How (and why) to develop a modern Geospatial Reference System

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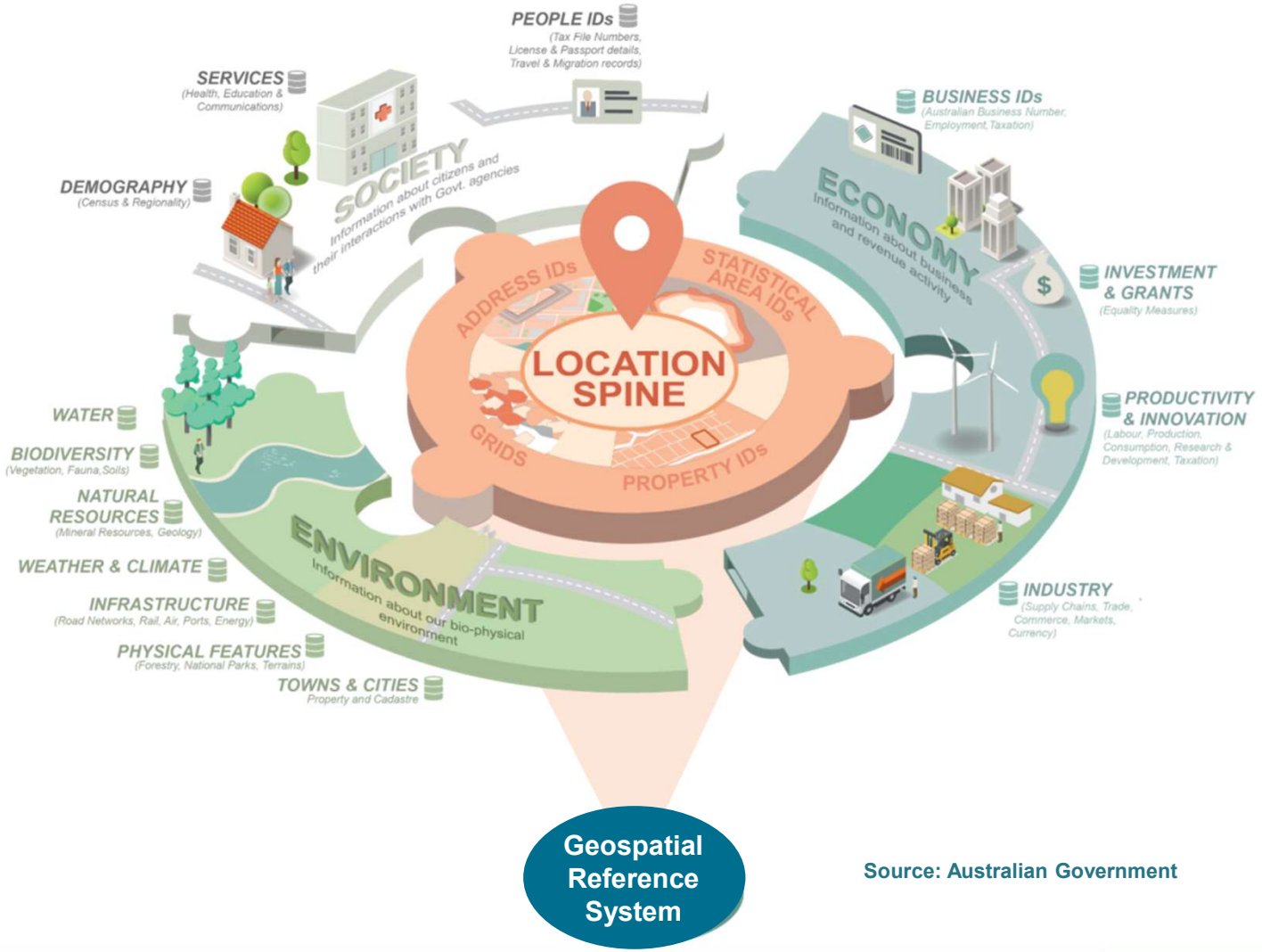
EVERYTHING HAPPENS SOMEWHERE

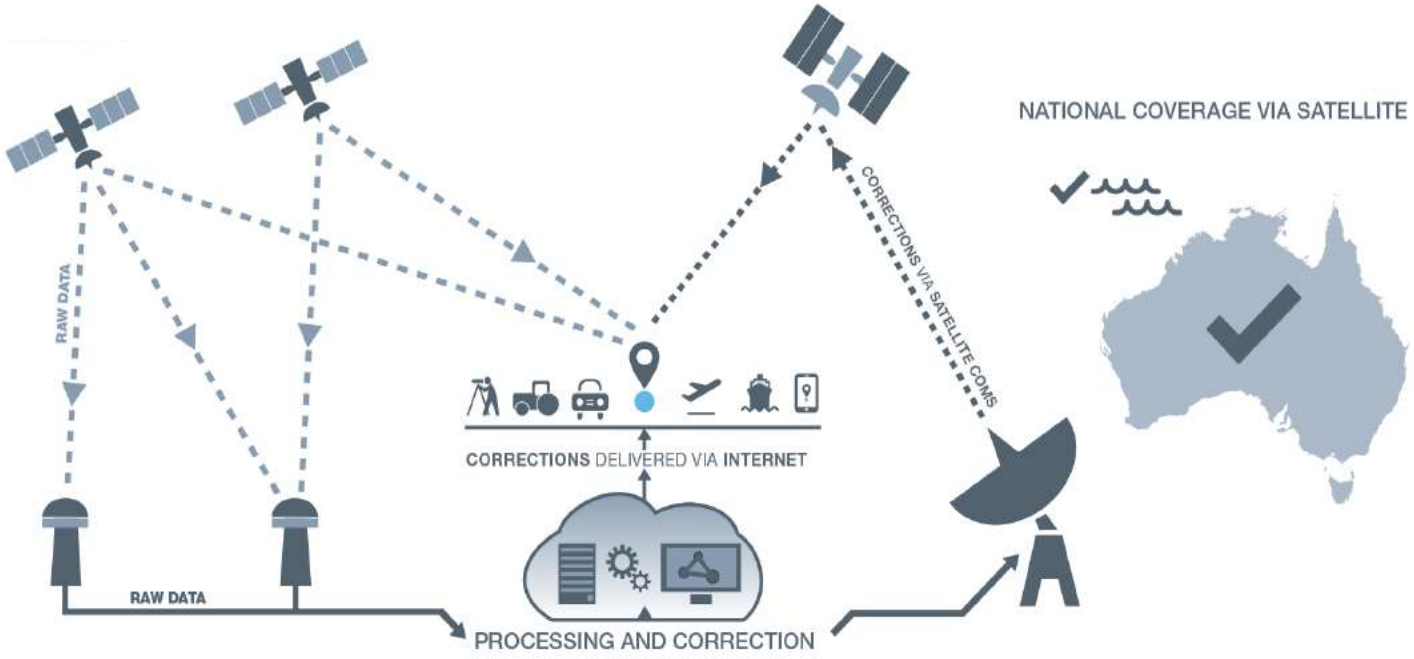


Source: Australian Government

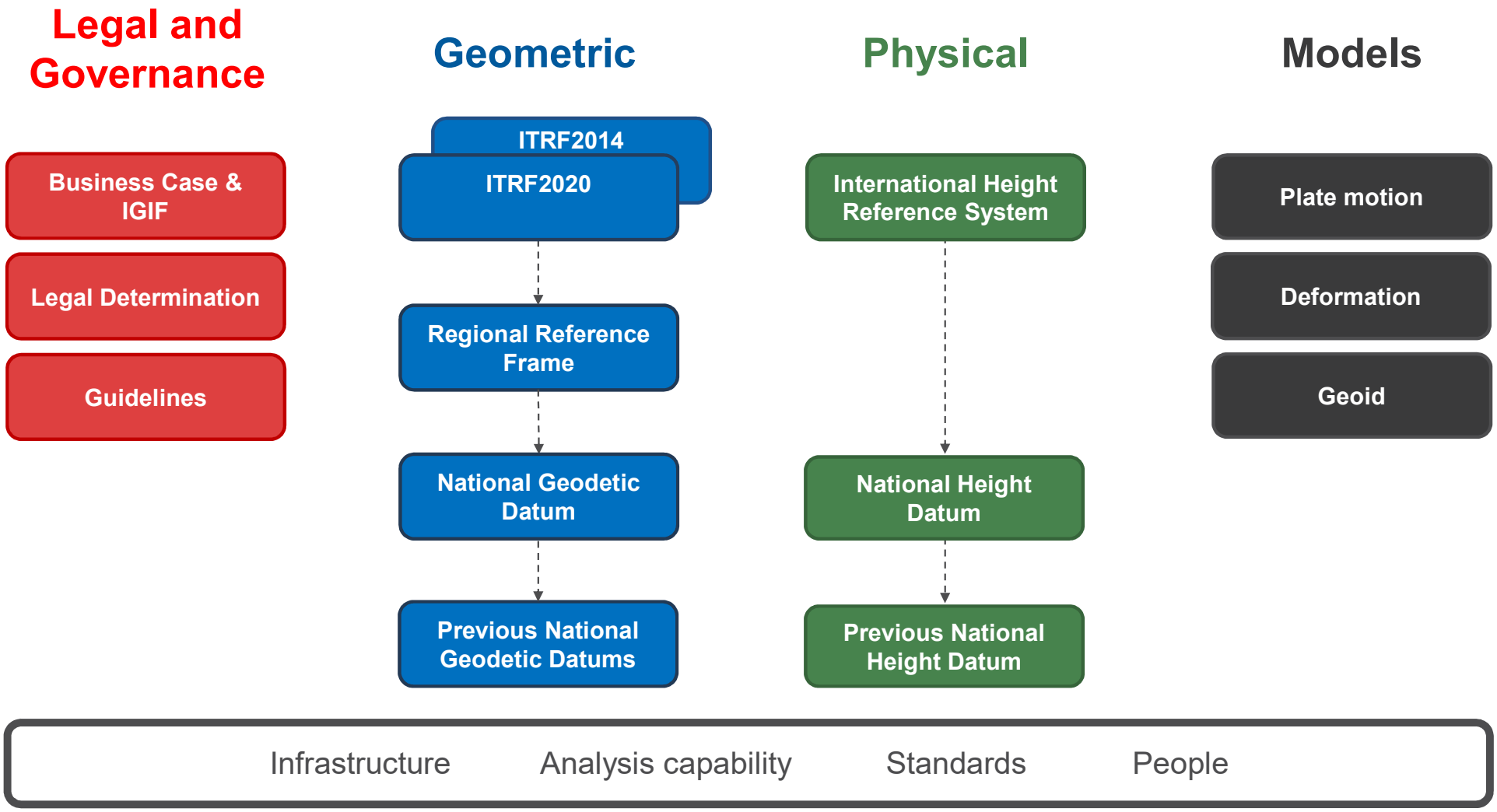

Stubble
40% non green vegetation
Stubble
70% non green vegetation
NON-PHOTOSYNTHETIC VEGETATION

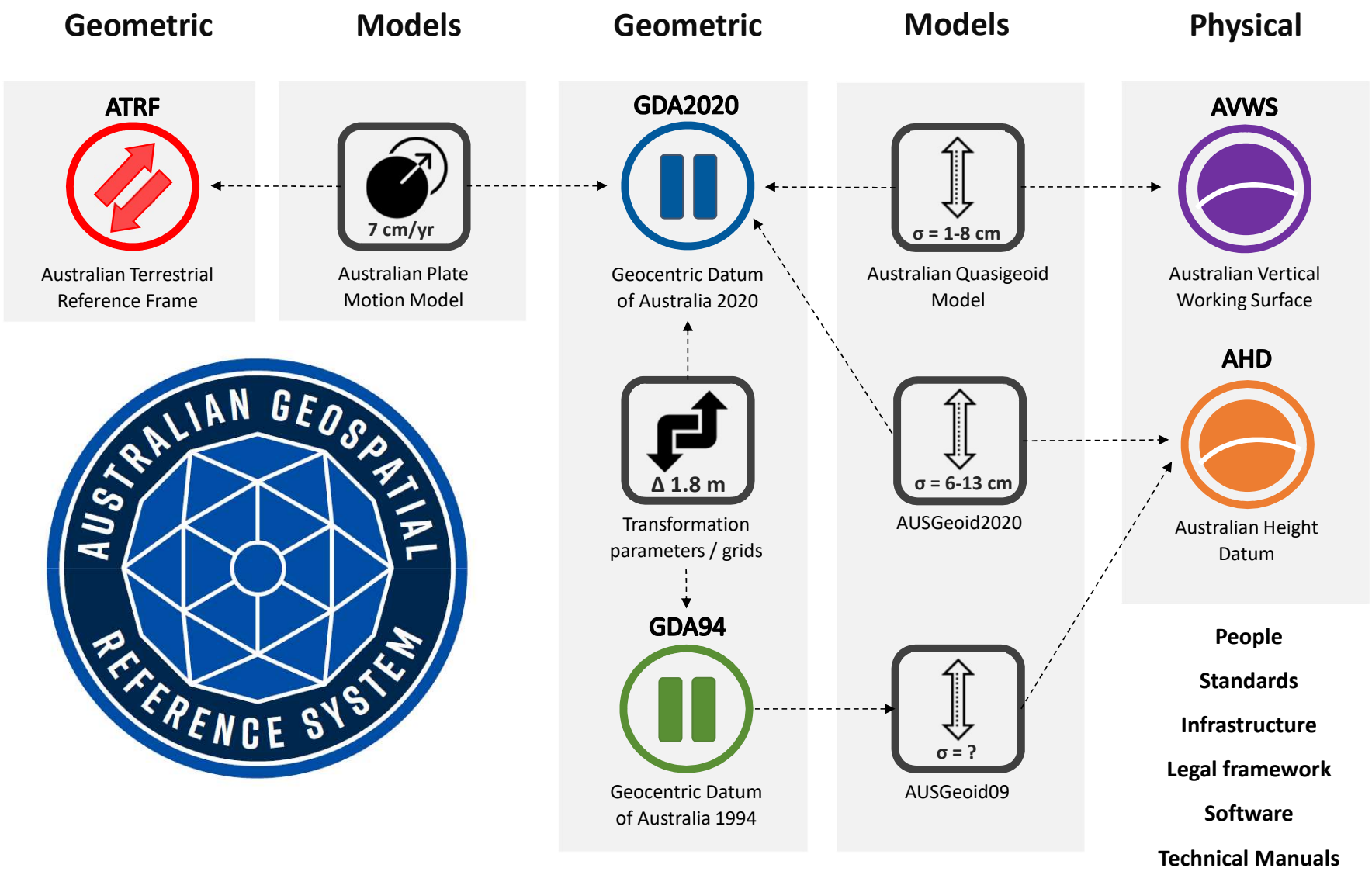
Australian Government
Geoscience Australia

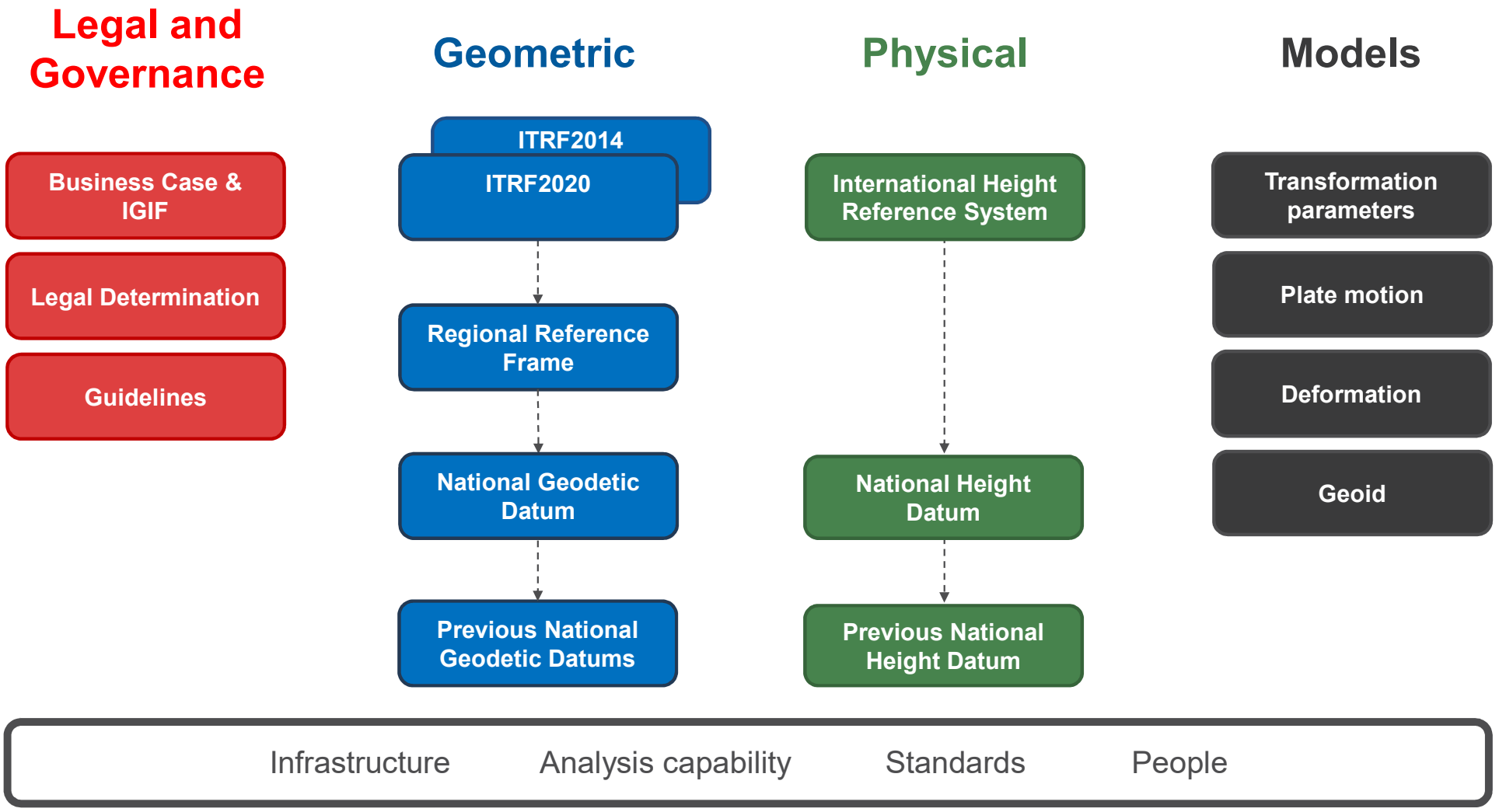
POSITIONING AUSTRALIA



Accuracy
3-10 cm




Geometric
Models
Geometric
Models
Physical
ATRF
Australian Terrestrial Reference Frame
7 cm/yr
Australian Plate Motion Model
GDA2020
Geocentric Datum of Australia 2020
σ = 1-8 cm
Australian Quasigeoid Model
AVWS
Australian Vertical Working Surface
Δ 1.8 m
Transformation parameters / grids
σ = 6-13 cm
AUSGeoid2020
AHD
Australian Height Datum
GDA94
Geocentric Datum of Australia 1994
σ = ?
AUSGeoid09
AUSTRALIAN GEOSPATIAL REFERENCE SYSTEM
People
Standards
Infrastructure
Legal framework
Software
Technical Manuals



Legal and Governance

Legal and Governance

Business Case & IGIF

Legal Determination

Technical Manuals and Implementation Guidelines

Business Case

Explain the 'why'

The importance of Geospatial Reference Systems was recognised by the United Nations in 2015 adoption of a General Assembly Resolution promoting the importance of an *accurate, sustainable and accessible Global Reference Frame to support science and society*.

A Geospatial Reference System underpins the collection, management and alignment of spatial information to make better decisions.

- survey, mapping and navigation;
- civil engineering, industrial automation, agriculture, construction, mining;
- recreation; location based services;
- intelligent transport systems, land use planning and administration;
- hazard assessment, disaster response and emergency management;
- environmental studies and scientific research.

The Geospatial Reference System is the glue that allows us to align these spatial data

Legal and Governance

Legal and Governance

- Business Case & IGIF
- Legal Determination
- Technical Manuals and Implementation Guidelines

Legislation

Is there a need to legally define components of the GRS?

Definition of national datum in national law

- Positioning and navigation

Survey Act

- Underpins cadastre and land management

Legal and Governance

Legal and Governance

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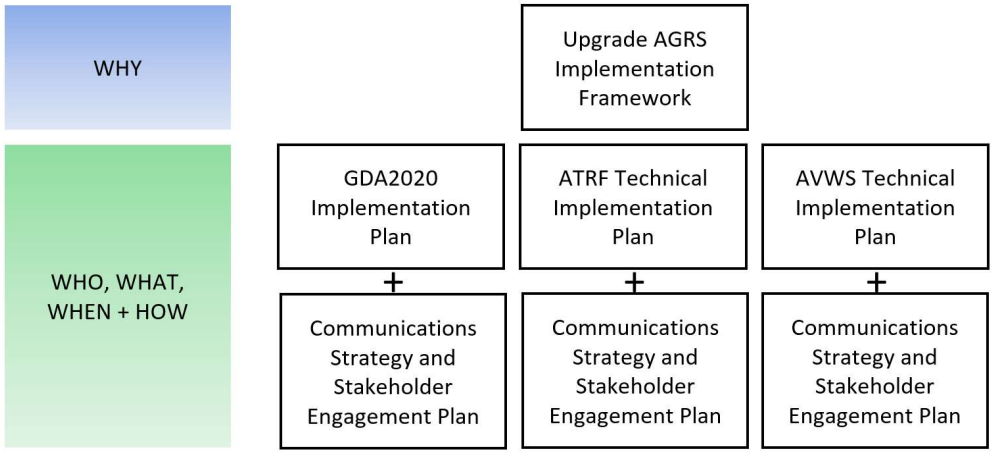
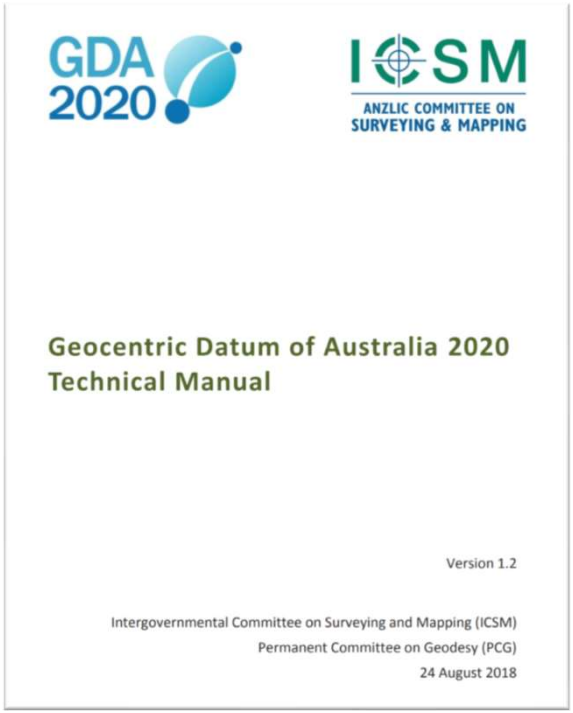
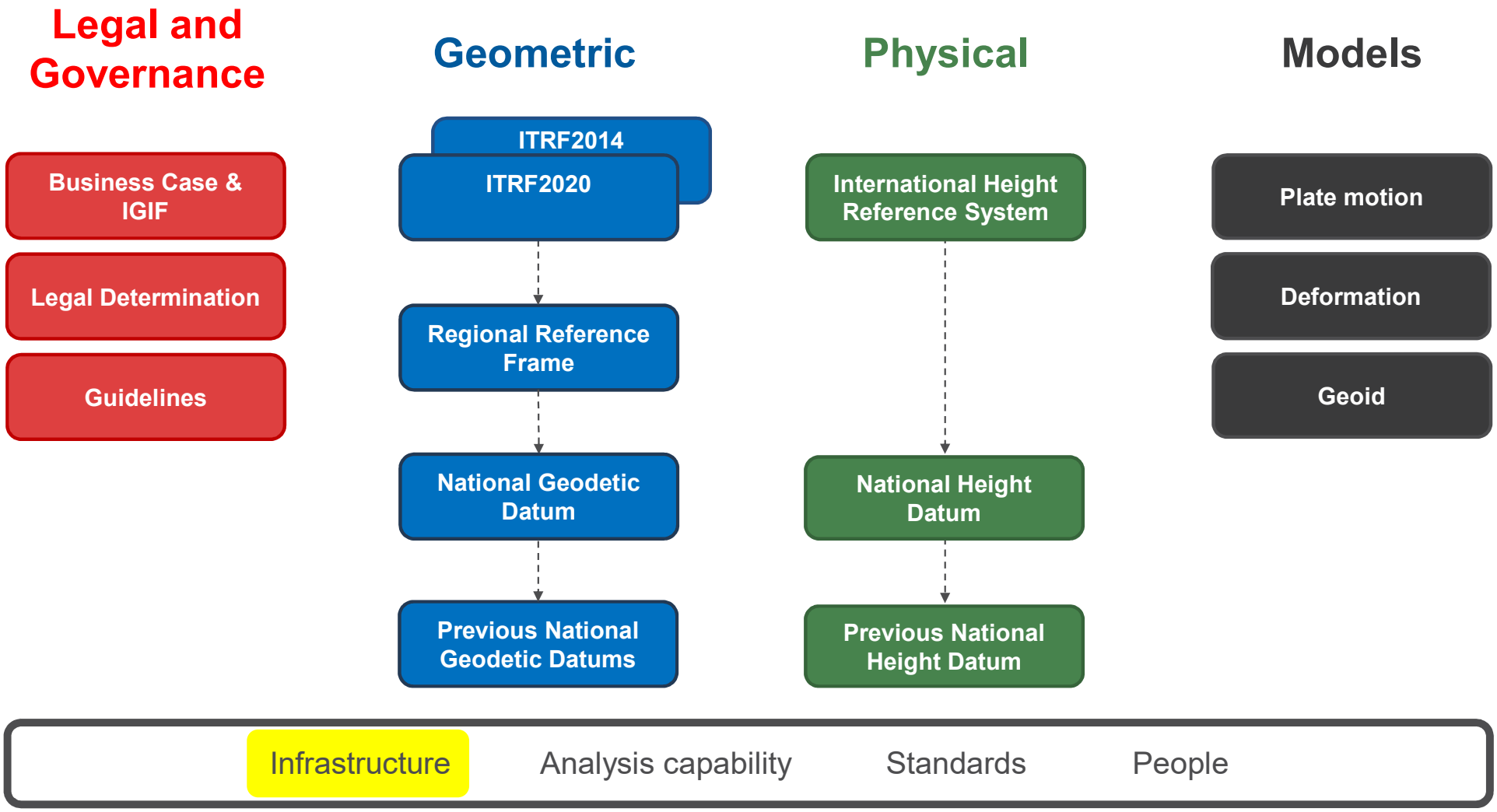
- Technical Manuals and Implementation Guidelines

Technical Manual and Guidelines

Describes how to operate within the GRS



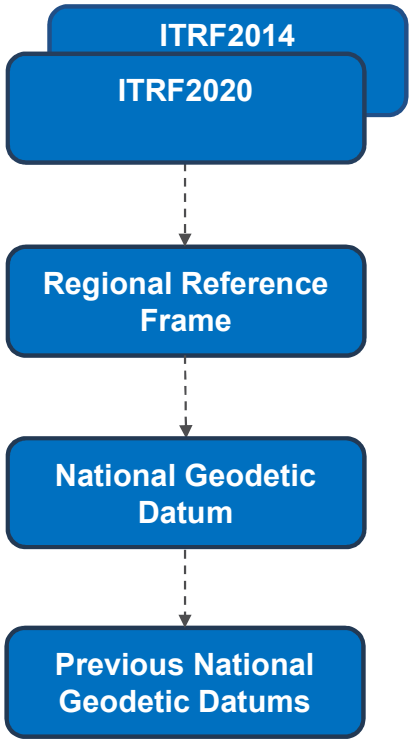




Infrastructure - Geometric

- **Definition and Access**
- High quality GNSS Continuously Operating Reference Stations (about 50-70 km spacing)
  - Provides alignment to International Terrestrial Reference Frame (via CORS)
  - GNSS campaigns on high stability survey marks
  - Digital versions of GNSS baselines and terrestrial observations
  - Assess critical gaps in ground infrastructure and fill it in

Geometric



1. Start global

- Global reference frame - Select an ITRF realisation and epoch
- e.g. GDA2020 is ITRF2014@2020
- Link to the global reference frame
- 20 GNSS stations in Australia

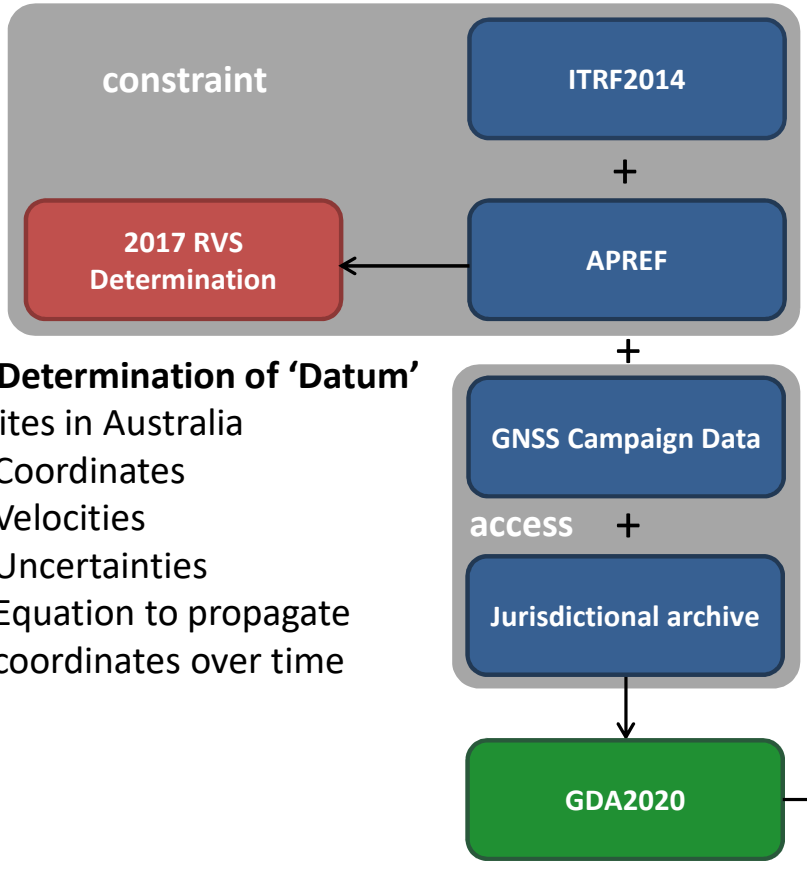
2. Increase density

- Asia-Pacific Reference Frame (Regional reference frame)
- 454 GNSS stations

3. Provide access

- Rigorous national adjustment
- Include all GNSS and terrestrial observations were
- Tools and products to transform to / from new national datum

Australian example



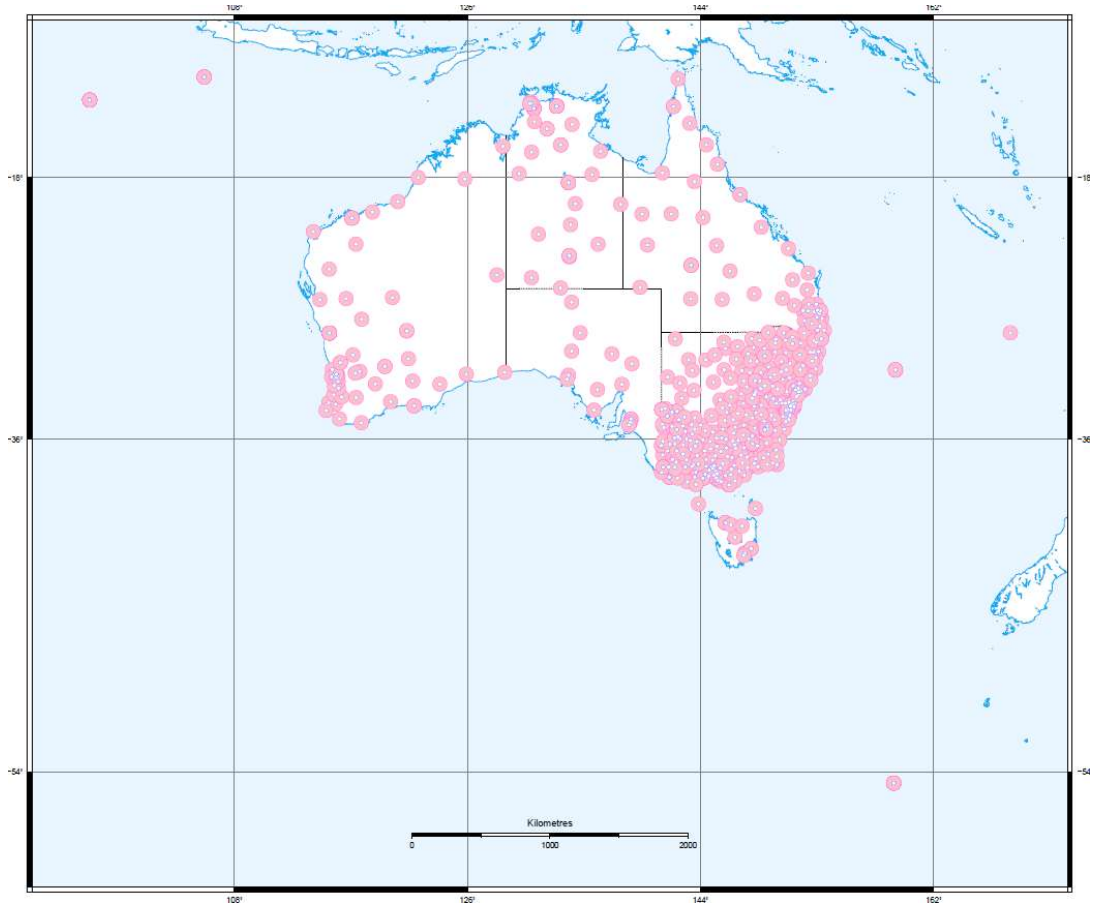
1. Start global
- Link to the global reference frame
- 20 GNSS stations in Australia

2. Increase density
- Asia-Pacific Reference Frame (Regional reference frame)
- 454 GNSS stations

3. Legal Determination of 'Datum'
- 109 sites in Australia
  - Coordinates
  - Velocities
  - Uncertainties
  - Equation to propagate coordinates over time

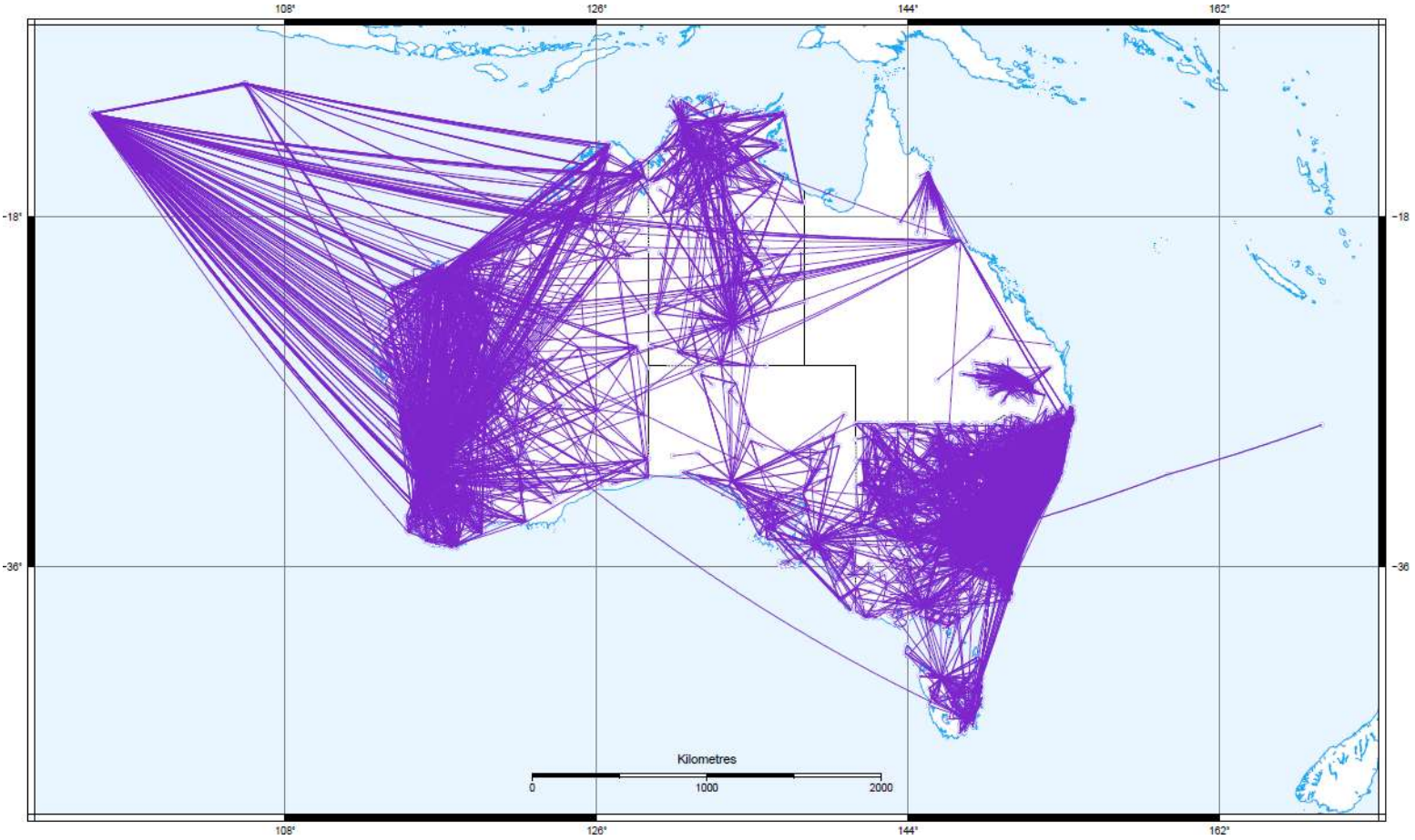
4. Provide access
- Rigorous national adjustment (all GNSS and terrestrial observations were used in the same adjustment)
  - ~2 million observations
  - ~250,000 stations

APREF



- 454 Continuously Operating Reference Stations (1996-2016)
- Weekly solution time series combination

GNSS baselines



- 6+ hour GNSS observations
- 6,092 stations with 11,578 baselines
- Input as measurements; doesn't define datum

Models

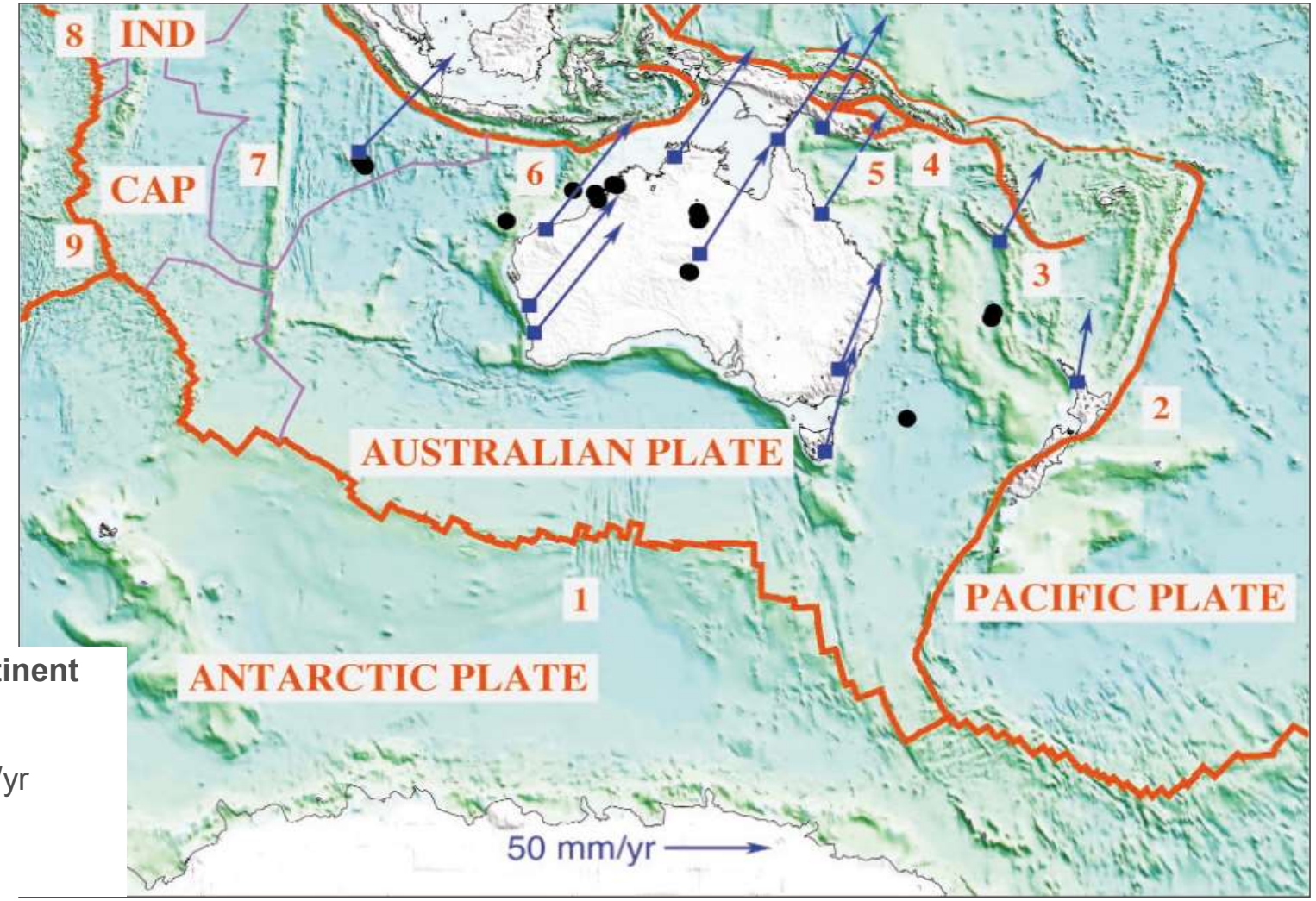
Transformation parameters

Plate motion

Deformation

Geoid

- Transformation parameters from old to new datums
  - Solve for rotation, translation and scale parameters (7 parameters) using coordinates common to both old and new datums
  - Transformation grids (for use in software)
- Plate motion model (maybe)
- Deformation model (maybe)



Fastest moving continent

Karratha: 70 mm/yr

Alice Springs: 67 mm/yr

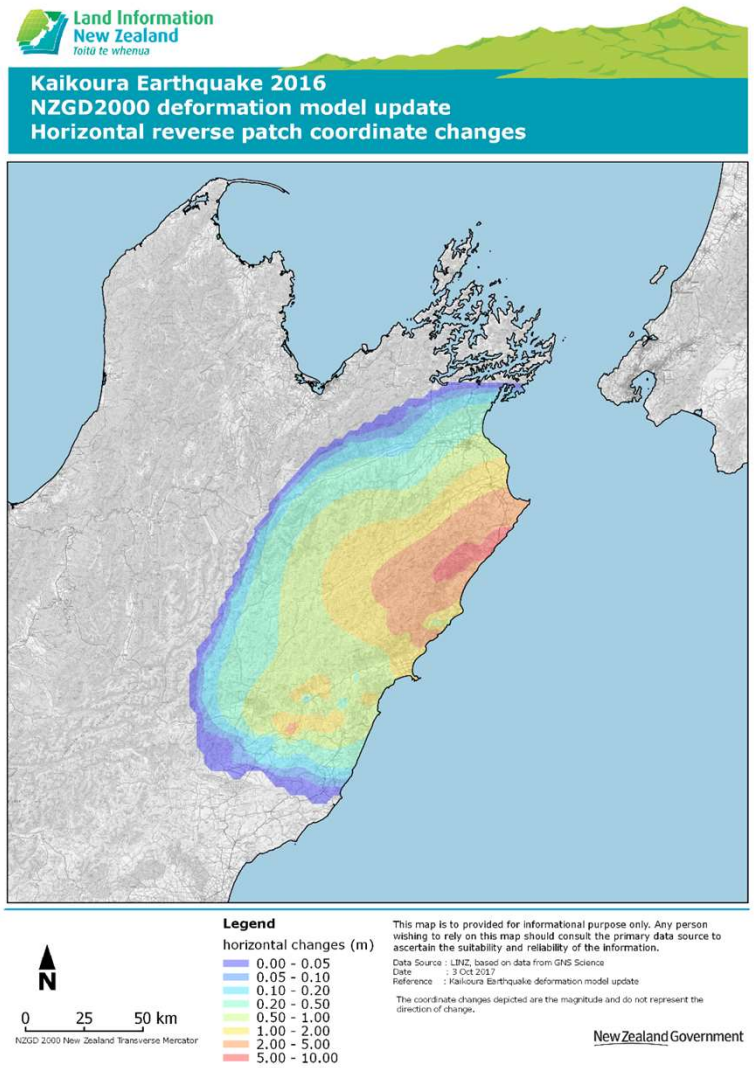
Canberra: 58 mm/yr

Plate Motion Model

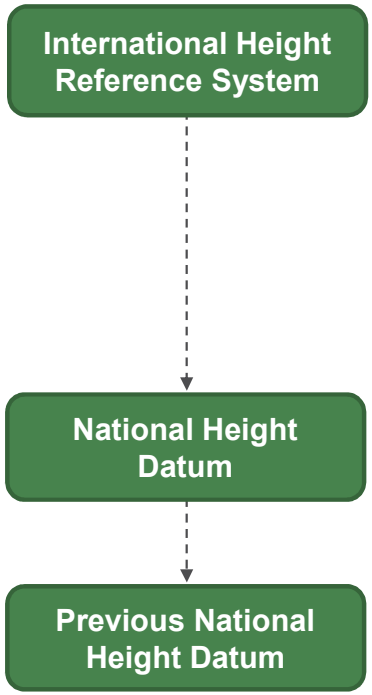
- Computed from 109 reference sites which define GDA2020
- Only **rotation velocities** of the 14-parameter transformation
- Internal deformation of the Australian plate is less than 1 mm / yr with the exception of isolated areas of intraplate earthquakes and subsidence (Tregoning et al., 2013).
- A rigid plate motion model is appropriate to describe the dynamics experienced by the Australian tectonic plate and is sufficient to maintain compatibility with ITRS realisations in which GNSS operate.

Deformation Model

Required in regions where coordinates of features change are complex and spatially variable (e.g. earthquakes)



Physical



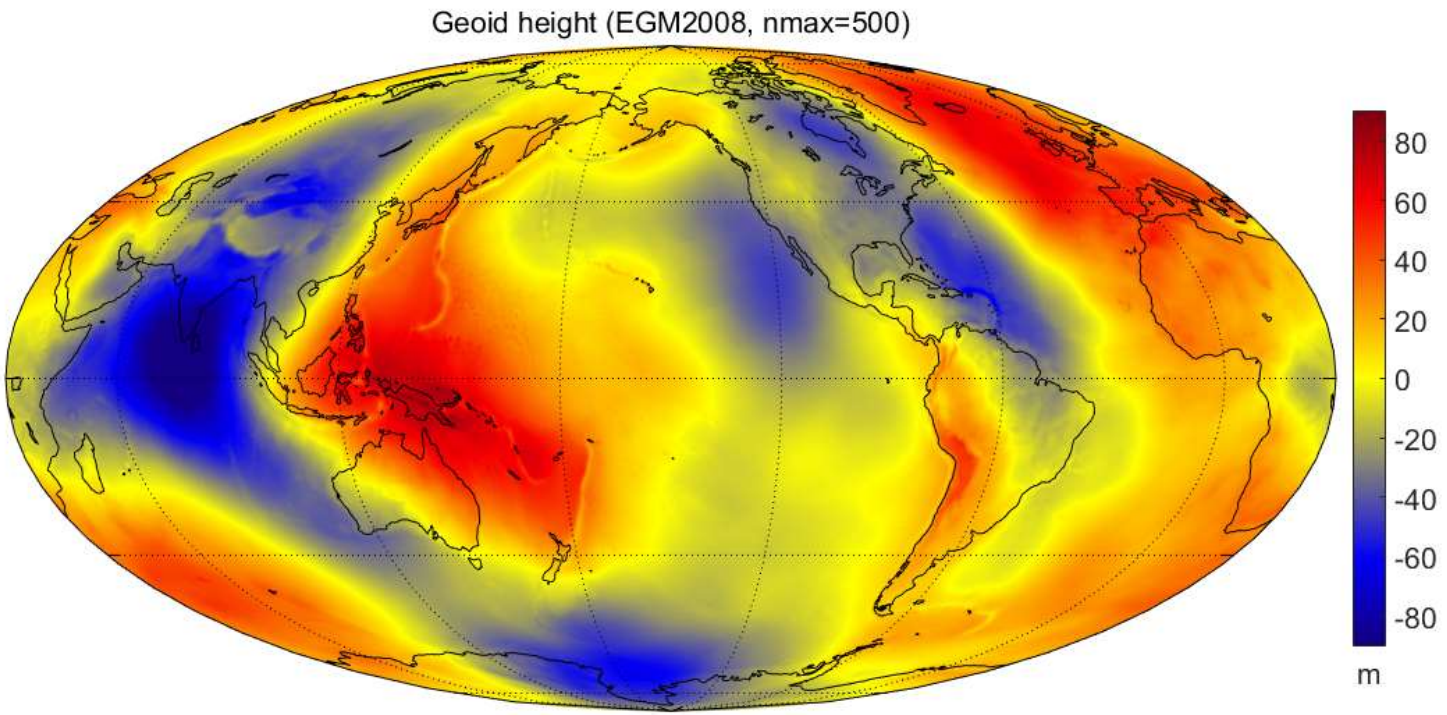
Global models of the geoid are available

- E.g. Earth Geopotential Model 2008
- E.g. Earth Geopotential Model 2020 (available soon)

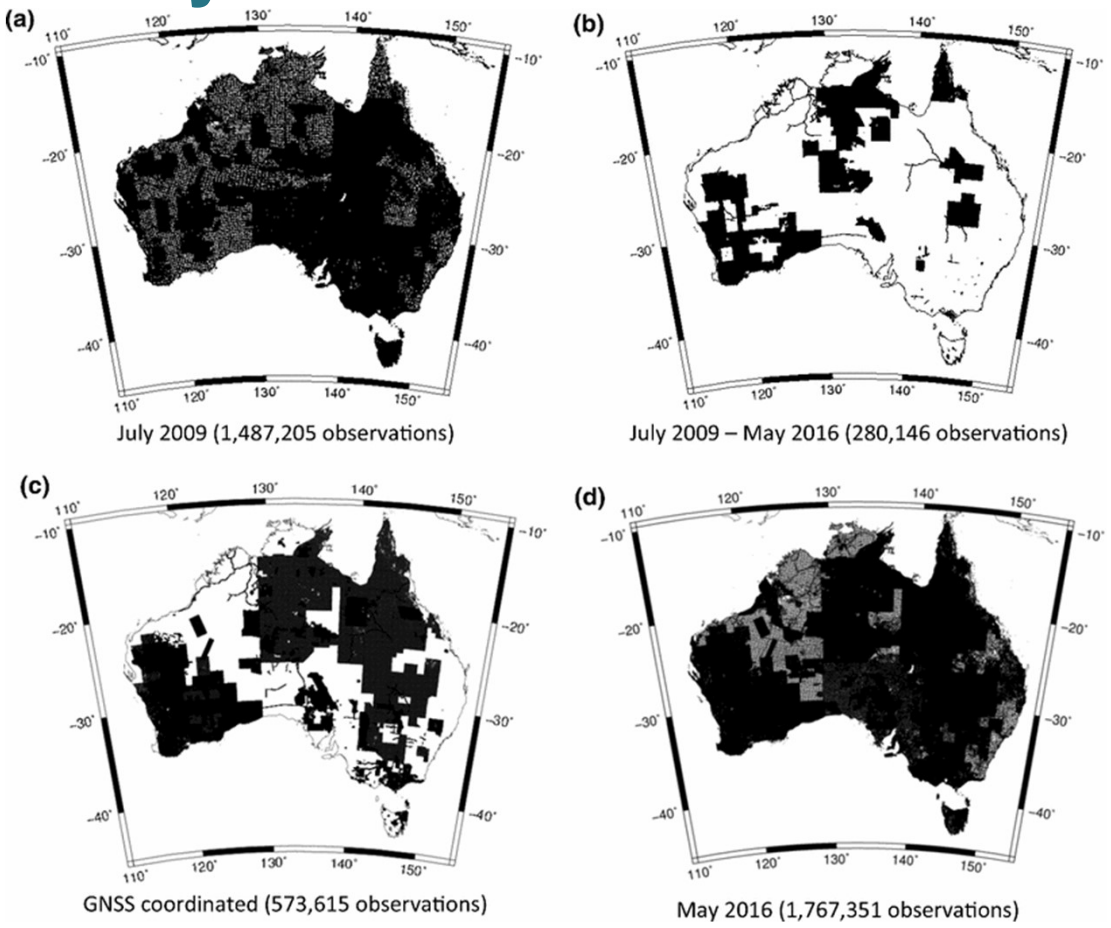
- Locally enhanced versions of the global models
  - Incorporate additional gravity observations from multiple sources: terrestrial, shipborne, airborne and altimetry
  - These improve the accuracy of the geoid models from ~10 cm to ~2-5 cm

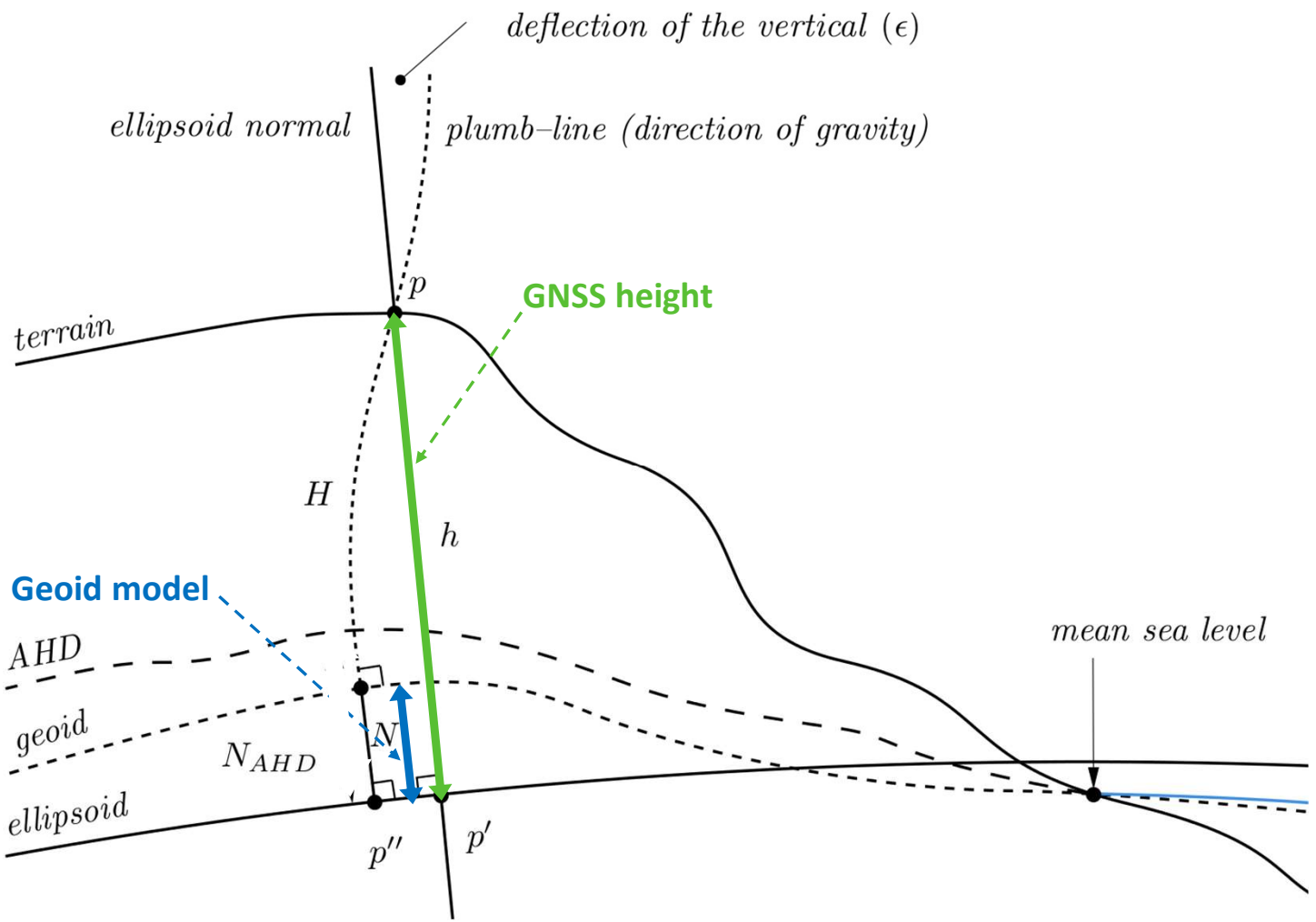
Validate using GPS+levelling data

Earth Geopotential Model 2008

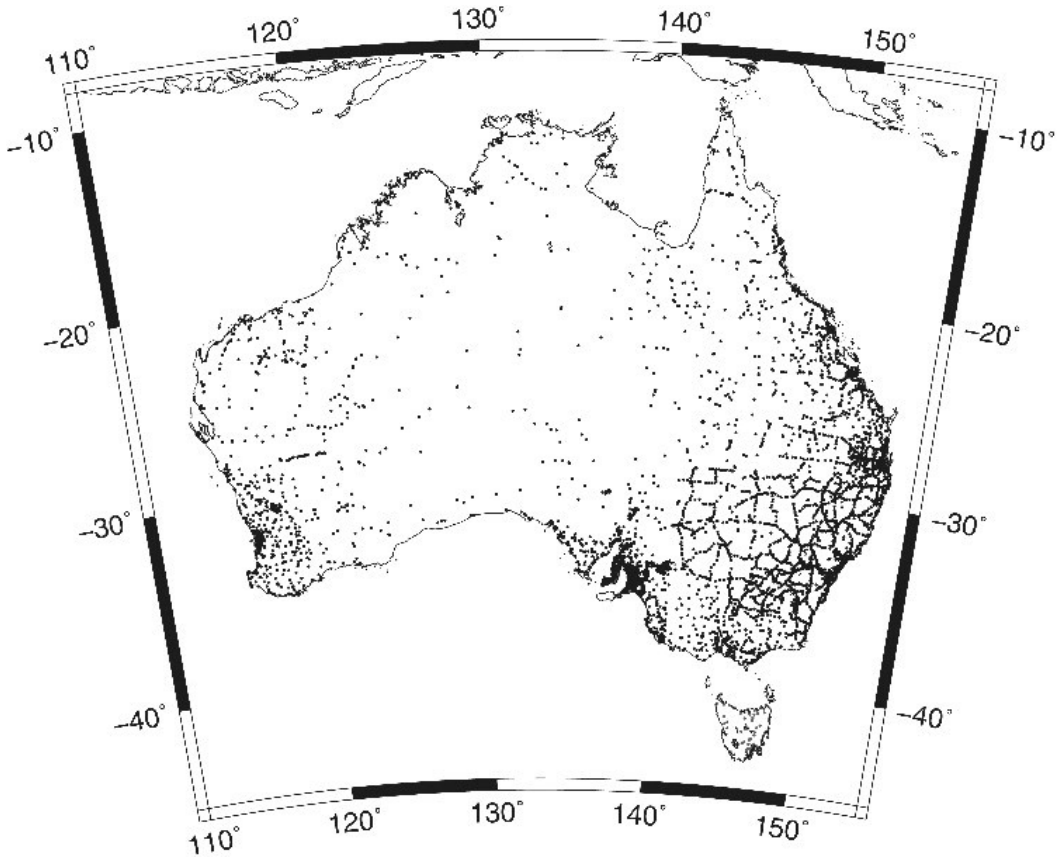


Terrestrial Gravity Data





Validation dataset



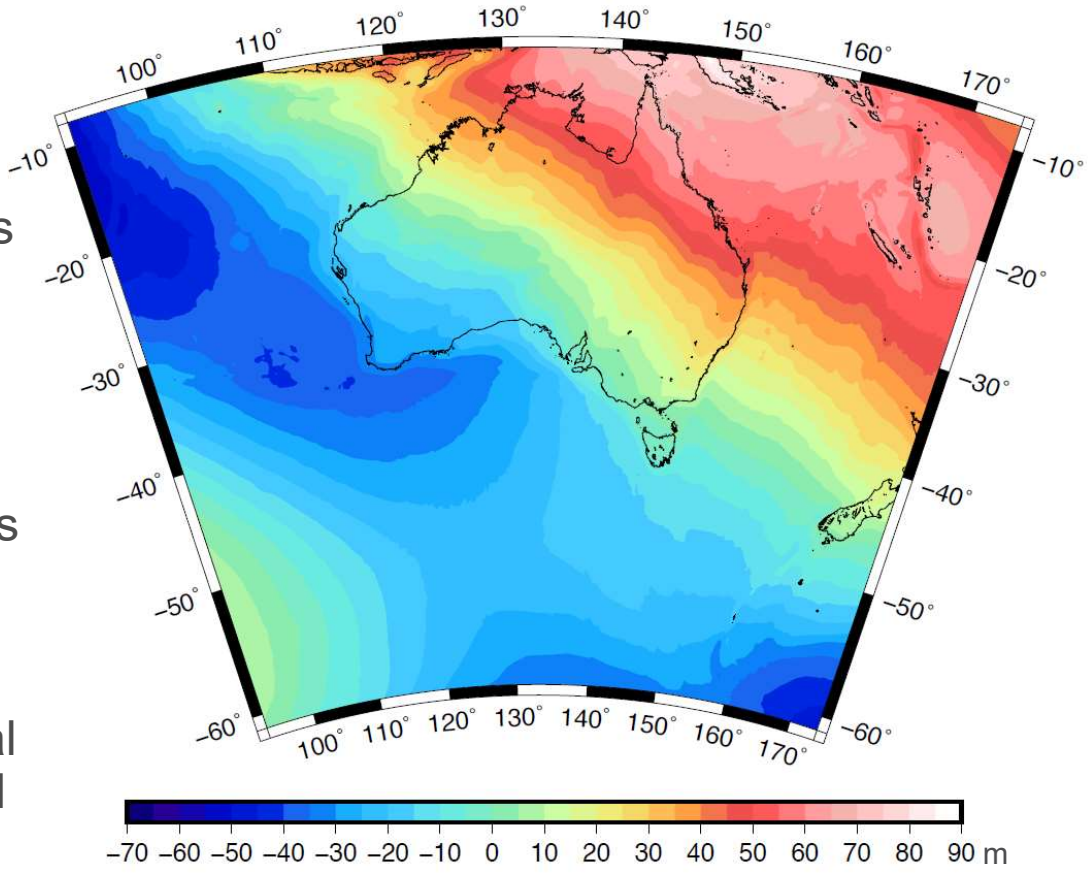
- GPS+levelling data
- Points at which ellipsoidal height and above geoid height are known
- Independent source to check the accuracy of the geoid model

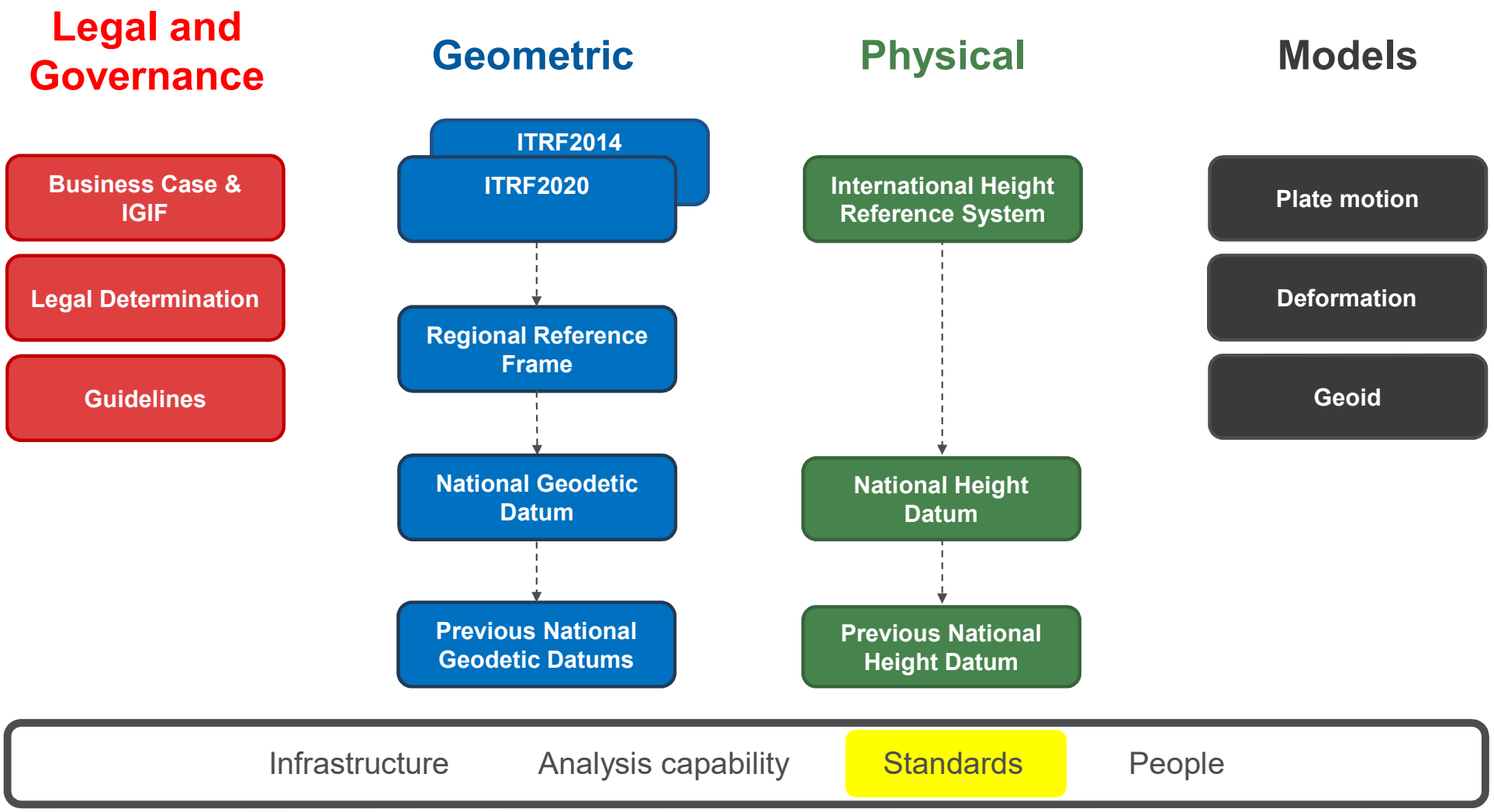
Desirable attributes for a geoid model

- Accessible anywhere
- Compatible with geometric datum
- Fit for purpose – meets user needs
- Maintainable and assessable

Consistent, authoritative heights are really important for all governments and society

The determination of national/regional height datum is complex (technical and implementation)





Standards

- Current standards for delivering geodetic data will not adequately serve the needs of new (non-geodetic) users, who will emerge on account of the rapid growth in precise positioning services.
- Broad, multi-domain, standards are important for combining geodetic data with data from other domains.
- Internationally, several groups (e.g. Inspire, DCAT, ESIP, CODATA) are working on defining standards for geospatial and geophysical metadata and enhancing interoperability.
- However, there is no international strategy to ensure geodetic data is **Findable, Accessible, Interoperable and Reusable (FAIR).**

UN GGIM SCoG (intergovernmental)	IAG GGOS	FIG Comm 5	ISO TC 211	GEO (intergovernmental)	…

Many groups active in this space

Efficiency?
Experts from Standards?
Experts in software development?

Standards (ISO/OCG/GeodesyML)

Some open geodetic standards exist

Unknown gaps

Industry / Research Community / IAG Services / Software Developers

Mostly proprietary?

Unknown gaps

End User (mobile phone holder / autonomous vehicle)

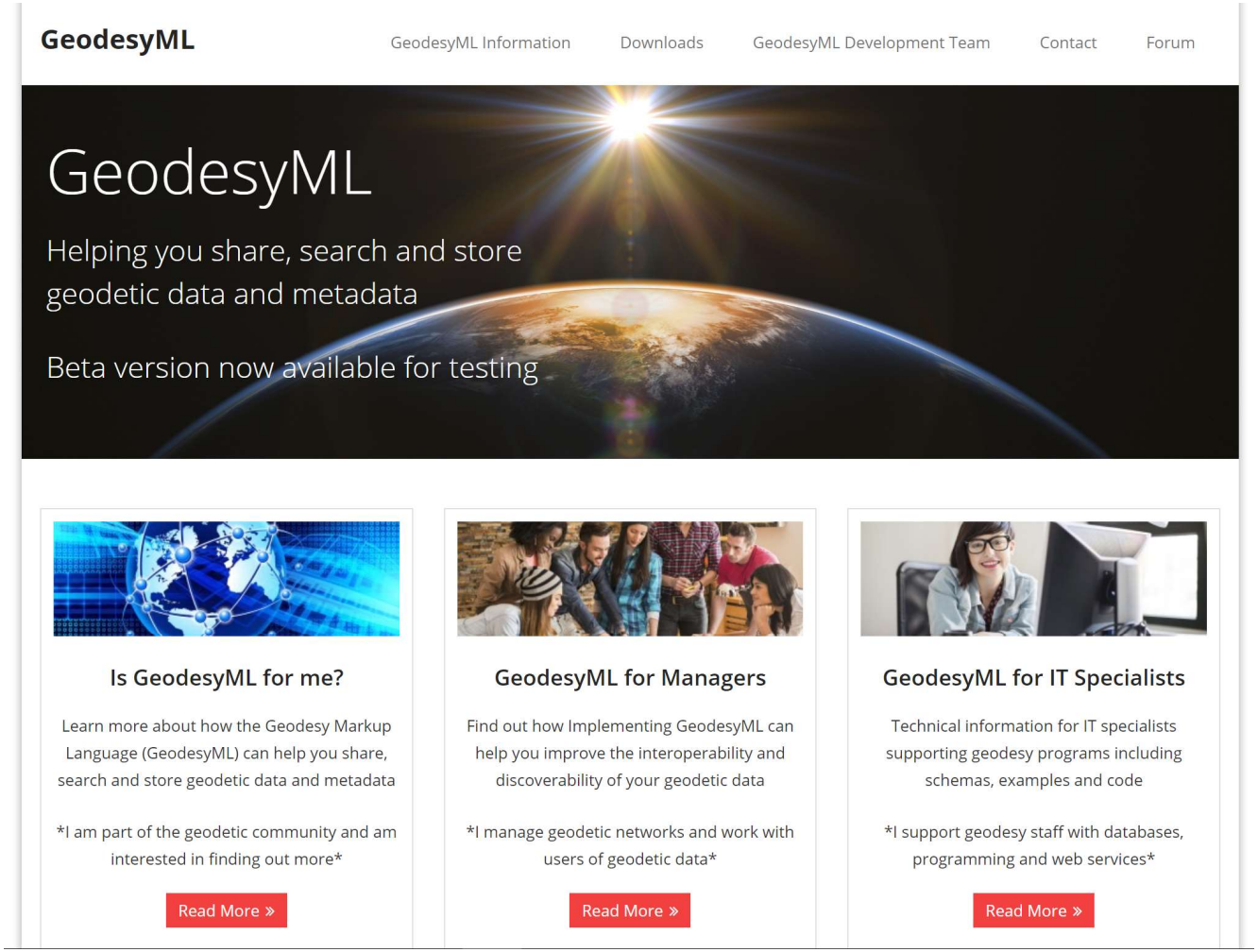
Standards

International Organisation for Standardization

ISO 19136:2007

- TimeSeriesML
- Observations and Measurements
- ISO19111 – Spatial Ref. by. Coords
- ISO19127 – Geodetic Register
- ISO19161 – ITRS

+ GeodesyML (proposed GML Application Schema)



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GNSS Site Manager

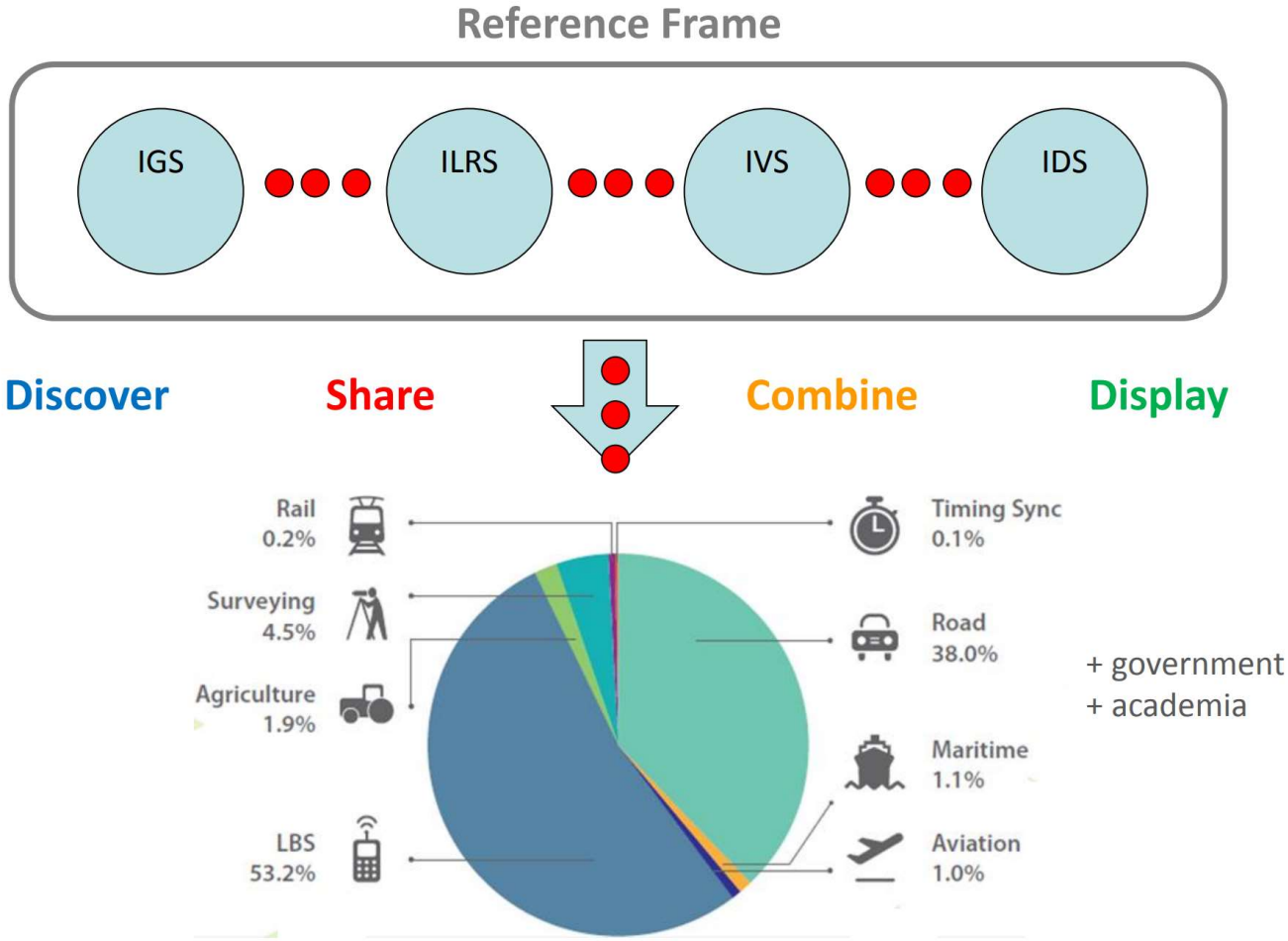
YAR2

You have not logged in and are not authorised to edit YAR2.

- Site Administration
- Site Information
- GNSS Receivers — New, Update
- GNSS Antennas — New, Update
- Surveyed Local Ties — New
- Frequency Standards — New
- Collocation Information — New
- Local Episodic Effects — New
- Humidity Sensors — New
- Pressure Sensors — New
- Temperature Sensors — New

Applications

- The standards required to deliver to this set of users is unknown
- Scoping study is underway to identify critical gaps in standards
- We need to collaborate
- Not just geodetic agencies
- ISO/OGC/Open Source
- Software developers



People

- The most important element of a Geospatial Reference System
- Capability (skills, knowledge, training)
- Capacity (time, resources, commitment from senior management)
- Training and Development opportunities (workshops, secondments)

Summary

- Geodesy is no longer an esoteric science; we are mainstream
- We provide the foundations for important economic, environmental and societal decisions as well as science (from where we began)
- Modern Geospatial Reference System (datums, reference frames, working surfaces, standards) are required to meet user needs
- UN-GGIM Integrated Geospatial Information Framework will provide an mechanism to describe current status, and assistance required.