FIG WORKING WEEK 2017
Helsinki Finland
29 May - 2 June 2017

Transitioning to a New Paradigm – the Development and Implementation of a Modernised National Datum from a Regional Perspective

Amy Peterson and Rob Sarib – 31 May 2017
TS05C Reference Systems and Frames - Paper 8931

Surveying the world of tomorrow –
From digitalisation to augmented reality

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Facts & Figures
Northern Territory - Australia

NORTHERN TERRITORY GOVERNMENT

Land Area

1,349,129 km²

Finland 338,424 km²

Population

244,307

People

Finland 5,503,879

Employment

98,916

Jobs

Finland 2,231,000

Gross Domestic Product

$23,139

Million AUD

Finland $310,37 Billion AUD

Department of Infrastructure, Planning and Logistics
Land Information - Survey

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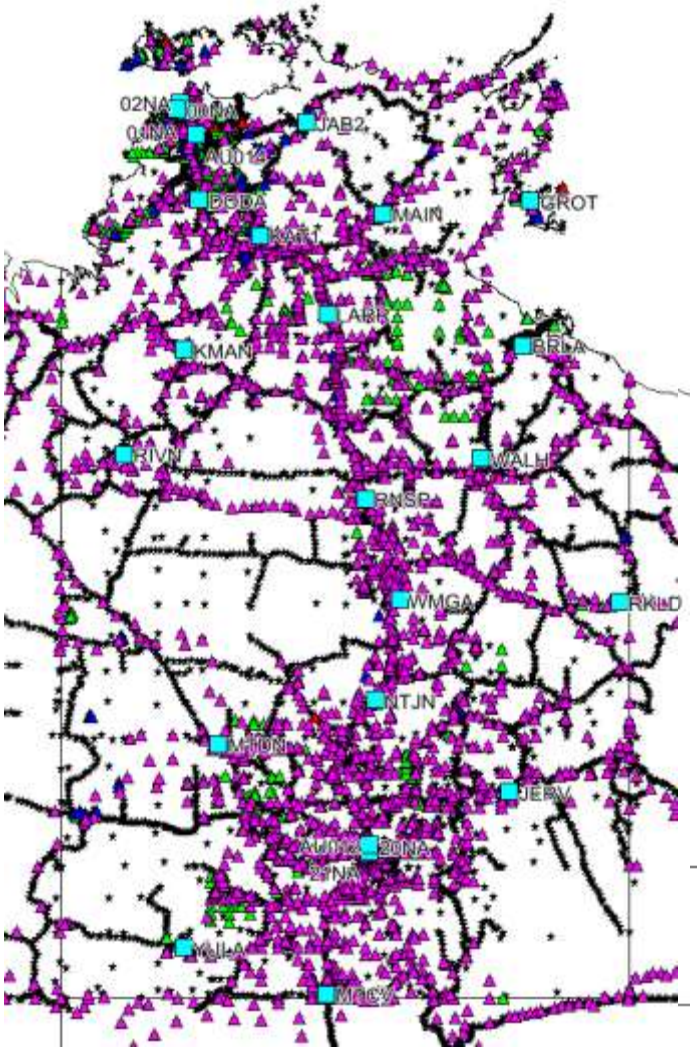

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DEPARTMENT OF INFRASTRUCTURE, PLANNING AND LOGISTICS

LAND INFORMATION, SURVEY

- Staff – 10 operational surveyors
- 2 offices – Darwin, Alice Springs
- Responsible for the administration of the geodetic framework, cadastre, and related survey infrastructure and systems
- **~ 100 000 parcels, 23 CORS, 28 000** geodetic marks
- Annual Survey budget – operational and personnel $2.5 million
- Oracle spatial, web based architecture Integrated Land Information System ILIS

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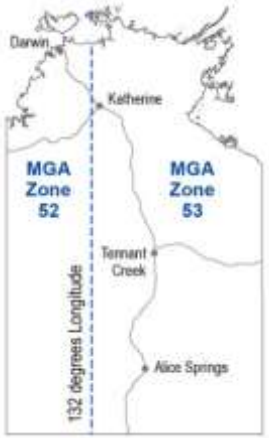
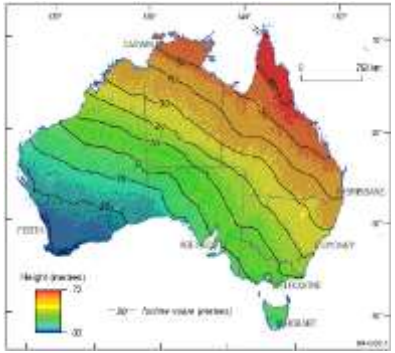
What was the NT's Geospatial Reference System (GRS)?

- ***G**eocentric **D**atum of **A**ustralia -**GDA is a "static" /* **plate fixed** datum.
- *Based on* ***International Terrestrial Reference Frame*** *(ITRF) 1992 at epoch 1 January 1994,* Reference Ellipsoid - GRS80
- **Grid coordinates:** UTM, *Map Grid of Australia 1994 (MGA94)* – **easting and northing** metres
- **Geographical coordinate set:** *Geocentric Datum of Australia 1994* (GDA94) - **latitude and longitude** degrees
- AusGeoid 98 (±0.5m); AusGeoid 09 (±0.1m) for GNSS measurements
- Working height surface AHD - Australian Height Datum

GDA





NT Geodetic datasets prior to modernisation

- Compromised of a “passive” network – terrestrial data, episodic / campaign style GPS measurements
- Constrained by AFN (2), ANN (15) and TGN (120) GPS campaigns
- Adjustment, observations, results information stored / accessed via a series of “static” file and paper based system
- Estimated Positional Uncertainty > 30mm – Horizontally, >50 mm - Vertically

What is a modernised GRS?

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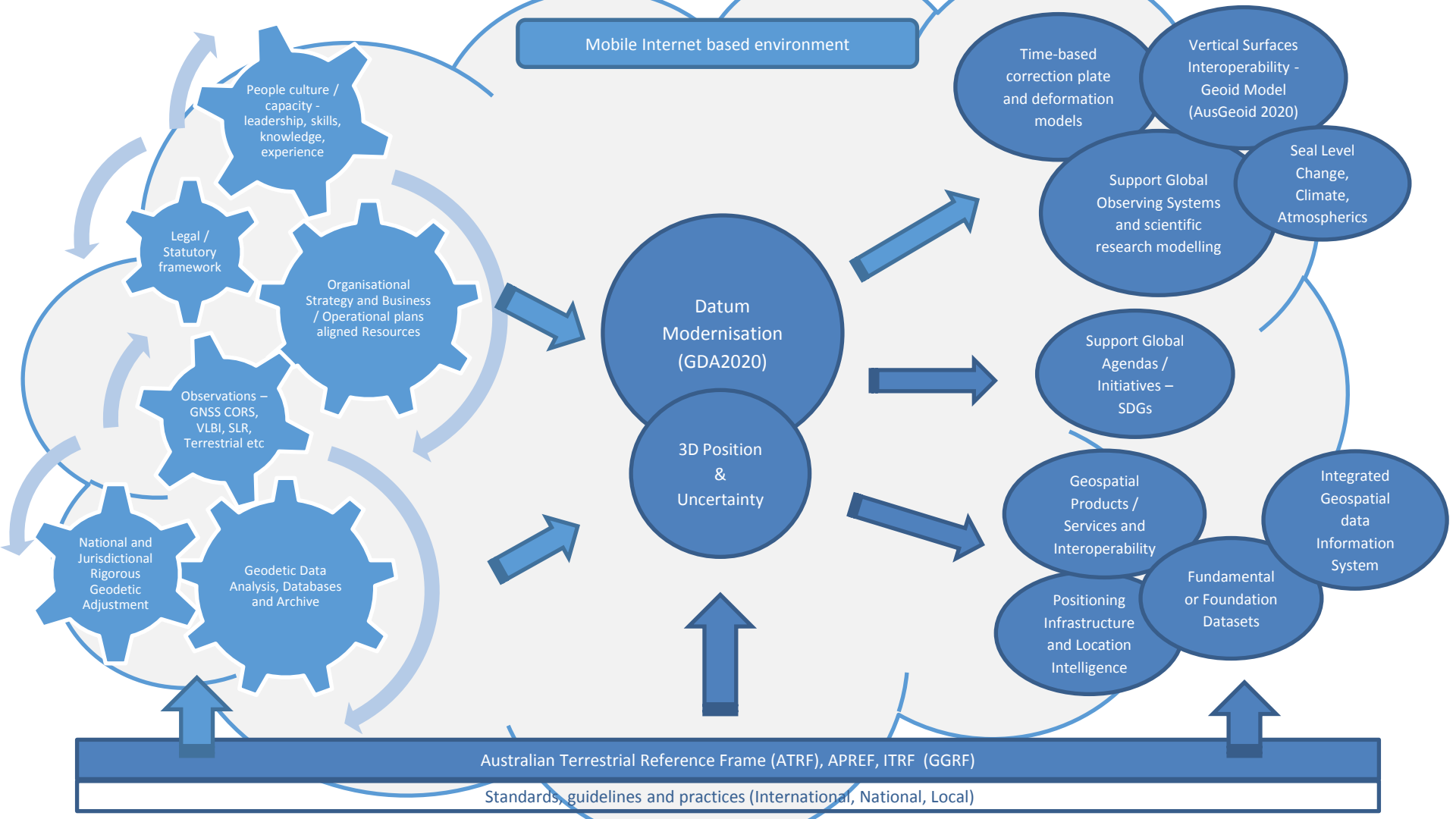
Characteristics of a Modernised GRS

- Accurate traceable connection to ITRF, APREF
- Propagation of co-ordinates and uncertainties via a rigorous, nationwide adjustment of geodetic information / observations
- 3D with a national Geoid model
- Enable time-based correction plate and deformation models.
- Support positioning with HORIZ uncertainties < 20mm, VERT < 50mm
- Seamlessly aligned with positioning infrastructure and services.
- Users contribute measurements to an automated system for exchange of geodetic data.
- Products and services are delivered through web based systems (Cloud?)
- Datum (real time positioning) realised through digital communications and the Internet (Mobile)
- Supports global trends in geospatial, location intelligence, fundamental datasets etc
- Underpinned by standards, guidelines, practices
- Sustained by agency strategy, policy, resources


Mobile Internet based environment
People culture / capacity - leadership, skills, knowledge, experience
Legal / Statutory framework
Organisational Strategy and Business / Operational plans aligned Resources
Observations – GNSS CORS, VLBI, SLR, Terrestrial etc
National and Jurisdictional Rigorous Geodetic Adjustment
Geodetic Data Analysis, Databases and Archive
Datum Modernisation (GDA2020)
3D Position & Uncertainty
Time-based correction plate and deformation models
Vertical Surfaces Interoperability - Geoid Model (AusGeoid 2020)
Support Global Observing Systems and scientific research modelling
Seal Level Change, Climate, Atmospherics
Support Global Agendas / Initiatives – SDGs
Geospatial Products / Services and Interoperability
Integrated Geospatial data Information System
Fundamental or Foundation Datasets
Positioning Infrastructure and Location Intelligence
Australian Terrestrial Reference Frame (ATRF), APREF, ITRF (GGRF)
Standards, guidelines and practices (International, National, Local)

Why did we need to modernise?

What are our drivers?

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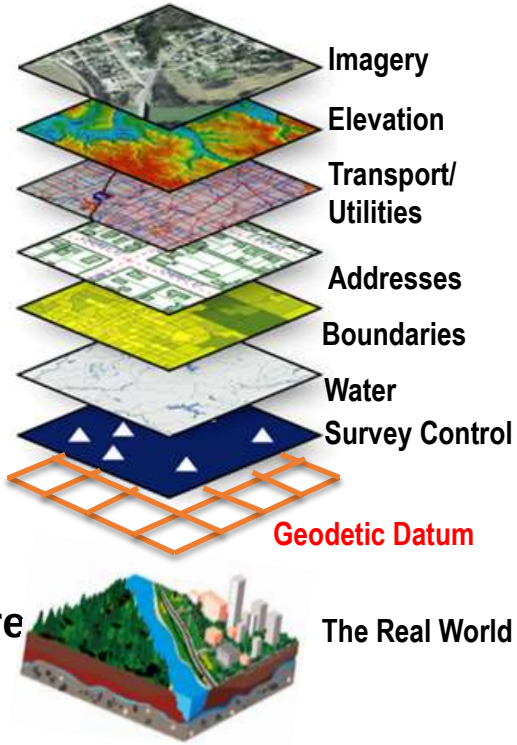
The NT GRS in the future will no longer be

“ fit for purpose ”

Drivers for NT GRS Modernisation

- To improve the order of GDA to be “mm” accurate as GDA 94 is not accurate enough to meet future geospatial users needs
- To be the **reference layer that underpins** most geospatial land, water, space datasets and the spine of GIS or LIS
- To facilitate **interoperability and integration** of our fundamental or foundation datasets
- To be recognised as **essential and enabling infrastructure supporting informed decision making** and sustainable economic development



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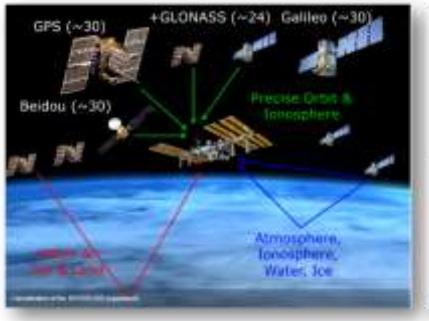
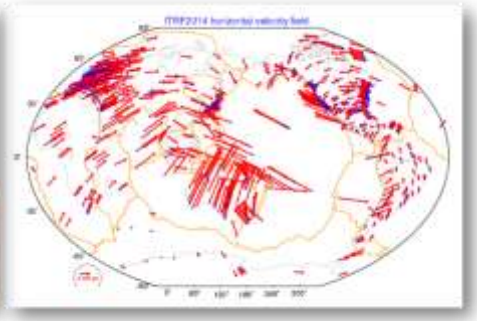
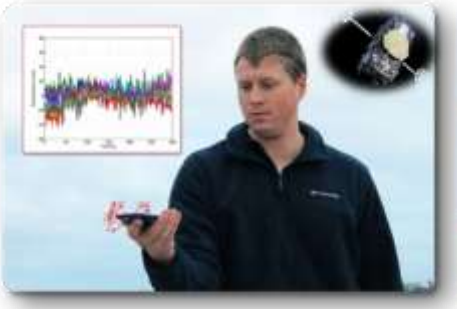
Drivers for NT GRS Modernisation

- To support geoscience activity, scientific research modelling, global observing systems that **measure and monitor the dynamics of the earth**; inter / intra tectonic plate deformation, sea level monitoring, climate change, atmospherics





- To be aligned with **ubiquitous positioning services and providers**



- To take advantage of a modernised **multi GNSS environment** and subsequent benefits

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How to modernise the NT GRS

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Organisational Structure

ANZLIC

ICSM
INTERGOVERNMENTAL COMMITTEE ON SURVEYING & MAPPING

NPI NATIONAL POSITIONING INFRASTRUCTURE CAPABILITY

crc•si

NCRIS
National Research Infrastructure for Australia

AuScope

- Permanent Committee on Addressing
- Permanent Committee on Geodesy
- Permanent Committee on Place Names
- Permanent Committee on Tides and Mean Sea Level
- Permanent Committee on Cadastre
  - ePlan Working Group
  - Digital Cadastral Database Working Group
- Permanent Committee on Topographic Information
- GDA Modernisation Implementation Working Group

membership

Jurisdictional Representation

Develop -
polices / arrangements / procurement / finances / data agreements / legal / advocacy / communication plans etc

Implement technical aspects,
Establish standards / practices / guidelines

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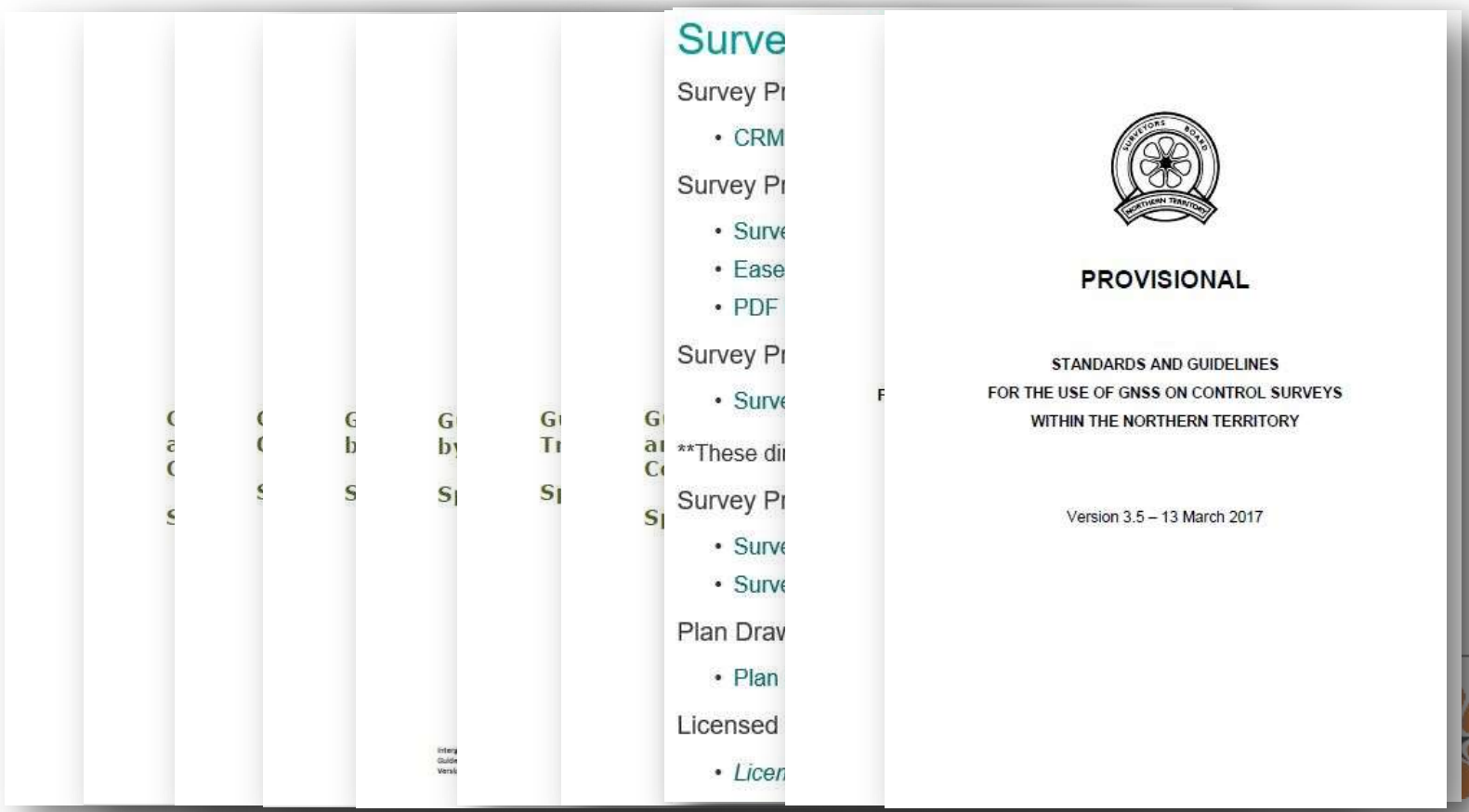
Standards, Guidelines , Practices



ISO International Organization for Standardization

STANDARDS Australia

ANZLIC

ICSM INTERGOVERNMENTAL COMMITTEE ON SURVEYING & MAPPING

IGS INTERNATIONAL GNSS SERVICE

OGC Making location count.

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The Operational Plan –

13 steps, linked to agency Strategy, timelines - realistic flexible, measureable, resource dependent!

	Activity or Task	Type	Work time
1.	Complete the rollout of geodetic quality permanent GNSS CORS (i.e. AuScope stations) across the Territory by 2012/13	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	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.	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.	Operational	9 months
5.	Readjustment of the entire Territory geodetic network and subsequent survey control networks.	Operational	6 months
6.	Propagate the positional uncertainties for geodetic control.	Operational	3 months
7.	Integrate survey control positional uncertainty information into the Territory's geodetic survey control data base known as NTGESS.	Operational	6 months
8.	Adoption of the new ICSM PCG standards and best practices for datum control surveys, and the preparation of supporting Territory standards and best practices for datum control surveys.	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).	Institutional / Policy / Operational	On – going
10.	Consider and evaluate the creation of a vertical DynaNet data set for the Territory's bench mark network.	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.	Legal / Policy / Operational	Ongoing
12.	Support and actively participate in ICSM endorsed initiatives that preserve and facilitate the development and maintenance of the Territory's geodetic datum.	Institutional	Ongoing
13.	Support and actively participation in national initiatives that promote positioning networks as enabling or critical infrastructure.	Institutional	Ongoing

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Key NT Geospatial / Geodetic Infrastructure; Systems ; Components

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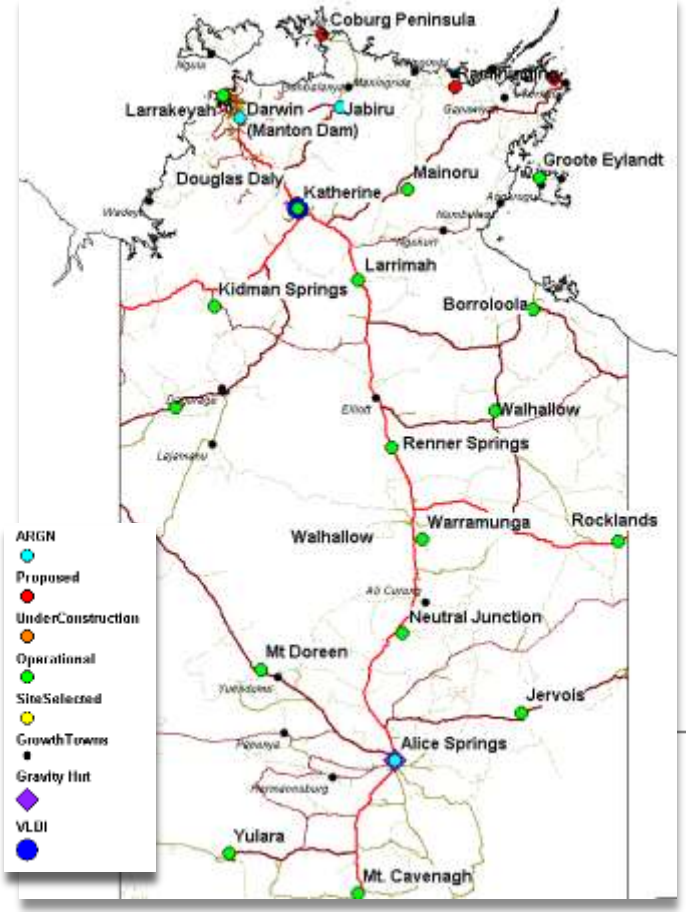
The NT GNSS CORS Network



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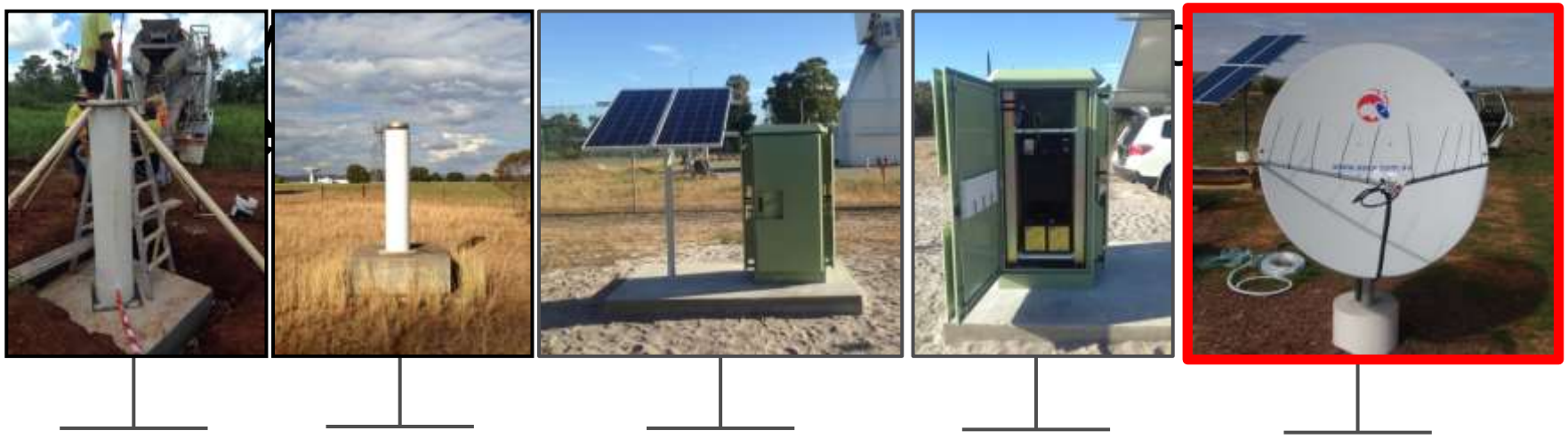
GNSS Station

- Permanent geodetic quality GNSS



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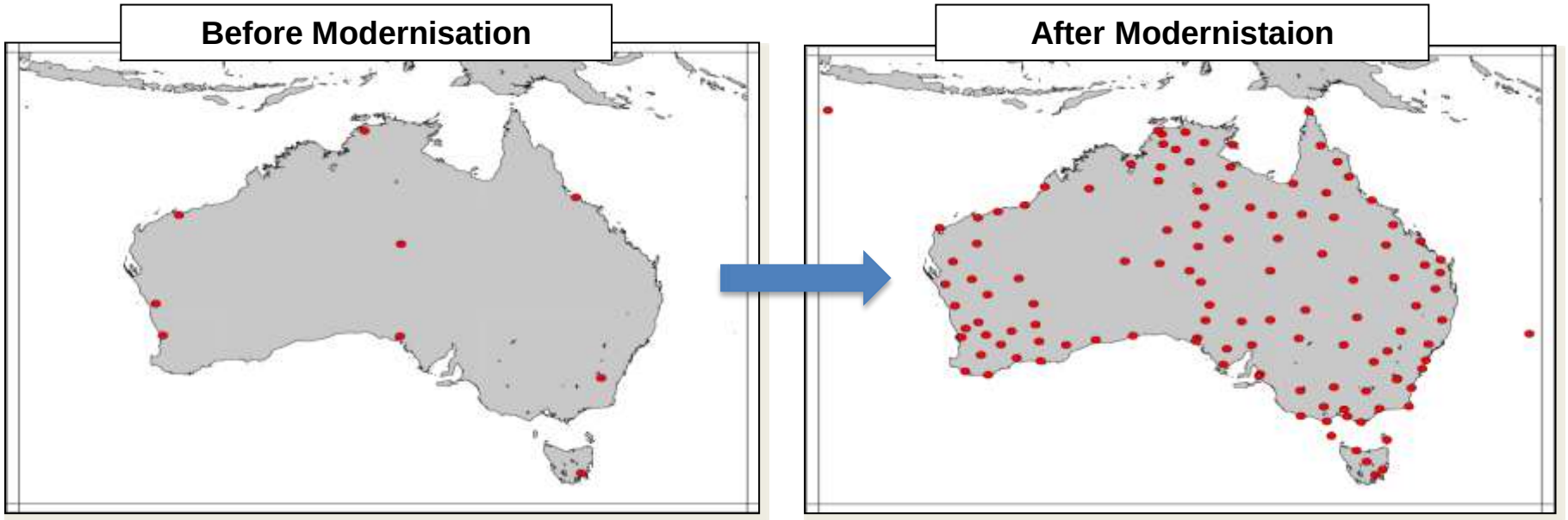
PROJECT MANAGEMENT PROCESS FOR THE CORS ROLLOUT

Network Design | Sourcing Funding | Reconnaissance | Approval in Principal | Land Acquisition | Clearances | Native Title Considerations | Finalising Site | Procurement of materials and equipment | Development of tender documentation | Release tender, assess, award of contract | Construction | Installation and Commissioning | Ongoing monitoring and maintenance

Northern Territory Government

AuScope

National GNSS Infrastructure



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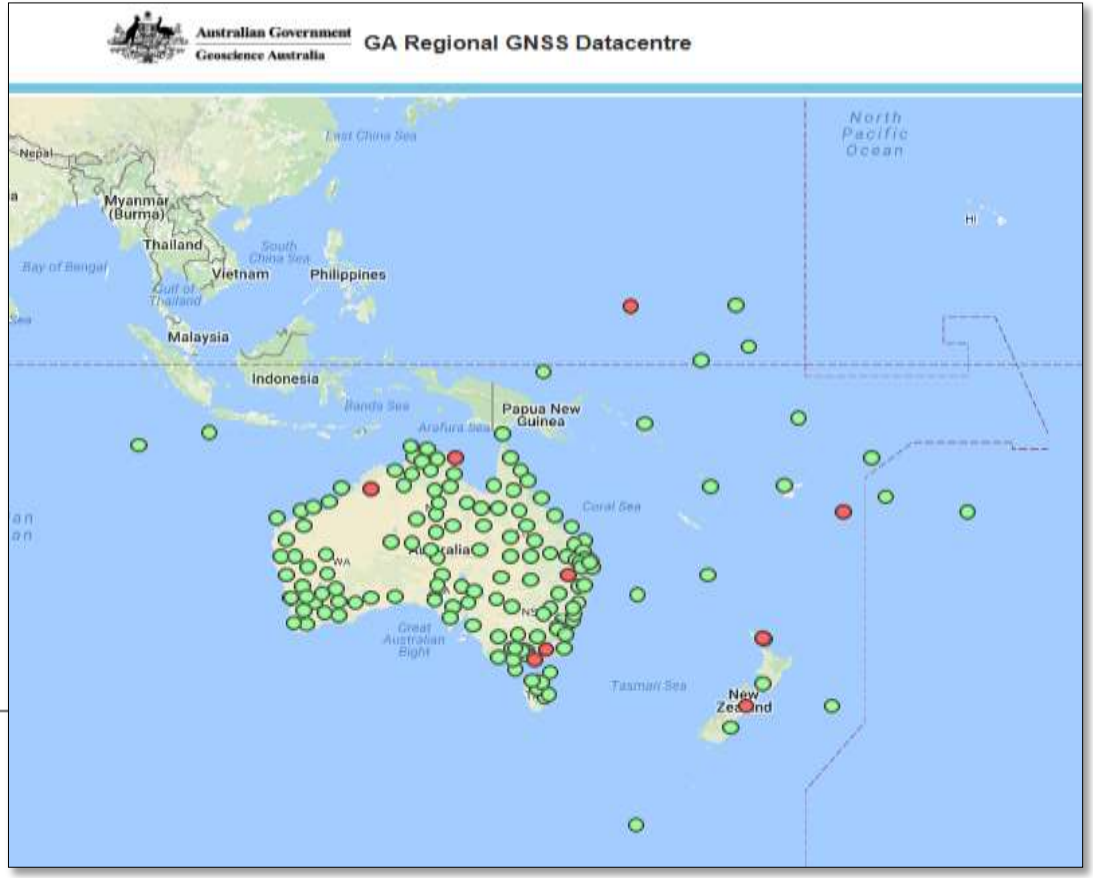
GeoScience Australia – the regional data centre

GeoScience Australia is the regional data centre responsible for managing, storing, analysing and archiving data and site logs, coordinates and maps from the co-operative network of Continuously Operating Reference Stations across the Australian region and the South Pacific.

GA also provides real-time GNSS data streams (AusCORS) and online processing facilities (AusPOS).

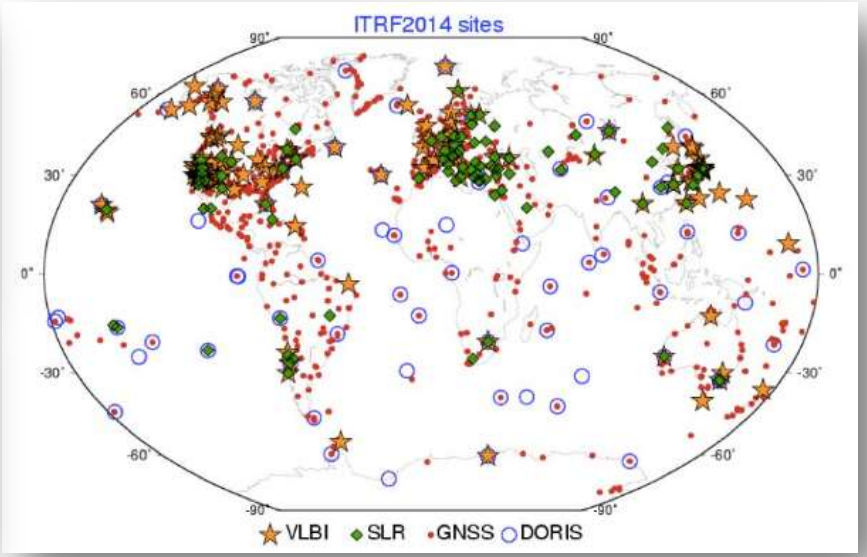
*The NTG recognise that **our 'role' is in supporting the ongoing densification, maintenance and operation of the infrastructure** and to build capacity within our jurisdiction to assist in meeting national and regional objectives*



Supporting ITRF Determination

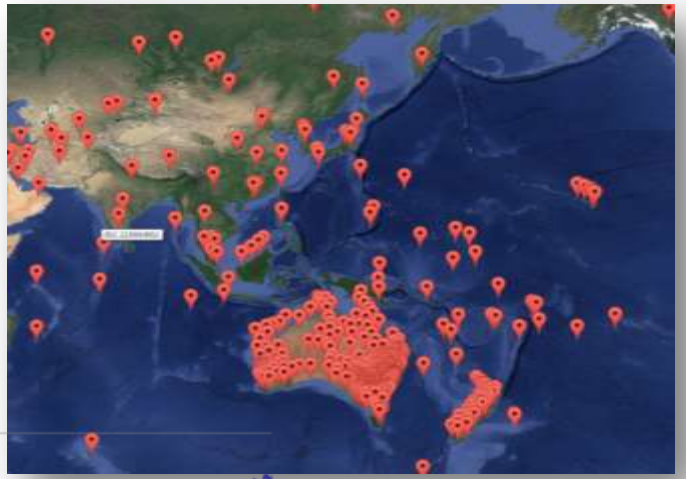
Key geospatial infrastructure investment includes :

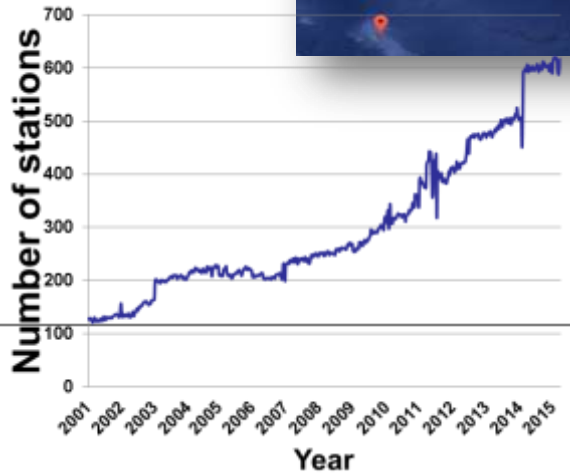
- Very Long Baseline Interferometry (VLBI) array
- Satellite Laser Ranging (SLR) facilities
- Global Navigation Satellite Systems (GNSS) ground stations and receivers, and
- Gravity measurement (GM) instruments.



Asia Pacific Reference Frame (APREF)

- Data from 28 countries
- 16 national agencies participating
- Approximately 420 Asia Pacific stations
- Approximately 600 stations routinely analysed
- Four independent analysis centres
  - Geoscience Australia
  - Curtin University
  - Department of Sustainability and Environment in Victoria, Australia
  - Institute of Geodesy and Geophysics, Chinese Academy of Sciences





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ITRF2014 versus APREF (IGb08)

- RMS coordinate differences at 2016.0
  - 3.1, 3.5, 5.0 mm (latitude, longitude, height)
- RMS velocity differences
  - 0.2, 0.2, 0.6 mm (latitude, longitude, height)
- Significant outliers: PARK, XMIS, SA45

ITRF2014 versus APREF (IGb08) after Helmert T.

- RMS coordinate differences at 2016.0
  - 2.2, 1.3, 4.0 mm (latitude, longitude, height)
- RMS velocity differences
  - 0.2, 0.2, 0.4 mm (latitude, longitude, height)

- ***ITRF2014 is fit-for-purpose***
- ***APREF realisation of ITRF2014 to be used for GDA2020***

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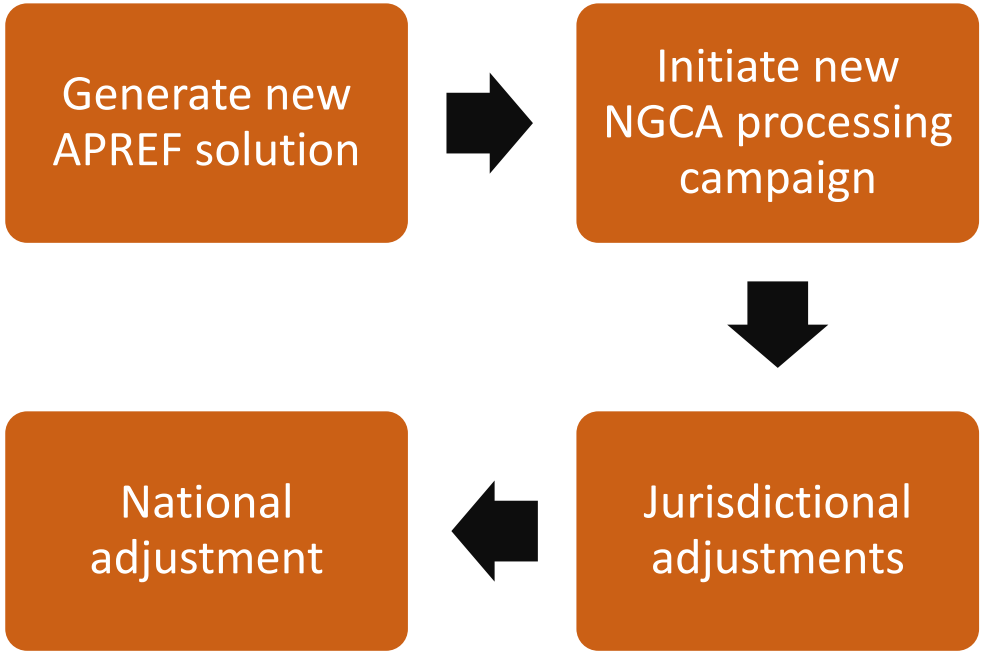
Propagation of Positional Uncertainty



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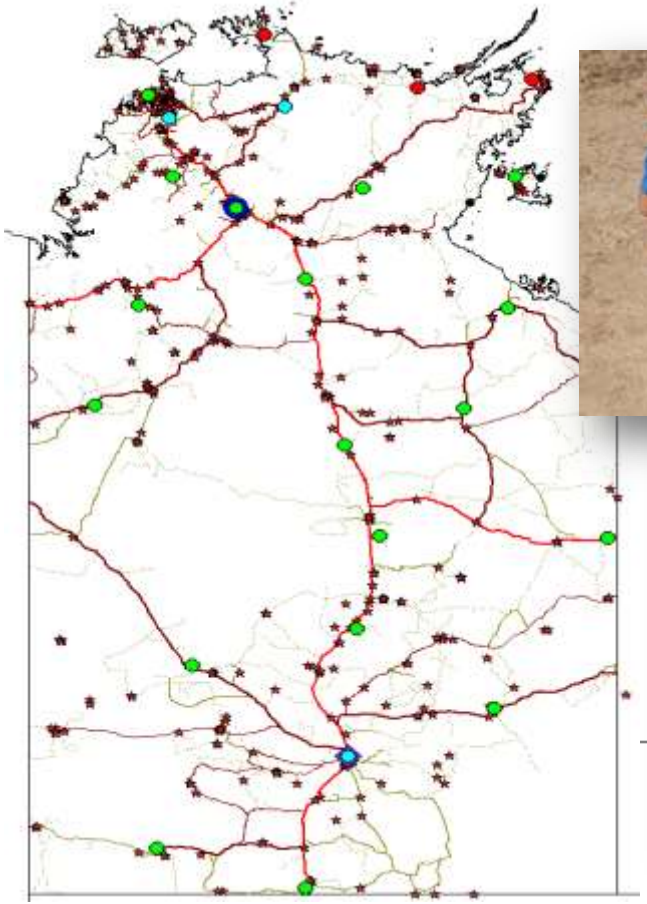
NGCA – National Geodetic Campaign Archive



- Ongoing contribution to the archives
- Currently 800 static GNSS observations of duration > 6hrs (from 2000 – 2017)
- 650 + unique stations
- To be continuously supplemented with additional observations
- 100% of the TGN marks (110) observed for GDA94 realisation have been re-observed during two concentrated campaigns
- Client supplied data verified and included

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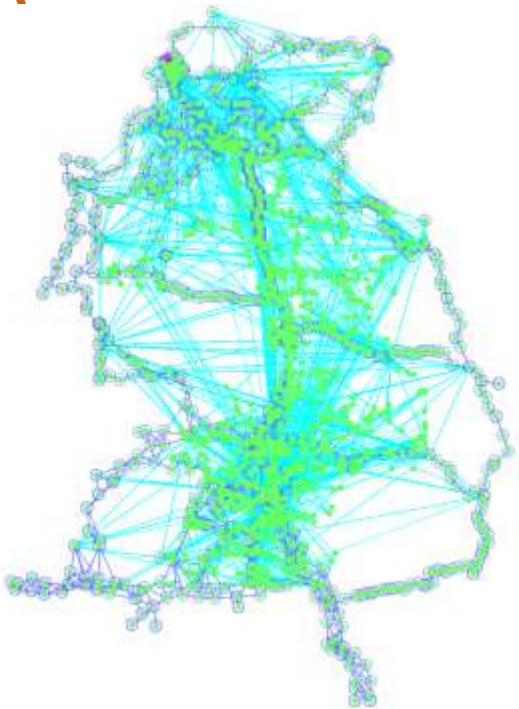
Jurisdictional Data Archive - JDA

- Creating a Jurisdictional Data Archive
  - Processing of >150 outstanding external consultant networks
  - Reprocessing existing observations and networks
  - Translation of existing datasets
  - Piecing together larger datasets (ZED and DNA)

- GNSS
  - GNSS in-fill to link disparate/isolated networks
  - GNSS coordination of “Lodged” ground marks
  - Collaborative Coordination program, supporting Industry in coordination activities
  - 6 hour GNSS observation on high quality AHD marks to fill in gaps in the NGCA network and supplement AusGeoid



Jurisdictional Adjustments - JADJ

- JADJ includes the following data:
  - APREF solution
  - Jurisdictional data archive (JDA)
  - NGCA baselines
  - Seismic Zone Survey

National Adjustment (NADJ)

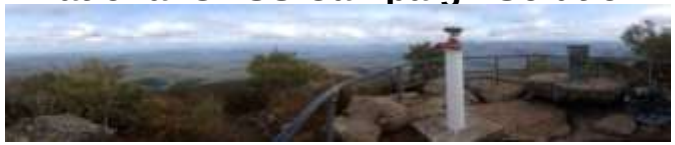
- NADJ consists of
  - Adjusted coordinates from the previous adjustment
  - APREF solution
  - Results of JADJ
- combined mega adjustment comprises of 1.97 million observations and 250889 points
- first continental scale geodetic adjustment of this size
- GDA2020 version 1.0 finalised by April 2017
- 150 hours, 4 iterations to converge

National GNSS CORS Solution

APREF

National GNSS Campaign Solution

AUSPOS 6hr+ GNSS Sessions



Jurisdictional Adjustments

National Adjustment of Australian Terrestrial Reference Frame (ATRF)

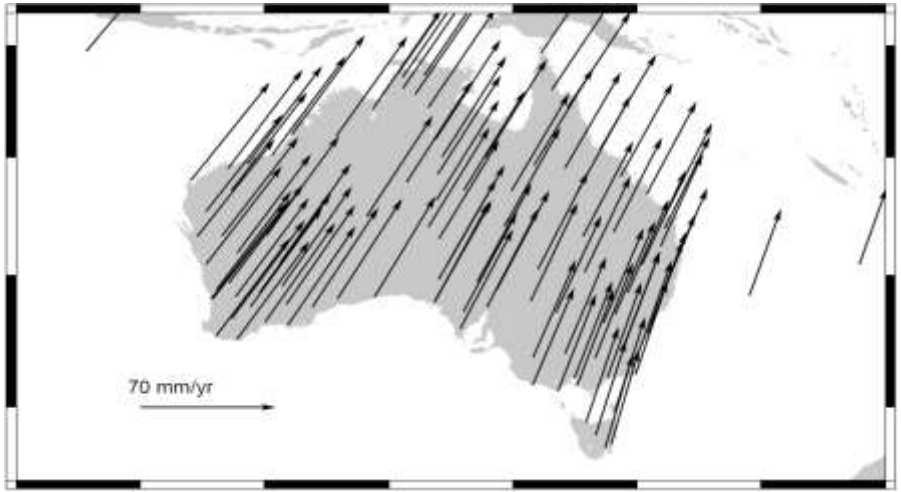
Fully rigorous geometric adjustment

→ aspire for an all station and observations adjustment (down to the street corner)

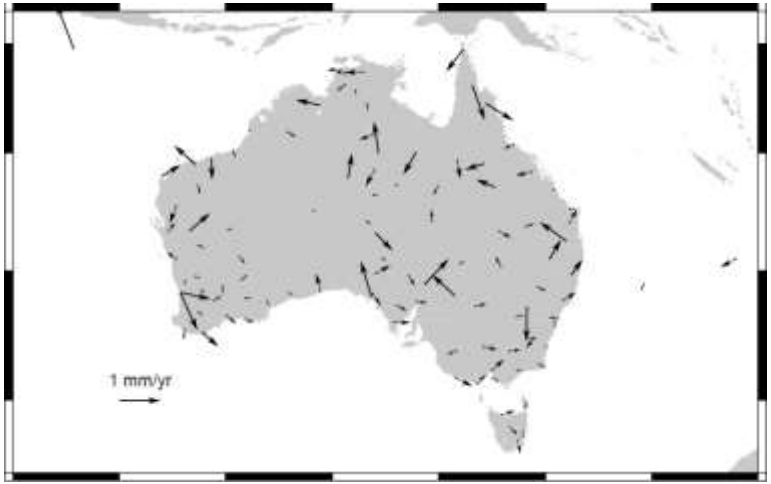
→ phased adjustment strategy

→ work flows managed automatically (using e-Geodesy technology)

Develop time based correction, plate tectonic and deformation models.



Crustal Motion



Residual Crustal Deformation

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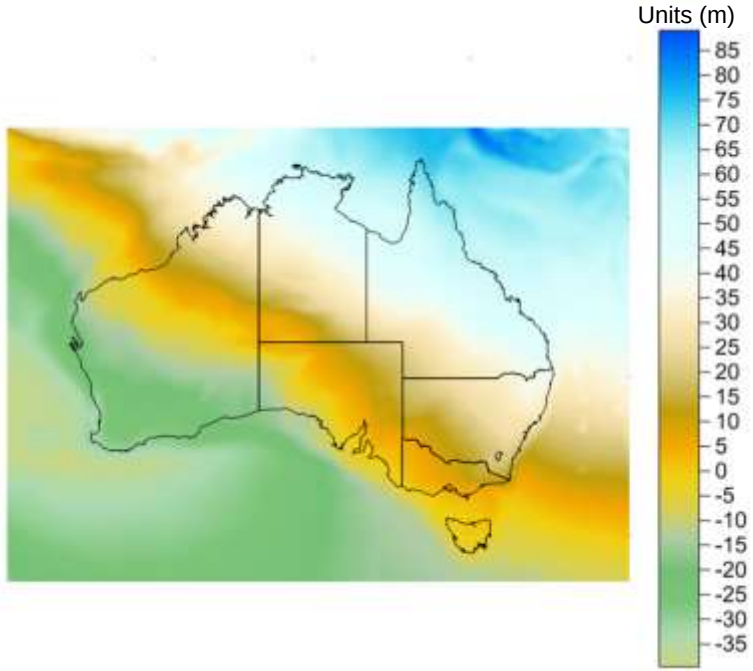
AusGeoid2020

- BETAV0.6 is available
- 4854 collocated GNSS+AHD data provided
- ~20% provided with uncertainty
- Computes uncertainty for geometric component
  - Propagation of uncertainty of ellipsoidal height and AHD height
- Gravimetric model is still AGQG2009
  - Uncertainty of 0.036 m everywhere



Brown (2016, Suva) - GeoScience Australia

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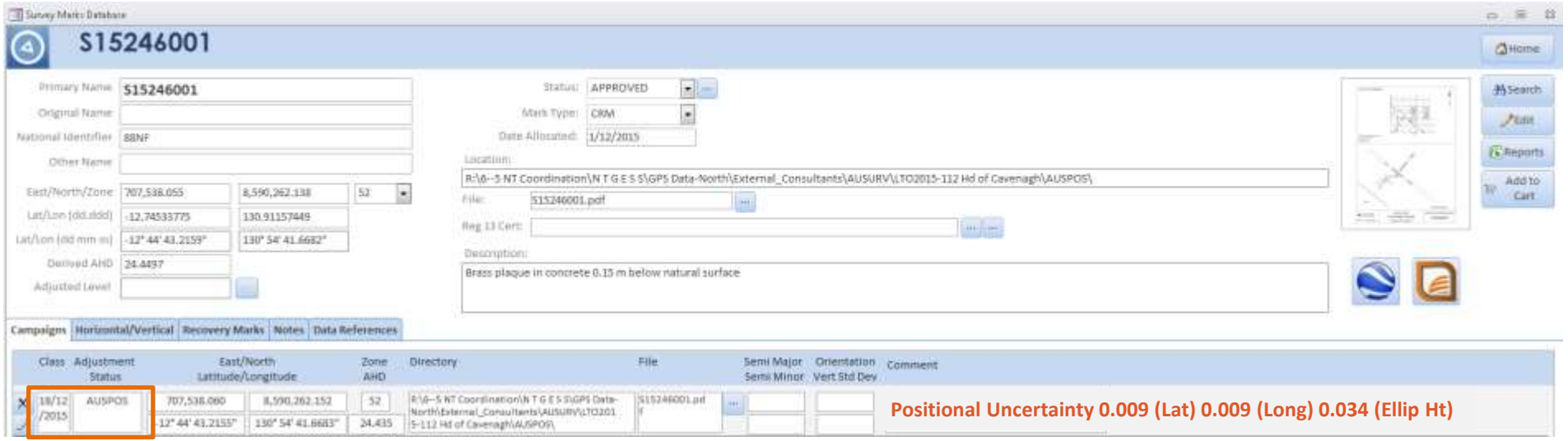
Data Products and Accessibility

Product	Sample Rate	Length	Format	Network	Latency
Daily	30 secs	24 hour	RINEX	ARGN, SPRGN, AuScope	2 hours after UTC day
Hourly	30 secs	1 hour	RINEX	ARGN, SPRGN, AuScope	5 mins after UTC hour
High-rate	1 sec	15 min	RINEX	ARGN, SPRGN, AuScope	2 mins after UTC quarter hour
Real-time	1 sec	stream	RTCM (NTRIP)	ARGN, SPRGN	2 secs after observation

Public Data Archive ftp://ftp.ga.gov.au/geodesy-outgoing/gnss/data

Local Geodetic Data Management



How do we *manage* data?

- Databases for storing/archiving observations, resultant coordinates; metadata and attribute information, including epoch and positional uncertainty
- Transfer of data within and outside of our Organisation

GDA 2020 Technical Specifications

Datum:	Geocentric Datum of Australia 2020 (GDA2020)
Geographical coordinate set: (latitude, longitude)	Geocentric Datum of Australia 2020 (GDA2020)
Grid coordinates: (eastings, northings, zone)	(Universal Transverse Mercator, using the GRS80 ellipsoid) Map Grid of Australia 2020 (MGA2020)
Reference Frame:	ITRF2014 (International Terrestrial Reference Frame 2014)
Ellipsoid:	GRS80
Semi-major axis (a):	6,378,137 metres
Inverse flattening (1/f):	298.257222101
Epoch:	2020.0

http://www.ga.gov.au/scientific-topics/positioning-navigation/datum-modernisation

Estimated Uncertainty of <10 mm – Horizontal, <15mm - Vertical

Summary of OUR activities

- Establishment of infrastructure to **support the maintenance of the ITRF**
- Contribution of data to a **regional reference frame realisation - APREF**
- Completion of **National Geodetic Adjustment**
- Realisation of **Uncertainty with respect to Datum**

Ongoing…

Achieved through

- **National collaboration, national approach** - technical/financial/administrative commitment
- Efforts over a **10-year + period**
- Consistent approach, supported by **standards and guidelines**

Actions and Challenges in the future?

- **Implementation of the new datum, GDA2020** – adoption, tools / utilities, propagation of datum and PU into datasets, “access” to datum
- Continuous Geospatial infrastructure and system **maintenance, refinement and upgrade**
- **Maintaining relevancy** within our Organisation – to obtain the political will, inclusion in strategic planning, allocation of resources – personal / finances – **“the value proposition”**
- Ongoing **capacity development** of our team
- **Supporting National initiatives** - *National Positioning Infrastructure (NPI), AuScope 2*

Kiitos !

Think Globally act Locally ! *Greg Scott UN GGIM AP (Sydney, 2017)*

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Department of Infrastructure, Planning and Logistics