital improvements to the GRS would be valued at $3.5 million. The tangible outcome or the return on such an investment is the realisation of a more accurate geodetic datum based on the International Terrestrial Reference Frame (ITRF), and the provision of significant benefits and opportunities not only for surveyors and geoscientists but other non-traditional geospatial users from various sectors.

This paper will present a brief summary of the status of the Territory's GRS and will also discuss the anticipated technical issues, operational workings, and administrative aspects of developing and maintaining a new geodetic datum in the modern era. An additional purpose of this paper is to also stimulate discussion amongst the survey community on the proposed derivation and implementation strategies of a new geodetic datum in a dynamic environment, and the subsequent change management of related datasets (such as the cadastre, assets and service utilities) via numerous spatial applications.

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1. INTRODUCTION

For the last 5 years, the surveyors of the Office of the Surveyor General (OSG) have produced several technical papers on the status and development of our geodetic infrastructure, in particular the Territory's Global Navigation Satellite System (GNSS) Continuously Operating Reference Station (CORS) network. To date, the progress of this geospatial infrastructure investment has been steady. Although there have been the typical government resourcing issues, budgetary constraints and other numerous technical and administrative challenges, sound project management by the OSG team has made possible the operation of geodetic quality permanent GNSS CORS, and localised clusters of CORS within in the Territory. The primary rationale of installing these type of GNSS CORS was to facilitate the streaming of GNSS data to Geoscience Australia[1] (GA) so as to assist with the maintenance, analysis and modernisation of Australia's and the Territory's geodetic datum.

This paper will review the existing motivations to modernise, the arguments to subsequently adopt a new geodetic datum in the Territory, and discuss the present and future operations by the OSG that will facilitate any potential future change in geodetic datum.

2. BACKGROUND

The Territory's geodetic datum is the Geocentric Datum of Australia 1994 (GDA94). It is a fixed coordinate datum whose origins began in 1992 as part of a global campaign through the (then) International GPS Service that involved continuous GPS observations at 8 locations across Australia. This network of permanent GPS reference stations formed the Australian Fiducial Network (AFN). In addition to these observations, numerous high accuracy GPS observing campaigns were performed during 1993-94 at 70 sites across Australia (15 stations in the Territory) at a nominal spacing of 500km. This network was named the Australian National Network (ANN).

The AFN and ANN GPS observations were subsequently combined into a single regional GPS solution in terms of the International Terrestrial Reference Frame 1992 (ITRF92) and the resulting co-ordinates mapped to a common epoch of 1994.0. The AFN co-ordinates (latitude, longitude and ellipsoidal height) were then adopted as Australia's recognized value standard for position thus defining the Geocentric Datum of Australia (GDA) 1994 in September 1995.

[1] Geoscience Australia is an Australian Government organization who manages national geodesy issues and monitors the movement of the Australian continent.

The AFN and ANN co-ordinates were subsequently used as constraint stations in "phased" or staged least squares adjustments of additional GPS observations / baselines and terrestrial networks to propagate GDA94 co-ordinates for the Territory's Geodetic Network (TGN) . This network comprised of 1000 survey control marks of which 110 were occupied with geodetic GPS receivers to form a unique GPS dataset that covered the major transects of the Territory. The TGN marks were then used as control in further least squares adjustments to propagate co-ordinates for thousands of ground marks across the Territory (called CRMs – co-ordinated reference marks), which were then used as the reference points for the establishment of the Territory's co-ordinate cadastre and numerous other geo-spatial datasets.

The official height reference for the Territory is the Australian Height Datum (AHD) and is defined as the "surface which passes thorough MSL at the tide gauges and through points with zero AHD height vertically below the other basic junction points in the leveling network" – NMC (1986). Consequently to shift between the GDA94 ellipsoidal and AHD surfaces a "quasi-geoid" separation model based on gravimetric and geometric data called AusGeoid09 is predominantly used. Refer to technical paper by Featherstone et al (2011) for more detailed information.

To manage the Territory's geodetic datum and framework the OSG has currently 9 operational surveyors, who also are responsible for the administration of the cadastre, and related survey infrastructure for approximately 70, 000 parcels that cover an area of 1,352,000 km^2. In previous presentations the Territory's geodetic infrastructure has been often referred to as the geo-fabric of the Northern Territory's Geospatial Reference System (NT GRS) that presently comprises of 'passive' and 'active' survey control infrastructure. From the OSG's perspective the NT GRS underpins all land related information, is the fundamental reference layer, and is an enabling infrastructure for many positioning applications.

As mentioned before the NT GRS is presently undergoing a major upgrade and consequently becoming a substantial investment and asset to the Territory's spatial data infrastructure. Funding and resources for this project has been provided through numerous Territory government funding mechanisms and bids, however a large portion has also been made available through the AuScope project. Briefly, AuScope is an initiative funded under the National Collaborative Research Infrastructure Strategy (NCRIS) of the Australian Government Department of Innovation. Its aim is to facilitate the development of infrastructure to measure and monitor the movement of Australia's tectonic plates, and thus to better understand the structure and evolution of the continent. Clearly a product of this geoscience activity is the realisation of a more accurate reference frame and subsequent geodetic datum, which from the OSG's perspective is one of the Territory's primary geospatial objectives.

The present status of the NT GRS can best be represented by the diagrams on pages 4 and 5.

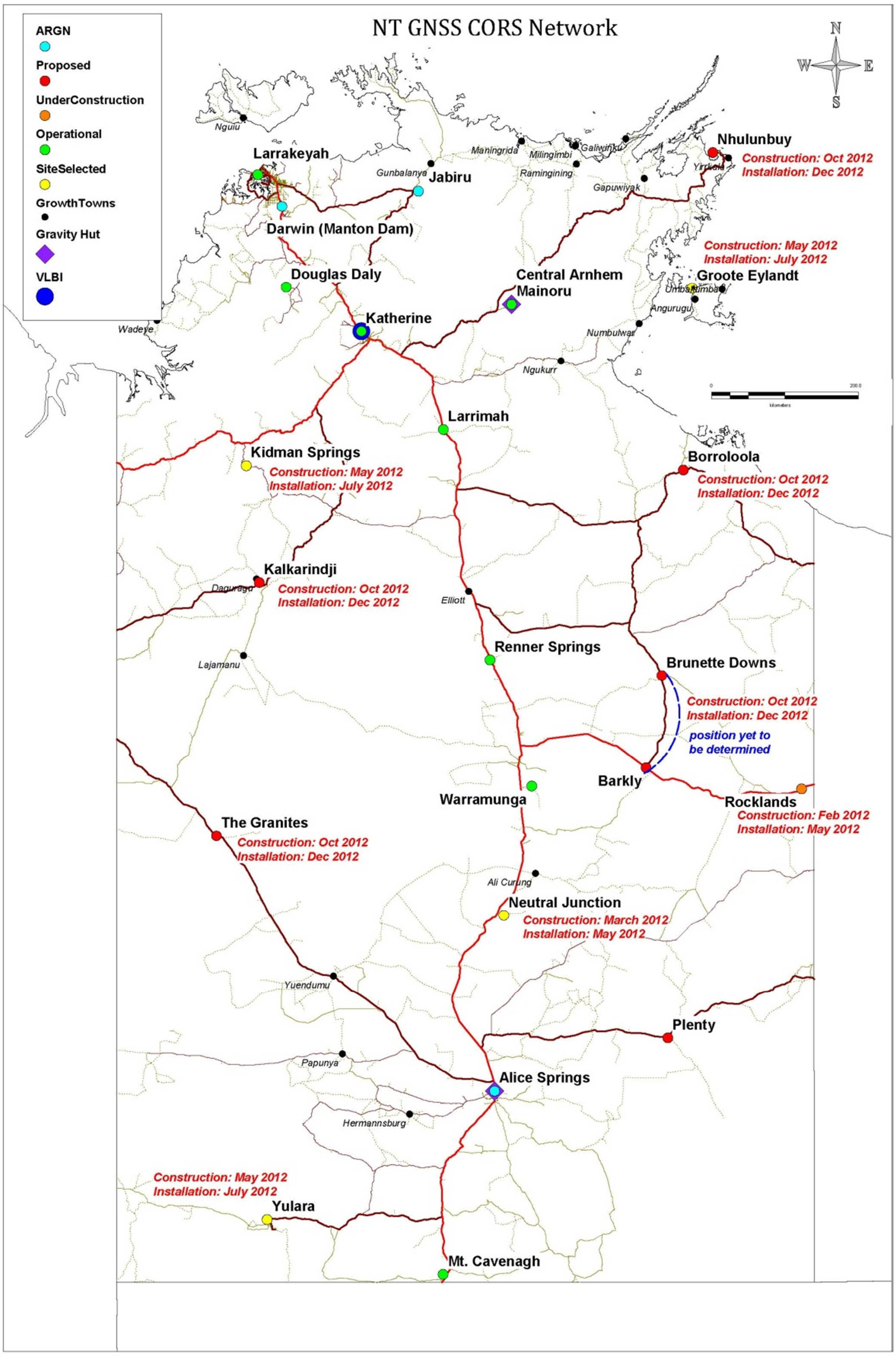


Diagram 1: Status of the active NT GRS - GNSS CORS (11 operational), Gravity Huts, and VLBI (operational June 2011)

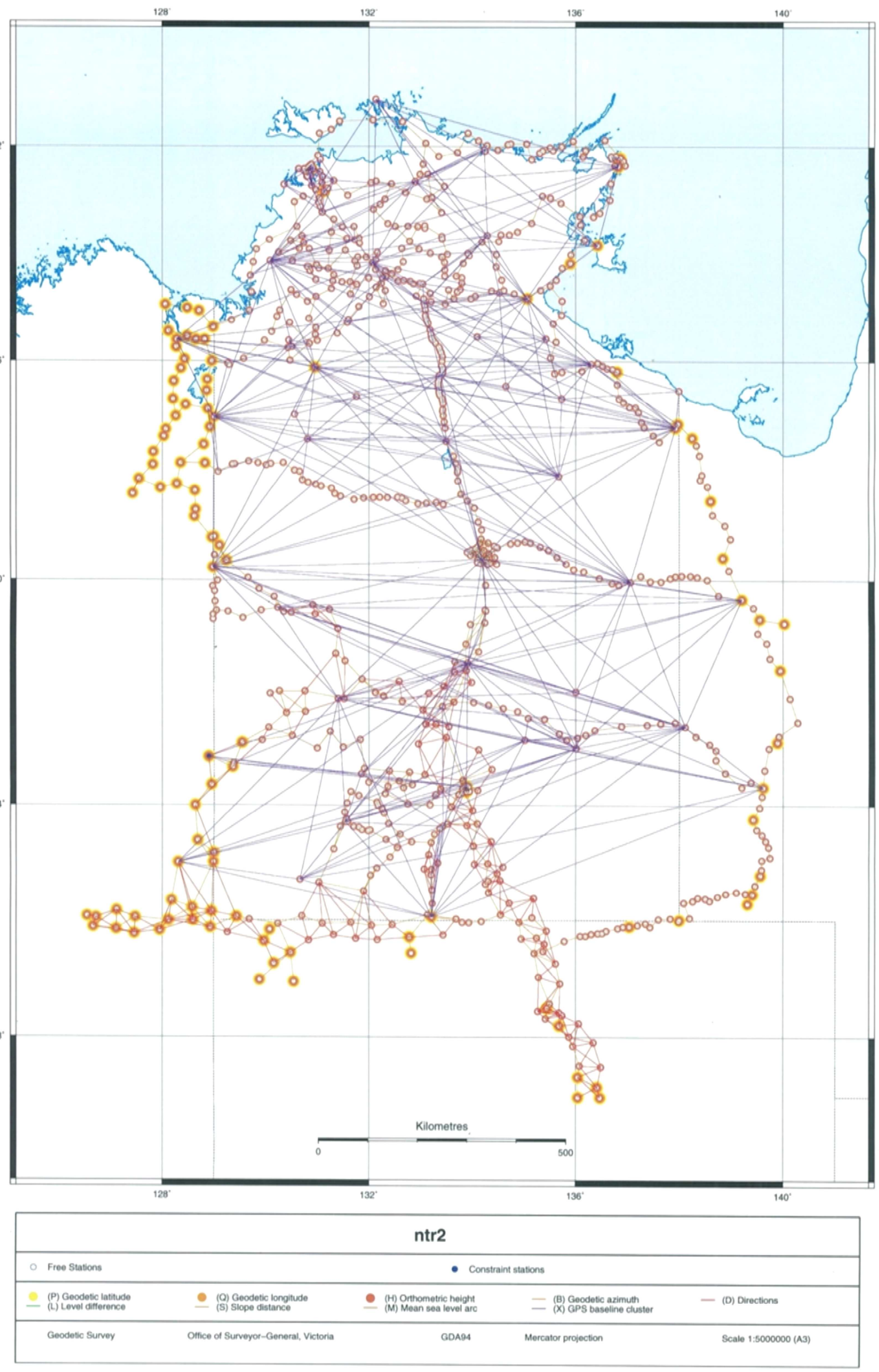


Diagram 2: The TGN (state network) of approximately 1000 primary geodetic marks that underpin tens of thousands of lower order marks and the cadastre.

3. MOTIVATION FOR A MODERNISED or NEW GDA

The national project to upgrade Australia's geodetic infrastructure through the proliferation of GNSS CORS, has been embraced by all of Australia's State and Territory governments and the geosciences community. The political drivers espoused by each jurisdiction to gain support and resources from their respective governments have varied, however from a geosciences outlook there was a unified approach, and an overwhelming consensus, to improve the integrity and accuracy of GDA94. Consequently as the GNSS CORS became operational in each State or Territory, GNSS data was streamed to agencies such as GA, University of New South Wales, and Curtin University, to enable the geoscience research community to access data for analysis, assist with the development of regional reference frame solutions (i.e. Asia Pacific Reference Frame – APREF) and of course the refinement or modernisation of GDA 94.

The technical paper by Dawson and Woods (2010) "ITRF to GDA94 coordinate transformations" utilised such GNSS CORS data. This paper critically analysed their own workings, outlined their procedures, the results for a range of ITRF-to-GDA94 transformation parameters, and their related uncertainties. It also discussed the short comings of the existing GDA94 datum, articulated an argument for a refinement or modernisation of GDA94, and then concluded with a recommendation for the geodetic community to consider a "dynamic datum" to accommodate future precise positioning applications and the inherent limitations of a static co-ordinate datum.

To summarise the points of view by Dawson and Woods (2010) for GDA94 modernisation, the following has been paraphrased from their publication –

- Significant residual co-ordinate differences at the centimetre level were apparent between the official gazetted or published GDA94 co-ordinates and those determined using 'state-of-the-art' GPS analysis and processing. This means that deriving GDA94 coordinates consistently across nation and meeting the user's future accuracy expectations of 1 cm level positioning, is not currently possible.
- According to Morgan et al (1996) the uncertainty of AFN co-ordinates is presently - horizontal 30 mm and vertical 50 mm at the 95% confidence level. Consequently as it is accepted that the uncertainty of GDA94 at the AFN sets the upper limit of uncertainty for geodetic infrastructures in Australia, the determination of uncertainty for new datasets propagated from the AFN down through State and Territory survey control will often fail to meet many users' expectations.
- The increasing divergence of ITRF and GDA94 (caused primarily by tectonic plate movement, crustal movement and ongoing refinement of ITRF) means less knowledgeable users will need to take care when applying complex transformations so as to avoid incorrect and inconsistent application.
- The recent development of national and state CORS infrastructure, and in particular the development of the AuScope network, will provide a new opportunity for densification of the recognised value standard for position from the 8 AFN stations used to realise GDA94 to potentially over 100 stations. A densification of the recognised-value standard would provide improved access to and robustness of the

‘legal traceability’ of position measurement in Australia, however it would need to be based on a refined or improved datum.
- Because of the discontinuities observed in present GNSS observations and the continuing deformation of the Australian crust means that for high accuracy positioning a static geodetic model for station coordinates can no longer meet the requirements of all users, especially those requiring a dynamic model.

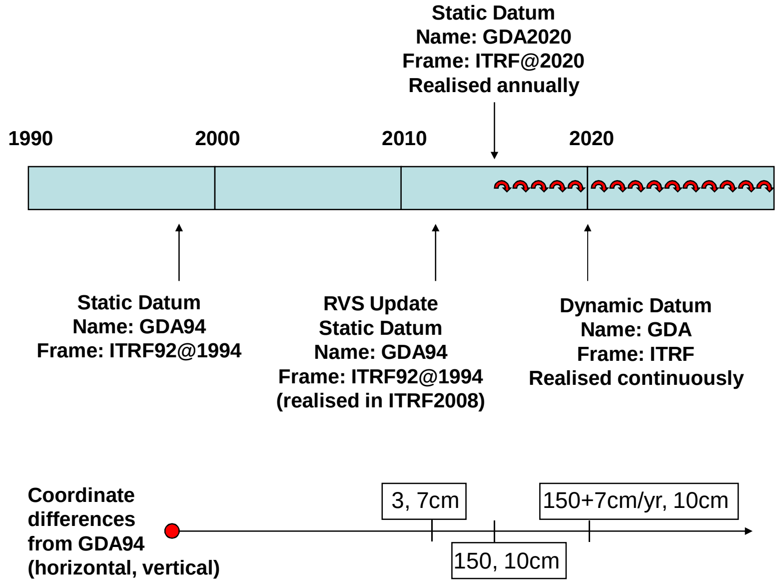
In support of Dawson and Woods, Johnston and Morgan (2010) also have similar reasons for a geodetic datum alteration and change. In this paper the authors’ state - “There are two components that will drive the need for a new datum in Australia – these are the quest for higher accuracies and the need to account for the absolute difference between GDA94 and ITRF. Both of these factors are complicated by the localised distortions of GDA94 as a result of intraplate deformation and errors or inaccuracies in the original propagation of GDA94.”

Recent meetings amongst the operational or technical geodetic specialists of each jurisdiction, that is the Intergovernmental Committee on Surveying and Mapping (ICSM) Geodesy Technical Sub-Committee (GTSC), of which the Territory is an active member, have also acknowledged the need for GDA94 to be modernised and changed. A précis and interpretation of their discussions on the motivations for geodetic datum change are as follows-

- the propagation of datum GDA94 co-ordinates and uncertainties had inconsistencies that were once sufficient and manageable by users, however these inconsistencies are now affecting users and cannot provide reliable positioning solutions for the future
- the need to stay ahead of the user community accuracy demands i.e. centimetre real time positioning
- the need for a 3 dimensional geodetic datum
- mass-market, new technology (decimetre level positioning) is emerging rapidly i.e. regional and global real time services delivered by digital communications and the Internet
- coordinate differences between GNSS CORS and ground marks can only be resolved through a national readjustment
- the importance of rigorously propagating uncertainty to all geodetic infrastructure
- the Earth, including the Australian Plate, is dynamic i.e. due to tectonic plate movements the absolute magnitude of difference between ITRF and GDA is diverging, thus by 2020 the difference will be approximately 1.7m, 0.1m
- if there is no datum change then transforming between ITRF based solutions back to GDA94 could be confusing and complex for the less competent user

Also, ICSM GTSC has drafted a roadmap which depicts the *proposed* incremental approach for a “dynamic geodetic datum”. This graphic timeline depicts a dynamic datum by 2020 and that by this date any datums thereafter will be realised continuously! Refer to Graphic 1, page 8. ICSM GTSC also *propose* a new Geodetic Model of Australia (GMA), which appears to be similar to the re-adjustment concept / principles adopted by the geodetic community in the 1970’s and 80’s, but with greater emphasis on the use of GNSS measurements in the adjustment model; geodetic data exchange formats; specified roles and responsibilities of stakeholders; and the ‘automated’ maintenance of the geodetic framework. Refer to Graphic 2 below.

Graphic 1 – Road map



Source - ICSM GTSC Melbourne (2011)

Graphic 2 – Geodetic Model of Australia

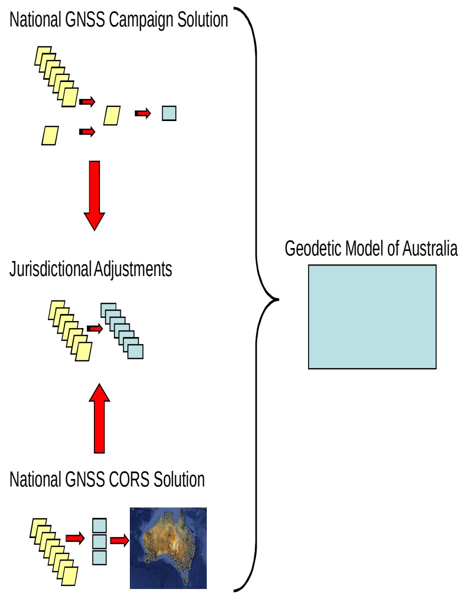
Fully rigorous geometric adjustment
→ aspire for an all stations and observation adjustment (down to the street corner)
→ phased-adjustment strategy implemented by DynaNet software
→ work-flows managed using e-Geodesy technology
→ if necessary activity to be hosted on super-computer infrastructure e.g., NCI

Solution Framework

Development
→ updated on a jurisdictional/researc h basis

Test
→ updated as observations added

Production
→ updated annually
→ release to remain the responsibility of States and Territory Governments



Source - ICSM GTSC Melbourne (2011)

4. IMPLEMENTATION – WHAT NEXT?

As one can see there has been some genuine discussion about a “datum change” for Australia. It appears the anticipated outcome by 2020 is a modern dynamic geodetic datum aligned to

ITRF, and to achieve this, milestones as suggested below need to be delivered -

- the AFN co-ordinates and subsequent "primary" geodetic survey control (i.e. GNSS CORS) to be refined and defined respectively and both to have more realistic uncertainties;
- implementation of an interim datum GDA 2015 that has been defined by 3 dimensional static coordinates mapped forward to 2020 so as to increase the life span of the datum;
- development and adoption a new Geodetic Model of Australia that administers the framework and workings of the geodetic datum; and
- the creation and execution of an effective change management and marketing campaign.

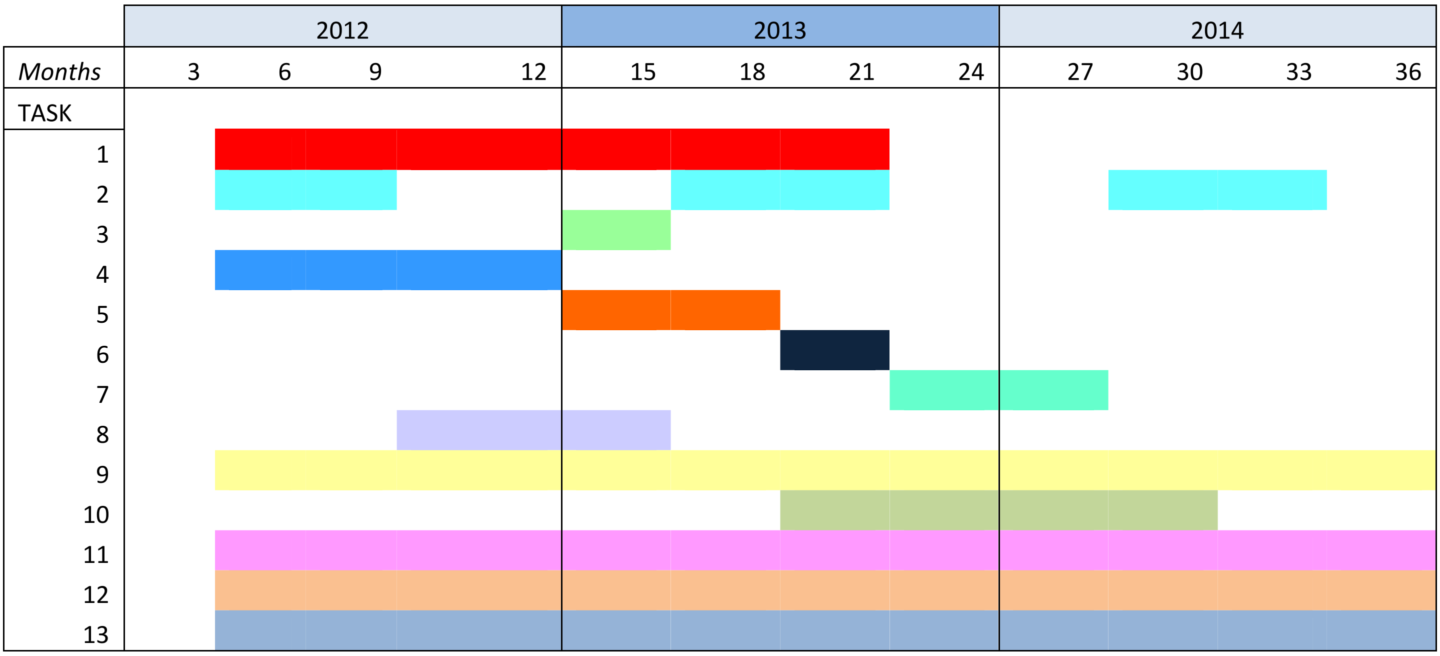
In the event that the Territory was to accept or not accept the impetus of a dynamic datum, the authors strongly believe that the OSG should nevertheless be proactive and modernise the Territory's present geodetic framework and adopt the necessary contemporary practices and processes required to maintain a modern datum. For either situation the fundamental question would be - what would the OSG need to do to facilitate an incremental approach towards a dynamic datum OR to modernise its GRS or geodetic framework? From a technical perspective the OSG would need to continue and consider undertaking the activities, as described in the following table –

	Activity or Task	**Comments**	**Type**	**Work time**
1.	Complete the rollout of geodetic quality permanent GNSS CORS (i.e. AuScope stations) across the Territory by 2012/13. This would include – 1. CORS construction / installation 2. development of IT and communication infrastructure for GNSS data streaming	This is indispensable as this GNSS CORS network will essentially become the new fiducial points and additional reference standards of position for the Territory and the nation. These survey control points will also become the "spine" of a national adjustment or the constraint stations for subsequent geodetic networks.	Operational	18 months
2.	Perform new high accuracy GNSS observations between GNSS CORS and the 110 TGN GPS stations that were occupied from previous GDA 94 campaigns	The baselines observed between the old passive marks and the new active marks will provide the crucial link between the old and new datums, and subsequent connections to the existing ground mark network and also terrestrial data. The field campaign will be a logistical challenge for the OSG and may require assist from neighbouring jurisdictions or the private sector.	Operational	18 months
3.	Consider re-processing of critical or salient GDA 94 TGN GPS campaign data / baselines with present day algorithms, models, techniques and ITRF based orbits.	The OSG would need to evaluate the impact of this project on the end results, that is would such activity change or improve the co-ordinates and the associated uncertainties.	Operational	3 months

4.	Convert existing geodetic least squares adjustment data files from a "Newgan" application format to a “DynaNet” format and engine platform. It includes work such as the cleansing, combining, validating and then building the observational datasets; designing and implementing business rules to manage such data.	Newgan is a least squares adjustment program developed by Dr John Allman that the OSG has extensively used for 20 years. However, due to software limitations and modern hardware and operating systems the end life of Newgan is nearing. “DynaNet” is a contemporary application that performs either ‘phased’ or ‘simultaneous’ fully rigorous least squares adjustments on large datasets. It was developed by Dr Phil Collier, Frank Leahy, David Mitchell and supplementary work is now performed by Dr Roger Fraser; and it incorporates the eGeodesy “geodetic” XML file format concept. Subsequently, the OSG has selected DynaNet as the primary software to perform geodetic adjustments in the future, and this has provided the OSG the opportunity to re-engineer and modernise our geodetic data management and processing.	Operational	9 months
5.	Readjustment of the entire Territory geodetic network and subsequent survey control networks.	This would involve using the solutions from national / regional GNSS CORS networks (i.e. AuScope and APREF) as constraint stations in the adjustment and incorporating validated national GNSS data from State / Territory / other (both old and new) campaigns into the dataset. This activity is already a necessity for the OSG as anecdotal evidence suggests that the local uncertainties in GDA94 coordinates caused by the original propagation technique of GDA 94 has resulted in GDA94 coordinates, produced by transforming ITRF coordinates, being significantly different to these propagated through the original GDA adjustment. This has also been experienced and documented in New South Wales – refer to Kinlyside et al, (2010).	Operational	6 months
6.	Propagate the positional uncertainties for geodetic control.	DynaNet would be used to propagate the positional uncertainties. This would then lead to the propagation of positional uncertainties for subsequent datasets such as the cadastre and other major land and / or geospatial data.	Operational	3 months
7.	Integrate survey control positional uncertainty information into the Territory’s geodetic survey control data base known as NTGESS.	In addition to this NTGESS data upload and cleansing process will also need to occur.	Operational	6 months
8.	Adoption of the new ICSM GTSC standards and best practices for datum control surveys, and the preparation of supporting Territory standards and best practices for datum control surveys.	This may invoke changes to the Territory’s survey practice directions pertaining to how surveyors derive the cadastral control required to define boundaries by co-ordinates. It may also extend to the development of a framework, system and policy to utilise GNSS data from non-government agencies for the purpose of geodetic datum maintenance and validation.	Legal / Policy	6 months

9.	Support the implementation of *eGeodesy* as the geodetic data model and standard for the exchange of geodetic information, results and observations as espoused by Donnelly and Fraser (2010).	This model would be integral to the work flow of geodetic information between stakeholders in the new GMA and also an important facet towards an ***automated approach*** to maintaining survey control infrastructure. Note - this may also require the OSG to review its survey data business processes to ensure such information can be administered in ILIS, which is the Territory's web based Integrated Land Information System. Refer to Rudd and Sarib (2007).	Institutional / Policy / Operational	On - going
10.	Consider and evaluate the creation of a vertical DynaNet data set for the Territory's bench mark network.	This would involve sourcing and examining geodetic leveling data from the 1960's to present, and creating an observations / height differences dataset for thousands of kilometres of level runs (based on AHD measurements) so as to be incorporated into a true 3 dimensional rigorous DynaNet adjustment. Undertaking this project will highlight problem areas but also assist the resolution of any currently unresolved inconsistencies that may be apparent. Like other retrospective projects of this nature the "end product and its value" will need to be scrutinized against the time and effort required to achieve the result.	Operational	12 months
11.	Expand the recognised value standard position through the proliferation of "Regulation 13" certificates to eligible survey control marks, thus allow surveyors to achieve legal traceability of their GNSS measurements via position and comply with the National Measurement Act (NMA) 1960.	Regulation 13 certificates are Certificates of Verification for qualifying geodetic control or subsidiary networks of the AFN as additional reference standards of measurement or recognised-value standards for position. Only an approved Verifying Authority, such as GA, can issue such certificates. Consequently, as it is the responsibility of the OSG to facilitate the compliance or adherence to relevant aspects of the NMA, the OSG would need to apply and comply with GA's requirements so as to obtain Regulation 13 certificates over eligible survey control, such as GNSS CORS or other marks that have been established using GNSS measuring techniques.	Legal / Policy / Operational	On - going
12.	Support and actively participate in ICSM endorsed initiatives that preserve and facilitate the development and maintenance of the Territory's geodetic datum.	Initiatives such as AusPOS (on line post processing positioning serviced provided by GA), Asia Pacific Reference Frame project, new Geodetic Model of Australia concept and so on.	Institutional	On - going
13.	Support and actively participation in national initiatives that promote positioning networks as enabling or critical infrastructure.	Initiatives such as NCRIS, AuScope and the wide area positioning infrastructure and / or services are prime examples.	Institutional	On - going

The diagram below is an indicative timeline of the geodetic activities to be undertaken over the next three years, as described in detail in the previous table.



5. IMPLEMENTATION CHALLENGES

To manage the change and implementation of a new geodetic datum, whether it is "static, semi dynamic or dynamic", it would be sensible for the OSG to identify the potential challenges associated with such migration. The authors foresee the following major issues or challenges for the OSG and provide some points for discussion –

- Acceptance of a geodetic datum change by the geospatial and non-related user community. It is expected that users will initially ask the question why? For the OSG to answer this effectively a more active marketing and research campaign will be required. It will need to be substantially better than the one employed for the original conversion to GDA94, especially when one considers that it took almost 7 years for some organisations to make the change! Market research may initially need to examine not only the technical restraints but also the mechanics and operations of the various users' business so as to understand their resistance to change. Also a variety of key drivers for the numerous users needs to be researched and determined, as the necessity or willingness for change is often different for each user. For example, the possible technical reasons for change could be –
    - As the Territory government (and other large agencies) are the custodian of major land related or fundamental datasets it would be prudent for users to be on the same geodetic datum thus allowing compatibility and integration of data at a local, national and regional level.

- Co-ordinates from wide area or survey accurate positioning service providers (national, regional and global) will most likely be using the latest ITRF based or local geodetic datum solution thus to have direct compatibility with such providers it would be logical for the user collecting or managing information to use a geodetic datum that is also based on the latest ITRF or local geodetic datum.
- Working on a common geodetic datum will minimise confusion and the need to understand complex geodetic datum transformations.
- To accommodate ubiquitous positioning and integration of information from nontraditional surveying and / or future devices.

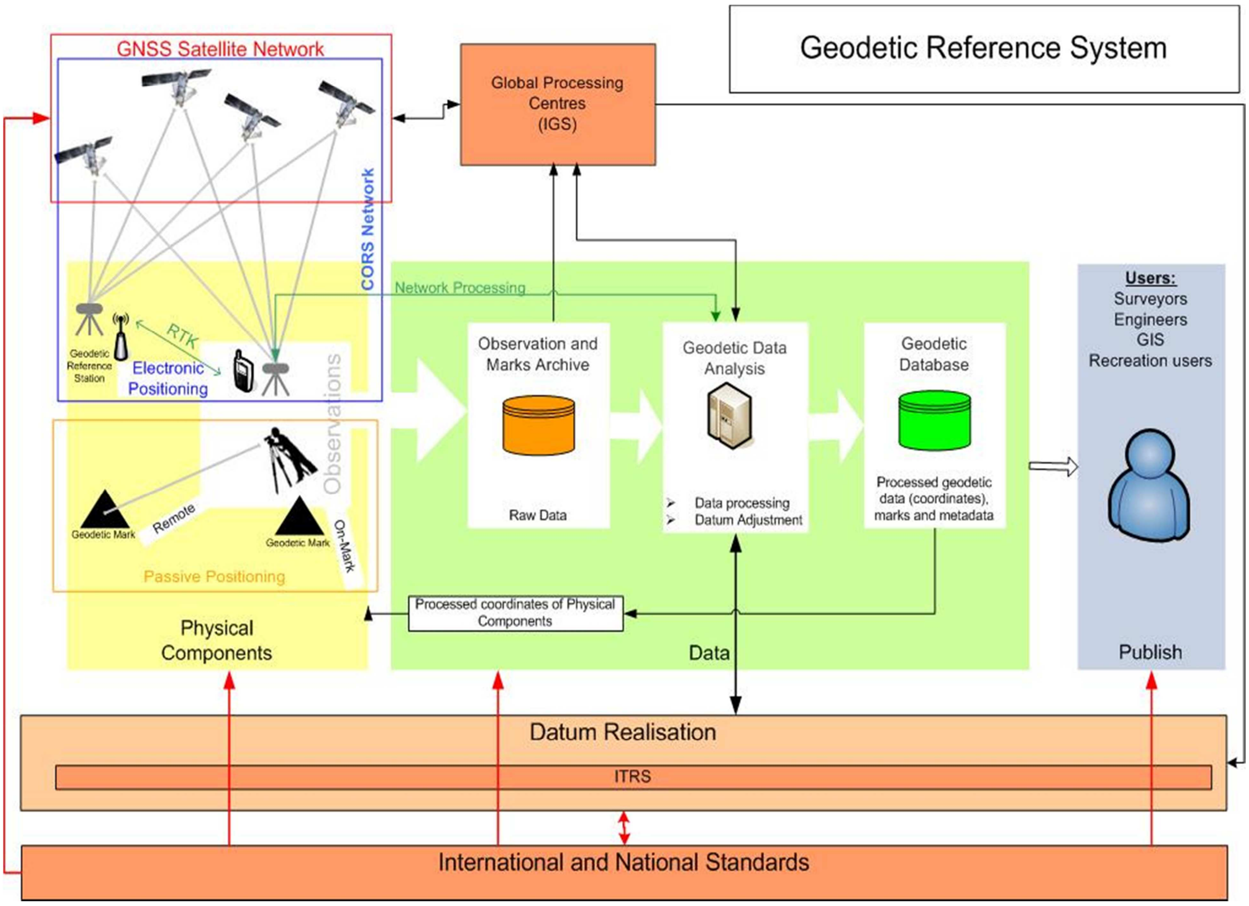
- Providing the technical assistance and education of dataset holders to transform their information to the new datum. To do this effectively simple 'tools or utilities' to perform this transformation are required. For example, another GDA 'xx' NTv2 binary grid file interpolation application, or a "velocity field" would be needed to manage most user's circumstances. However for organisations that are custodians of large "compiled" datasets (i.e. cadastre, utilities, and assets) that do not comprise of just simple point information but have complex associativity with other data (internally and externally) will require a more comprehensive tool. In this instance the Territory would need to examine alternate or upgrade existing vertical "topology" applications such as those currently being used by the OSG for the management and manipulation of cadastral coordinates, survey geometry and parcel data.

- Developing the appropriate business cases to justify ongoing support for resources and funding to administer and maintain the geodetic framework. In the present economic climate this is becoming more difficult as public funds are diminishing and work units are being rationalised. Presently the main driver for 'assistance' has been based on a "science and research" cause, as the geosciences community considered it necessary to verify and validate the present function of the geodetic network. In essence this has been achieved and hence the ensuing discussions of a future geodetic datum change. However, as positioning becomes ubiquitous in the Territory it is expected the demand for better real time positional accuracy will intensify. It is also envisaged that the public and industry will become more dependent on and insist upon greater integrity and reliability from the geospatial infrastructure that underpins such positioning services. Consequently the driver for the OSG will undoubtedly need to be changed. The focus of the driver will shift from an enabling mentality to one of maintaining critical geospatial infrastructure for a wide variety of users, services, and systems. This maybe the key to resourcing the modernisation or change of the Territory's geodetic datum.

- Also from a broader and longer term perspective it may be necessary for the OSG to review and extend its present statutory roles and responsibilities pertaining to spatial data infrastructure. Currently the OSG has the legislative mandate to concentrate on maintaining survey infrastructure for the cadastre or land titling, however careful consideration should be given to extending the OSG's statutory functions to encompass geospatial infrastructure. Such a change could be achieved via modifications of existing acts / regulations; however a more appropriate and direct way is to develop new policies and legislation that are specifically designated for the administration of spatial data information and / or infrastructure of which geospatial survey infrastructure is managed by the OSG.

- Automation of the geodetic or survey control data and processing. A long term objective and challenge of the OSG is to be able to manage survey control information in an electronic environment. That is, to streamline the survey control component of land development process by utilising digital technology and formats so that the Territory's land development process -
  - becomes more interoperable with contemporary land information management systems and spatial data infrastructures;
  - can be delivered and accessed via web services,
  - and viewed through spatial data visualisation services and software

  From an OSG perspective this a challenge to modernise our geodetic business and processes so that the geodetic reference system, as outlined in Graphic 3, could be automated in the future.



Graphic 3 – Geodetic Reference System

- Establishment of ellipsoidal height datum. The transition to such a height reference system in the Territory (and Australia) is not perceivable in the near future, and that AHD will remain as the "working height datum". However, from a regional and global perspective there is discussion about the establishment of a world height system for research and science initiatives (climate change / sea level monitoring). It is anticipated that models, such as AusGeoid 09 to transform ellipsoidal heights to AHD heights will be a necessary element of any geodetic datum change tool kit.

- Accuracy of Territory government geospatial datasets. A new or modernised geodetic datum will not improve the geospatial accuracy of existing datasets. With the advent of more accessible real time positioning services and techniques, such as precise point positioning, wide area real time positioning, and mobile phone positioning, the age and integrity of such datasets is now easily discernable to the most simplest of users. A new geodetic datum may only amplify this situation. In the future, custodians of such datasets will need to spatially upgrade their datasets so as to remain as the primary or definitive source for that information and avoid being made irrelevant or redundant. To achieve this, significant investment into improving the spatial data accuracy will be required, as well as changes to policies, frameworks and systems involved with data capture and maintenance so as to allow third parties to contribute effectively. In other words, facilitate data collection and positioning techniques emanating from crowd sourcing.

6. SUMMARY

The main purpose of this paper was to bring to the attention of the Territory's survey industry that the dialogue of a geodetic datum change is real and action is imminent. Consequently, the authors have endeavoured to deliver a paper that provided an overview of the current status of the Territory's GRS (geodetic framework) with respect to the issues and discussions concerning the national debate for a geodetic datum change, and also the work involved to modernise the management of geodetic framework and the data. From an OSG perspective it is hoped that this paper has achieved this and will stimulate feedback on the strategies articulated, and how we should manage and deliver such a change when it occurs.

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BIOGRAPHICAL NOTES

Amy PETERSON, GNSS CORS Manager, Survey Services in the Land Information Division of the Northern Territory Government's Department of Lands and Planning.

Amy has worked in the Surveying and Spatial Sciences industry for over ten years, having gained a variety of experience in both the public and private sectors. Amy's professional work experience extends from working as an Australian National Antarctic Research Expeditioner, to working across Queensland, Tasmania and the Northern Territory in the capacity of field surveyor, GIS and spatial consultant and Projects Manager. Amy is now working for the Northern Territory Government as the GNSS CORS Manager, focusing on maintaining and expanding the CORS network and developing the AuScope GNSS CORS component in the Territory.

Amy Peterson graduated from the University of Tasmania with a Bachelor of Geomatics in 2002, and completed a further Honours year in 2003. Amy is currently working towards registration as a Licensed Surveyor in the Northern Territory and is an active member of the Land Survey Commission and the Young Professionals of the Surveying and Spatial Sciences Institute.

Robert SARIB, Supervising Surveyor, Survey Services in the Land Information Division of the Northern Territory Government's Department of Lands and Planning.

Robert Sarib obtained his degree in Bachelor Applied Science – Survey and Mapping from Curtin University of Technology Western Australia in 1989. He was registered to practice as a Licensed Surveyor in the Northern Territory, Australia in 1991 and achieved this during his employment with the Northern Territory Government. Since then he has worked in the private sector as a cadastral surveyor, and was re-employed by the Northern Territory Government to manage the Northern Territory Geospatial Reference System and the Survey Services work unit of the Office of the Surveyor General. He also holds a Graduate Certificate in Public Sector Management received from the Flinders University of South Australia.

Mr Sarib has been an active member of the FIG Commission 5 since 2002, and the Northern Territory delegate on the Inter-governmental Committee on Survey and Mapping - Geodesy Technical Sub Committee. He is the Northern Territory representative on Land Survey Commission of the Surveying and Spatial Sciences Institute. He is also a board member of the Surveyors Board of Northern Territory for Licensed or Registered surveyors.

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