The Future of Geodetic Datums

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Quickclose

SSSI Land Surveying Commission – National Conference, 18-21 April 2012

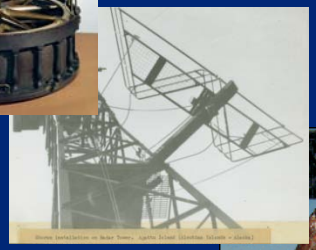
The evolution of absolute positioning precision

Ptolemy

100 km

10 km

ANG



1950
10 m

AGD66

1966
3 m

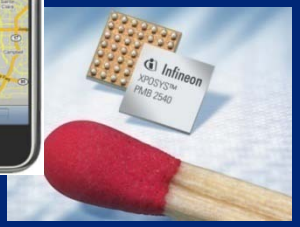
AGD84

1984
30 cm

GDA94

1994
30 mm

ITRF2008



2012 1 mm

multi-GNSS + augmentation
+ indoor positioning
+ nanotech
inertial positioning

circa 2032

real-time
precise broadcast
orbits

4D GIS CLOUD

real-time positions

active deformation model

mm accurate

real-time information currency

centralised data
+ clone

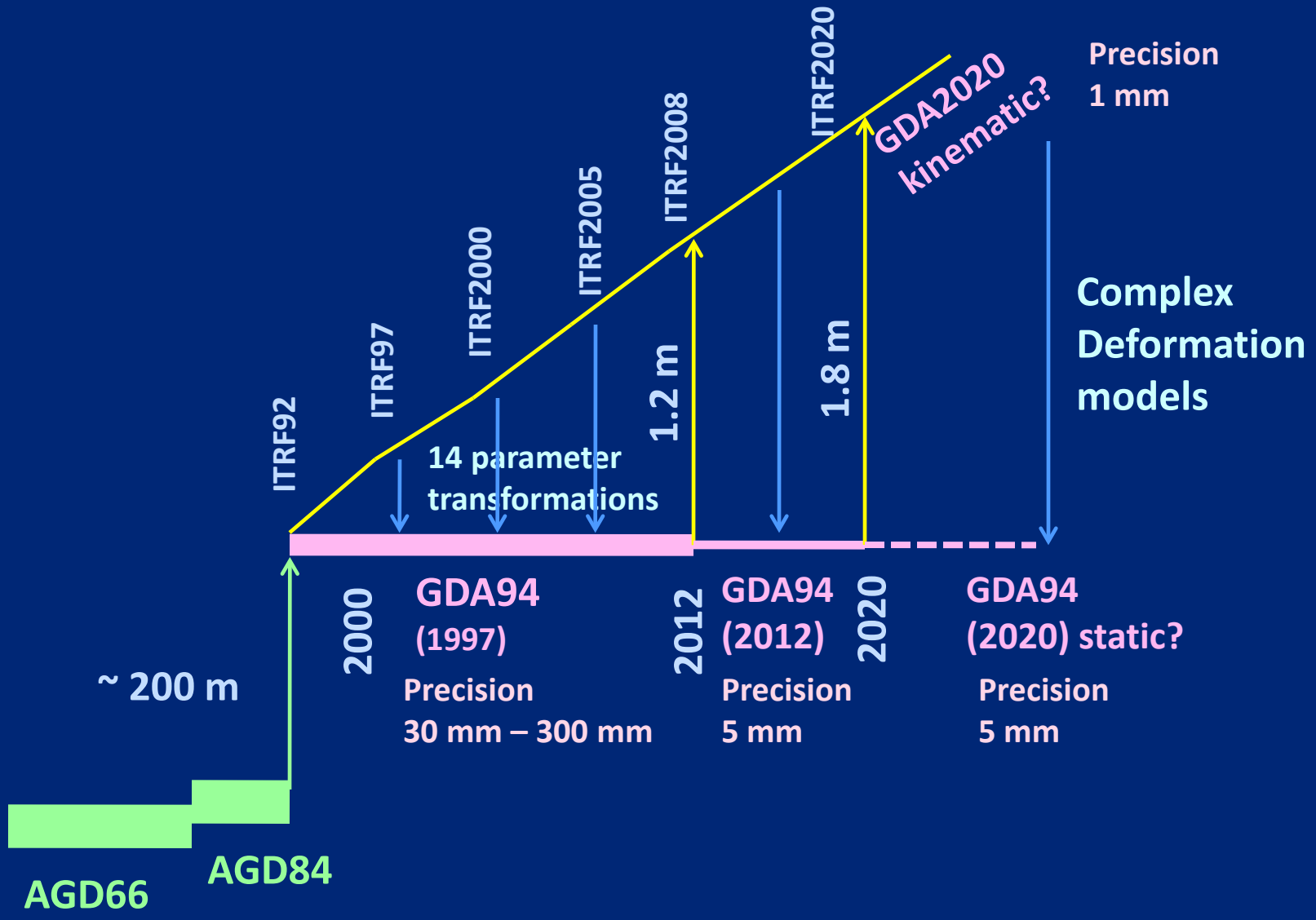
authoritative

ubiquitous

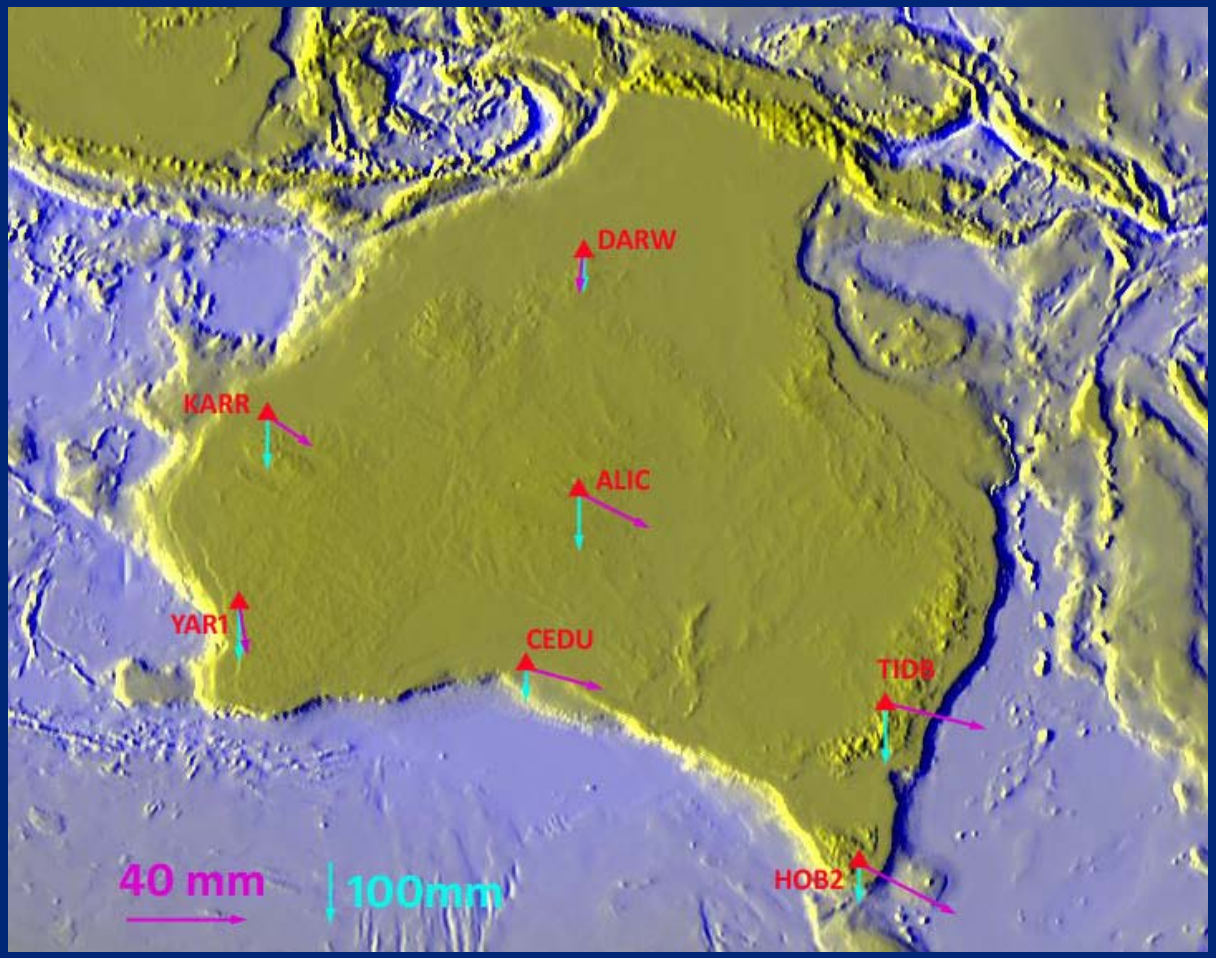
5G/6G wireless
NBN

mm/cm accurate real-time personal positioning
micro RFID on almost everything – even a wedding ring!

Recent evolution of Australian Geodetic Datums



Tweaking of GDA94 – to support CORS interoperability



ITRF92 at epoch 1994.0 to ITRF2008 at epoch 1994.0
Horizontal change of AFN (purple) and ellipsoid height change (turquoise)

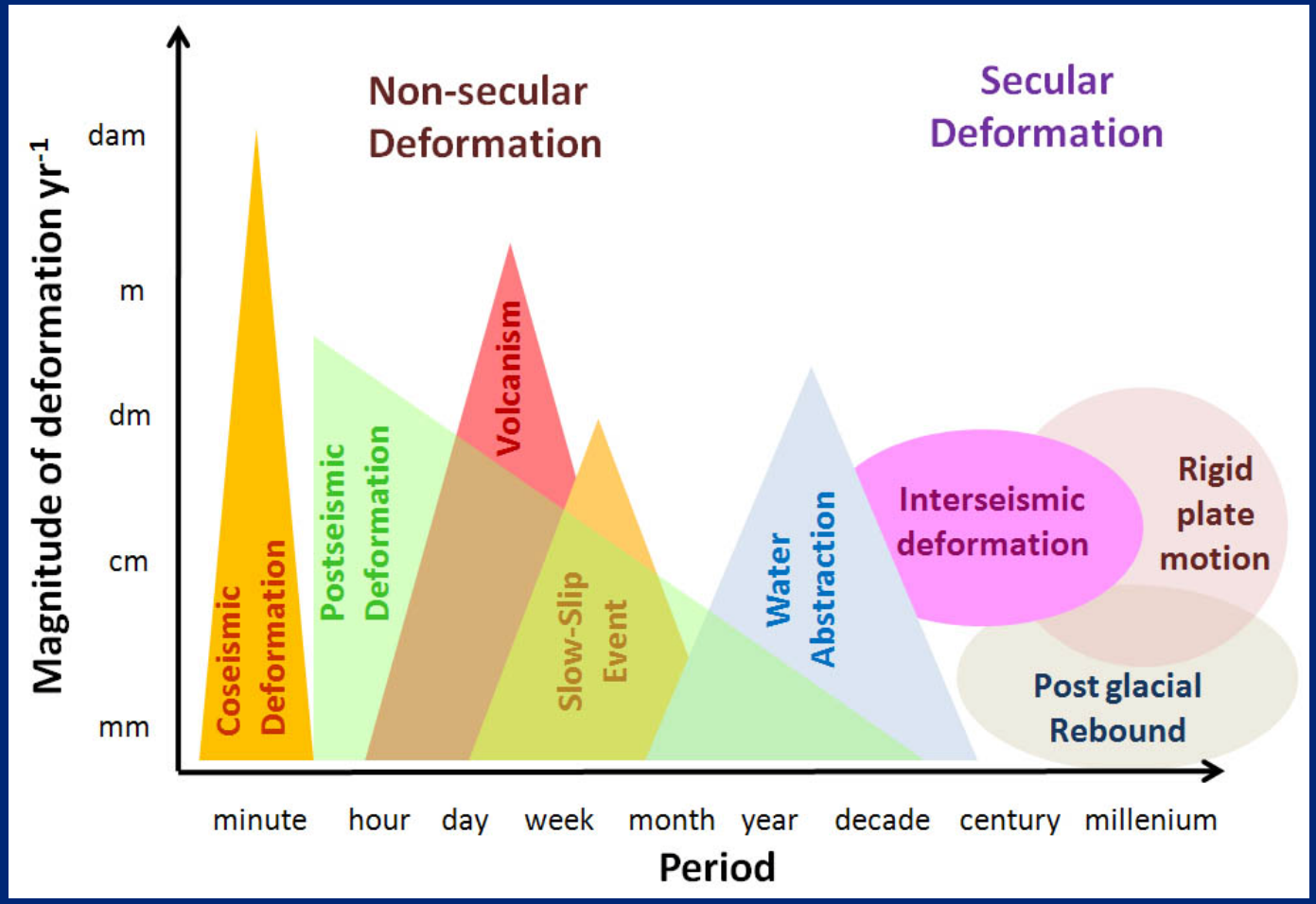
ITRF92

30 mm Horizontal Uncertainty and 90 mm Vertical Uncertainty

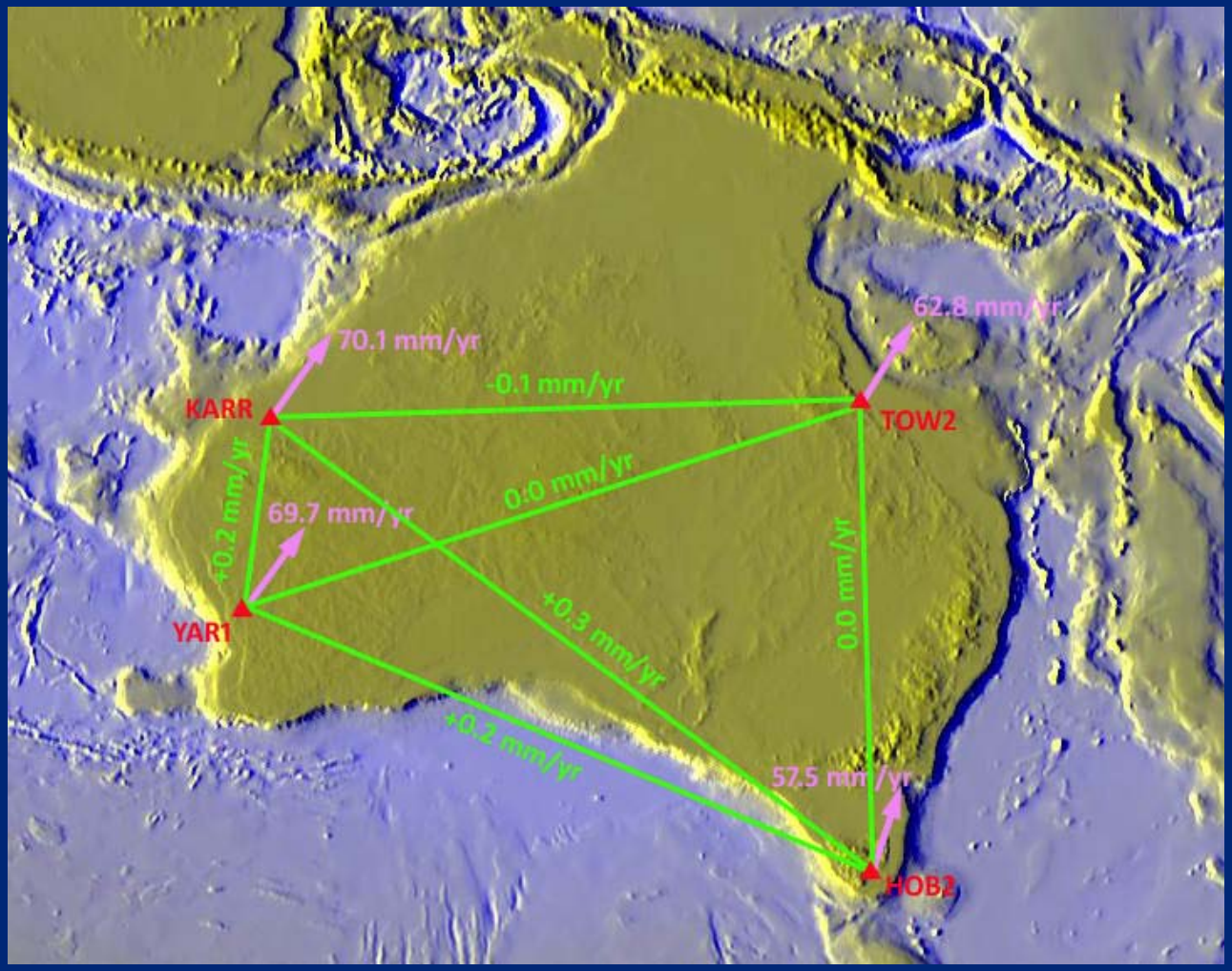
ITRF2008

2 mm Horizontal Uncertainty and 5 mm Vertical Uncertainty

Classification of deformation

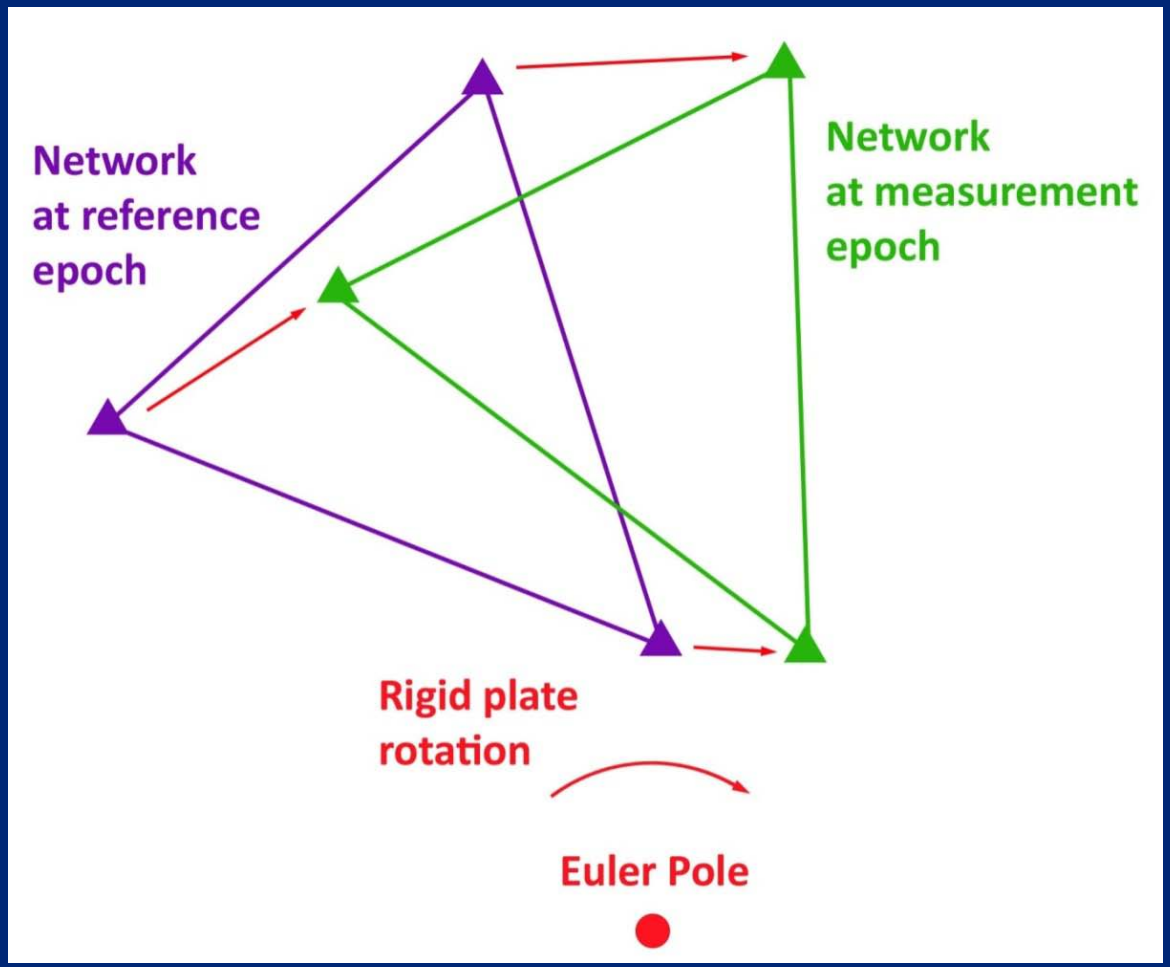


Secular deformation in Australia



purple arrows – tectonic movement, green lines – baseline changes per year

Rigid plate rotation



Australian
Plate rotates at
~0.63° / Ma

=

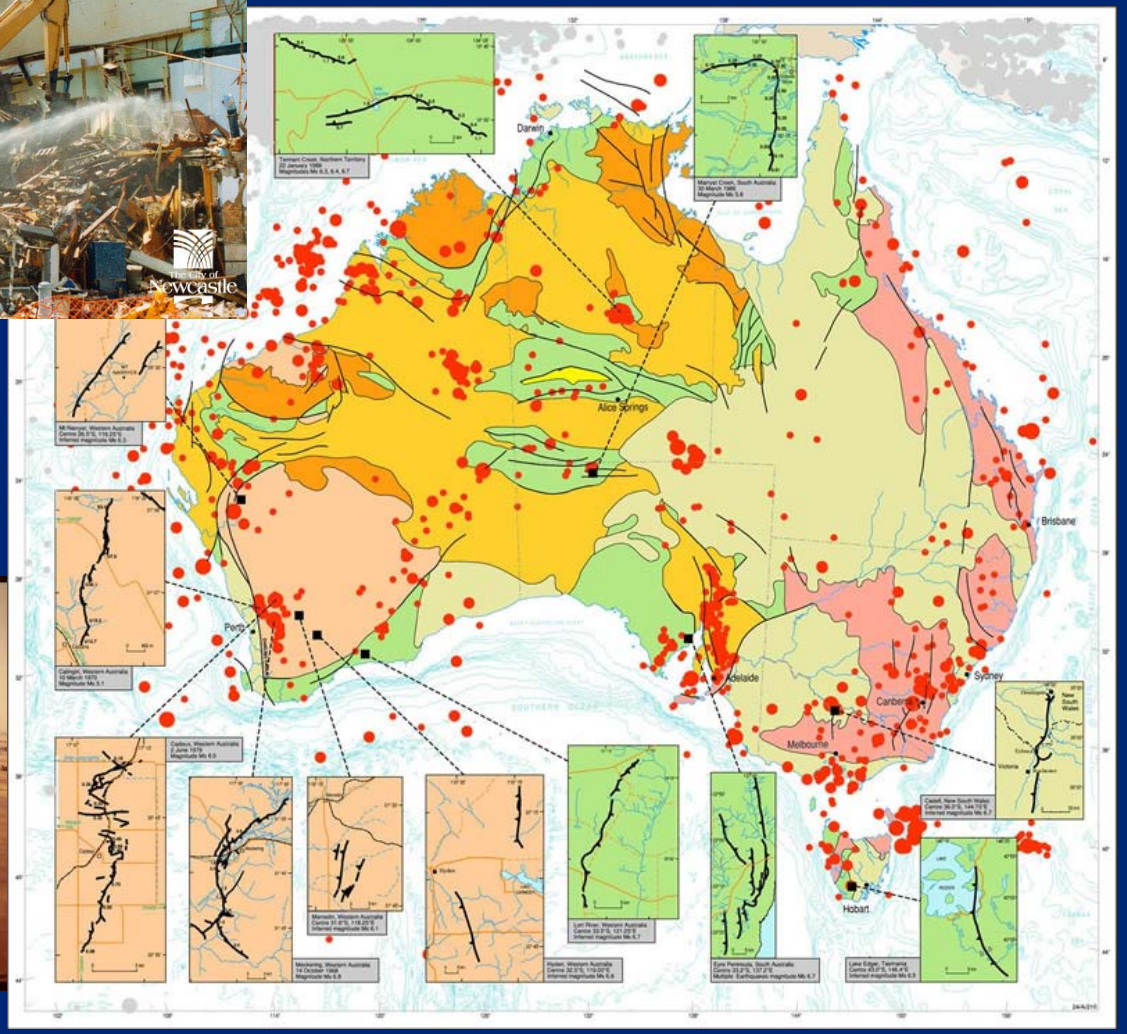
5 mm rotation of
a 30 km
GNSS baseline after
only 15 years

e.g. holding GDA94
coordinates fixed for
static processing or
RTK in 2009

Intraplate earthquakes

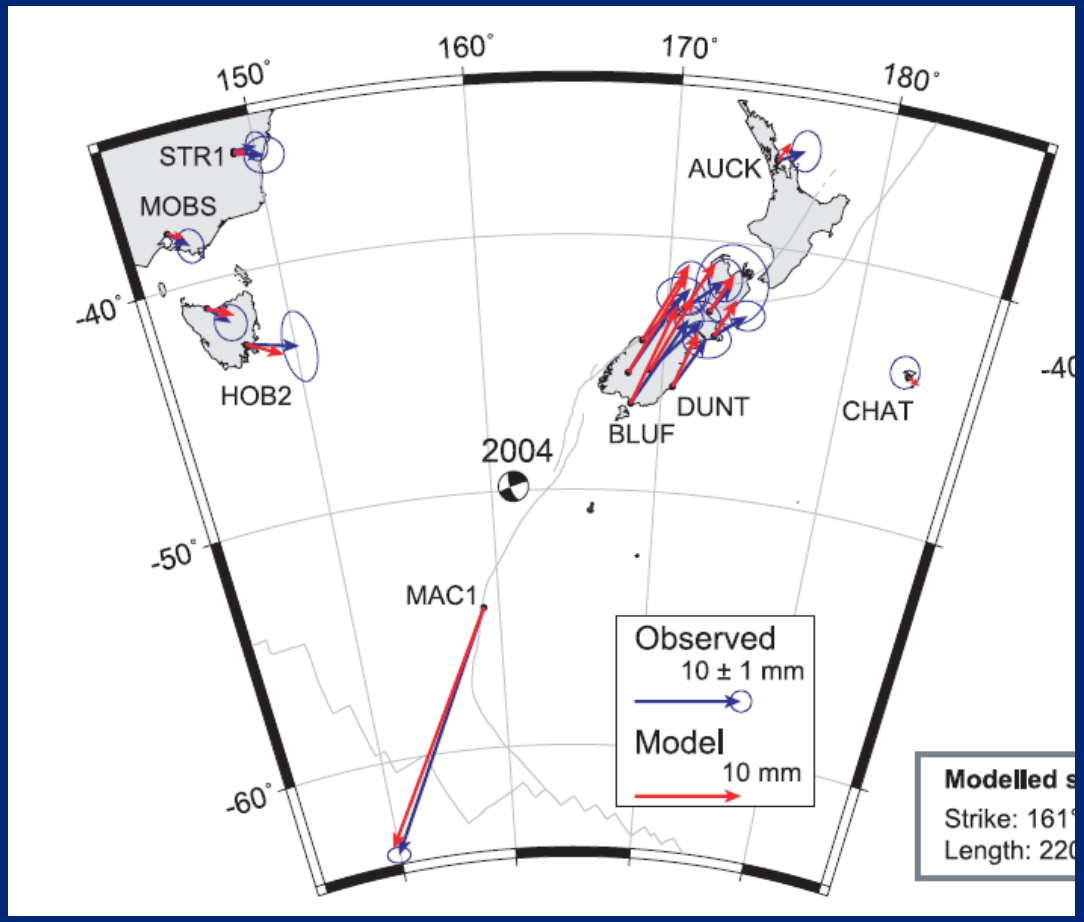
Newcastle, NSW, 1989

Meckering, WA , 1968



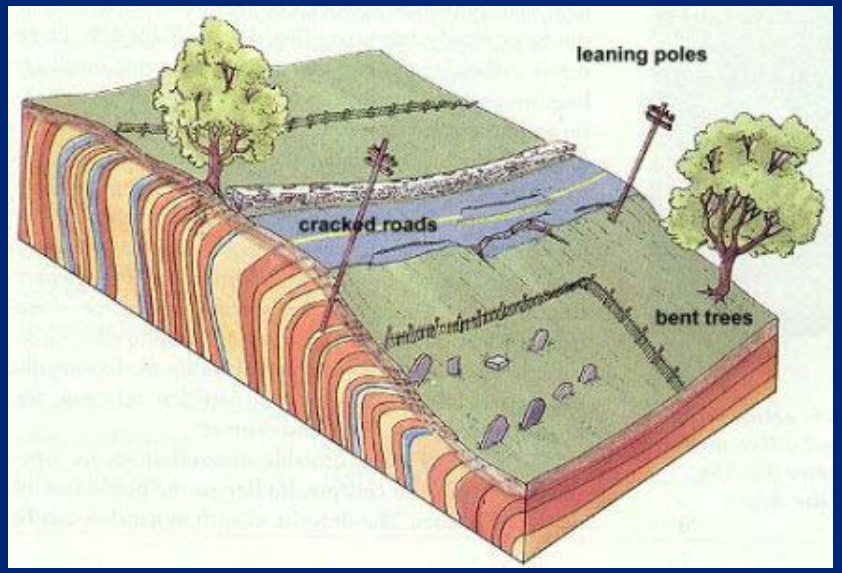
Images and plot, Geoscience Australia

Far field deformation effects in Australia



Far-field deformation from great earthquakes around the Australian margin (e.g. M_w8.1 23rd December 2004 Macquarie, from Watson *et. al*, 2010)

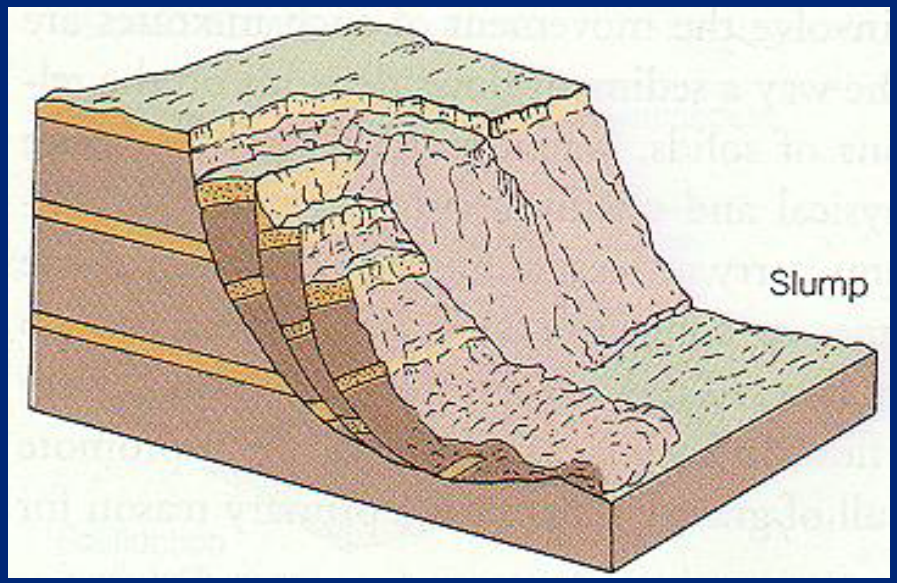
Localised deformation



Surface creep

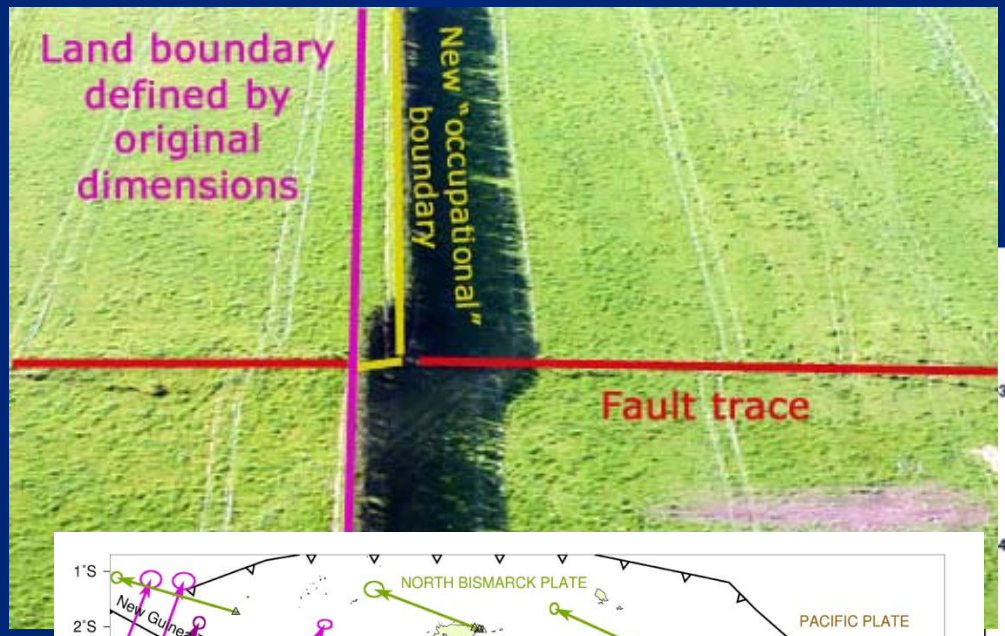
Subsidence

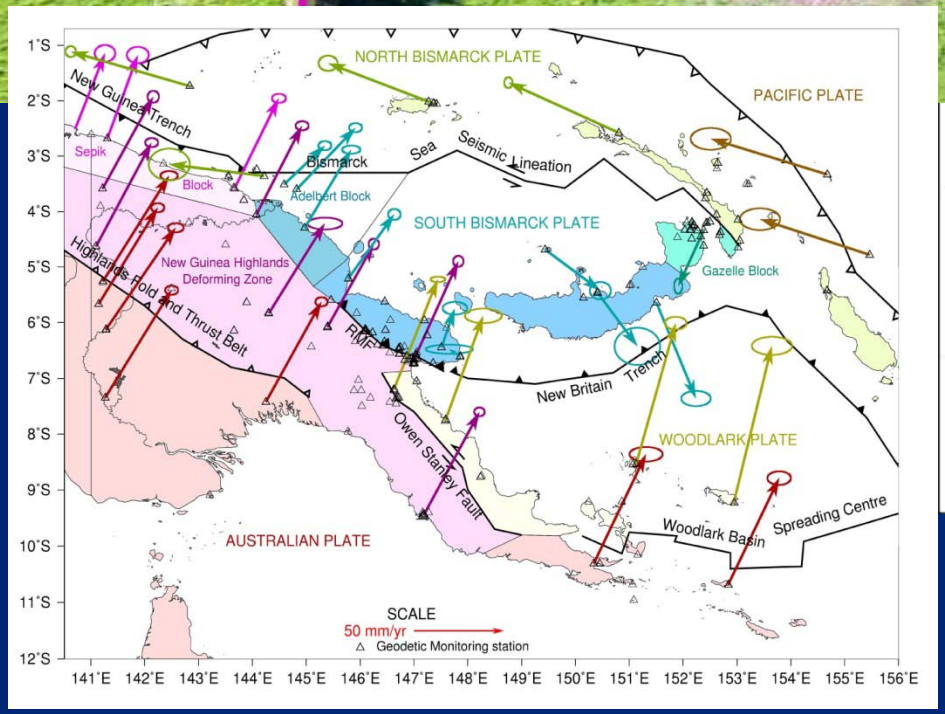
Landslips

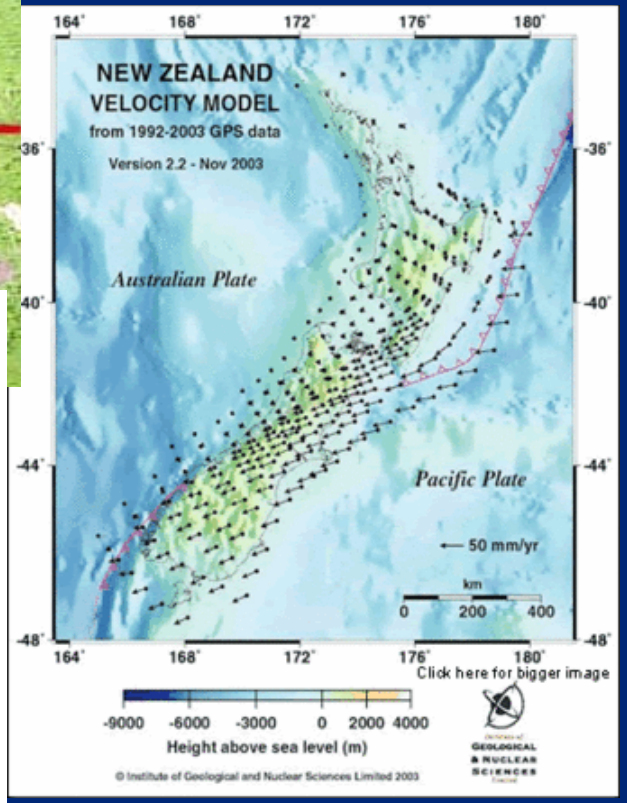


Images from USGS

Plate boundary deformation







Implications of kinematic (dynamic) datums

seamless integration with ITRF and regional reference frames

mm precise coordinates of the real world in real-time

consistency in GNSS and geodetic analysis – implicit deformation

coordinates of “fixed” features change by 1 – 1.5 mm every week

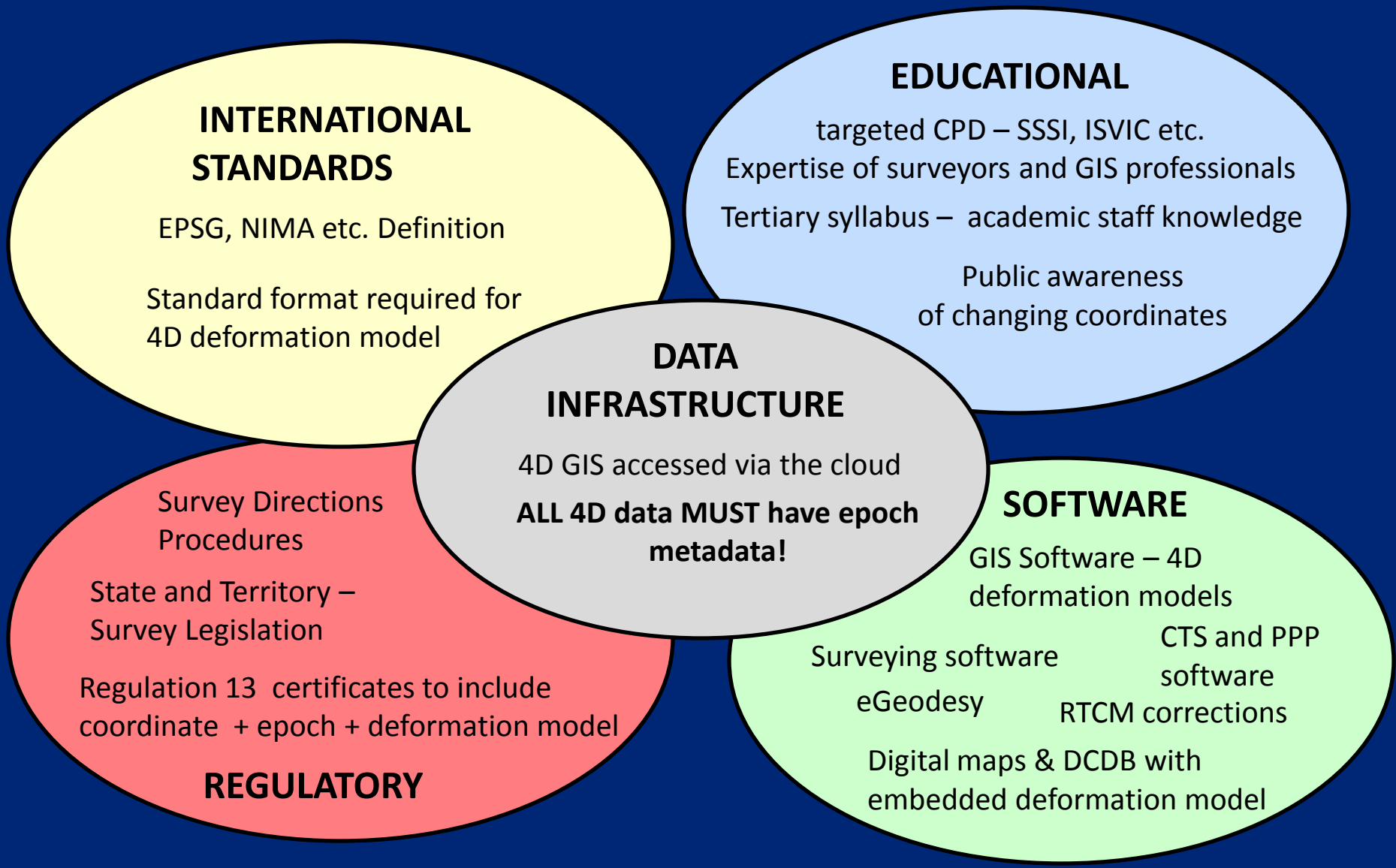
requires complex deformation models to combine or compare surveys from different epochs

consistency and accuracy of deformation models is paramount

lack of epoch metadata leads to 1-2 metre errors!

Cost of implementation of datum change and risk
(short term and long term)

Enabling pre-requisites for a 4D Datum



Deformation model to link kinematic and static datum components

Kinematic (dynamic) datum
(fully consistent with ITRF)

GDA2020
(kinematic model)

GNSS data capture
CORS operation
geodetic analysis
0.5% of users who
require mm accuracy

Secular deformation model (e.g. rigid plate, interseismic)

Patch deformation model (e.g. earthquakes, urban deformation)

"semi-kinematic" datum
fixed at epoch 1994.0

GDA94(2020)

99.5 % of users
who only require
cm accuracy

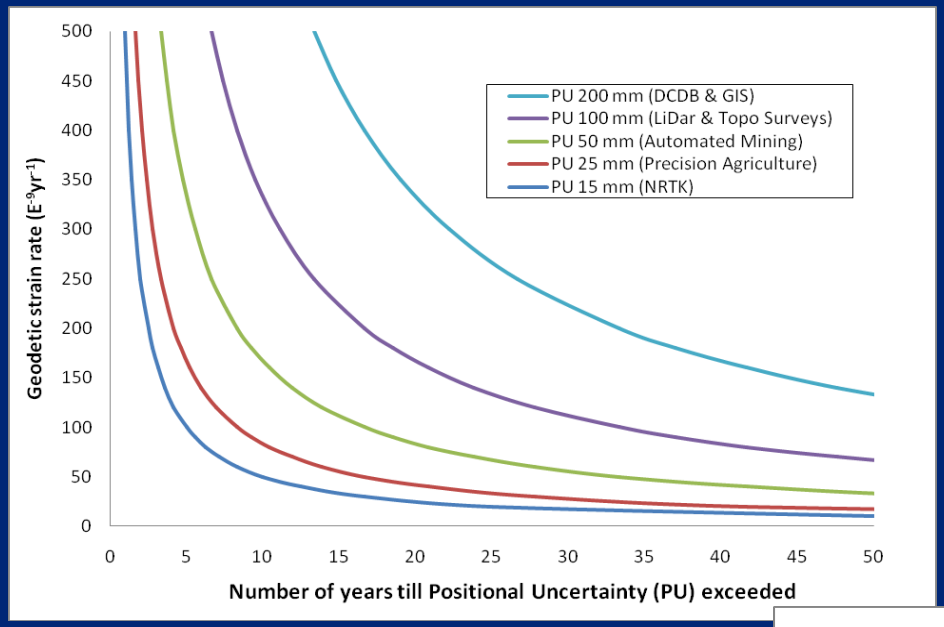
What precision do users need?

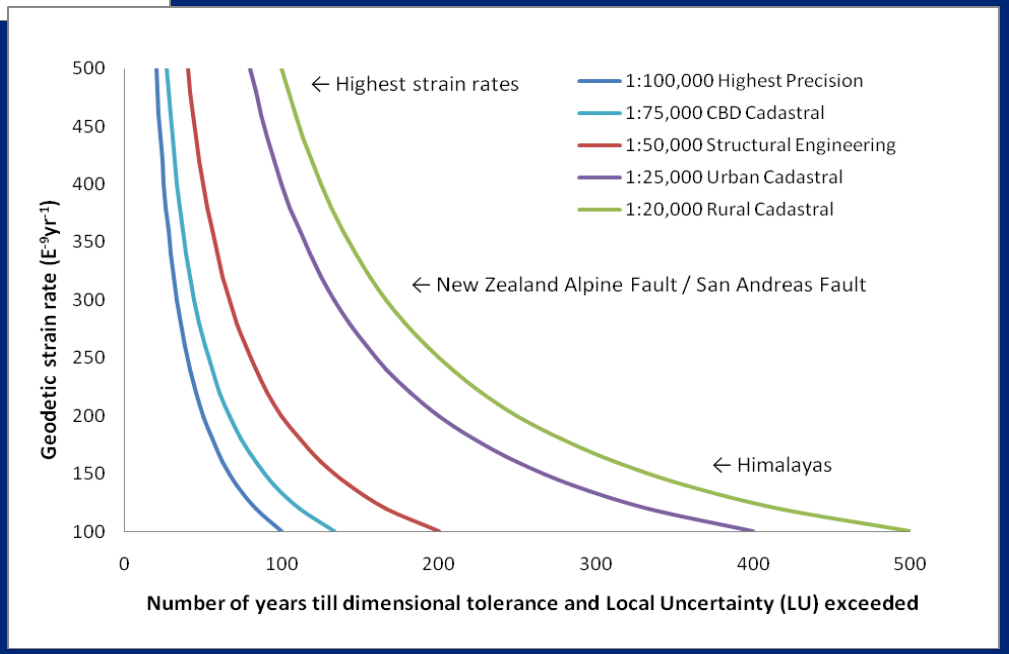
"Absolute" precision

"Local" precision

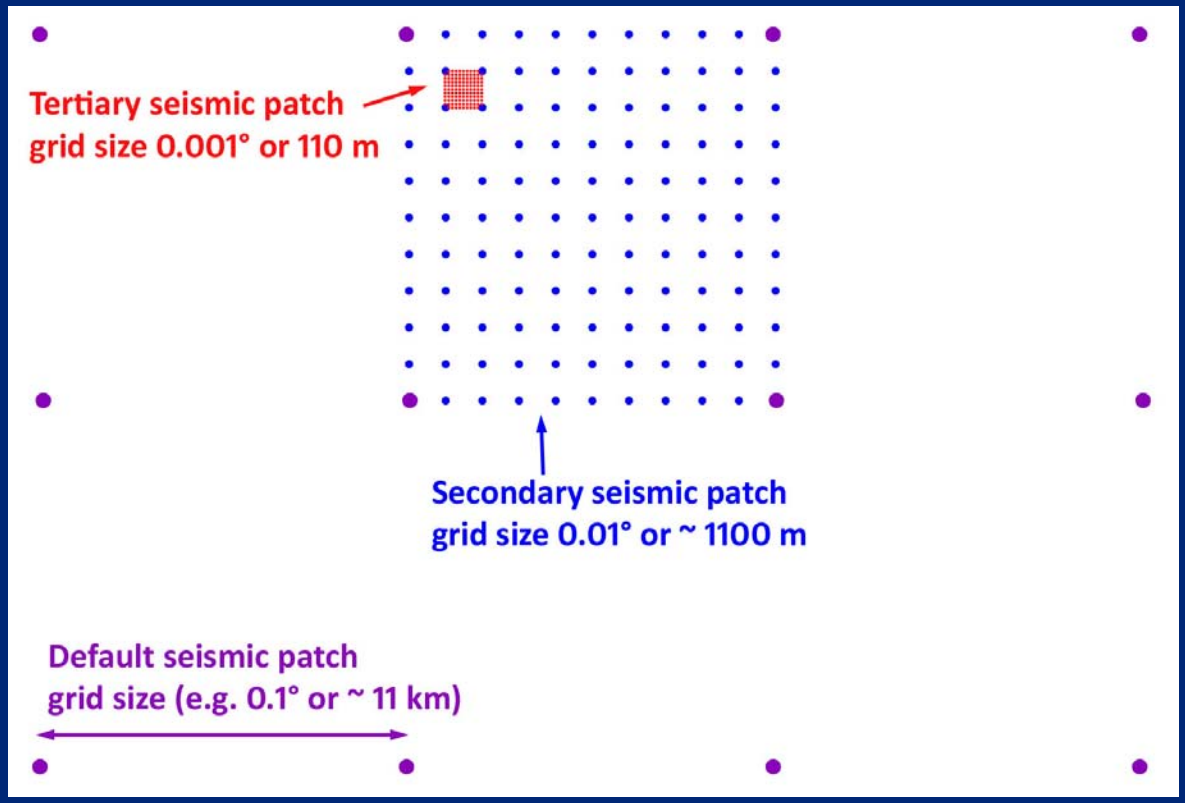
Positional Uncertainty	Local Uncertainty
Fiducial Geodetic Network	1 mm Deformation Monitoring Structural Engineering
	3 mm Construction
GNSS CORS - NRTK	10 mm
Precision Agriculture (e.g. inter-row cropping)	30 mm Urban Cadastral Excavation set-out
Automated Mining LiDar (ALS)	100 mm Rural Cadastral Bulk earthworks, open cut mining
Large scale mapping	300 mm

Deformation vs Precision



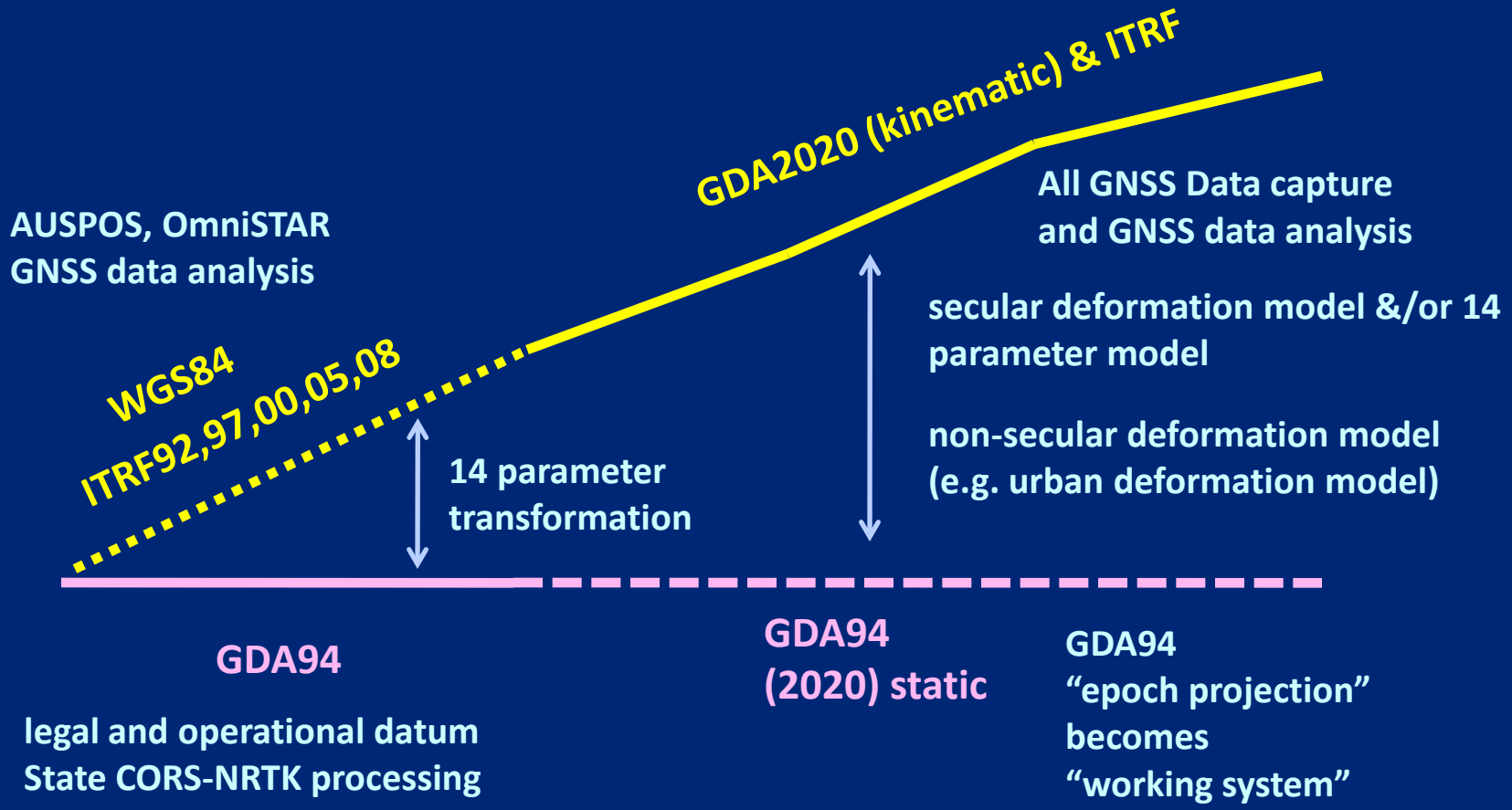


Nested structure of deformation models

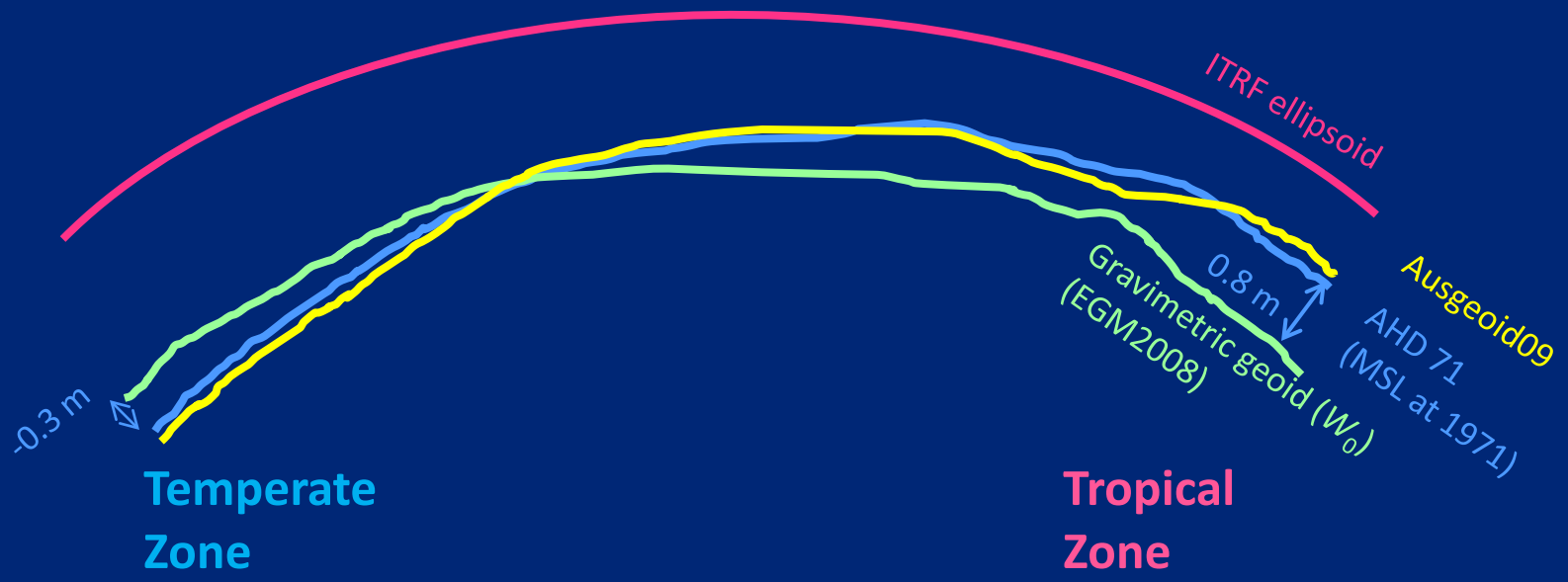


similar data structure and operation to the AGD66/84 to GDA94 grid distortion model

Interim Geodetic Model (2012 – c. 2032)



Height datums – the present



warmer oceans in tropics result in higher sea surface above W_0

issues with benchmark stability and levelling errors in AHD71

but AHD71 is sacrosanct – we shoehorn a geoid model to fit it!

Height datums in the future

From GNSS – precise (kinematic) ITRF ellipsoid height
apply vertical deformation model ?
apply vertical patch deformation model ?

MSL elevation (AHD71) - use Ausgeoid09 or later
local Ausgeoid - AHD71 offset model

Elevation above W_0 – use EGM2008 or later
(e.g. for continental scale hydrological engineering)

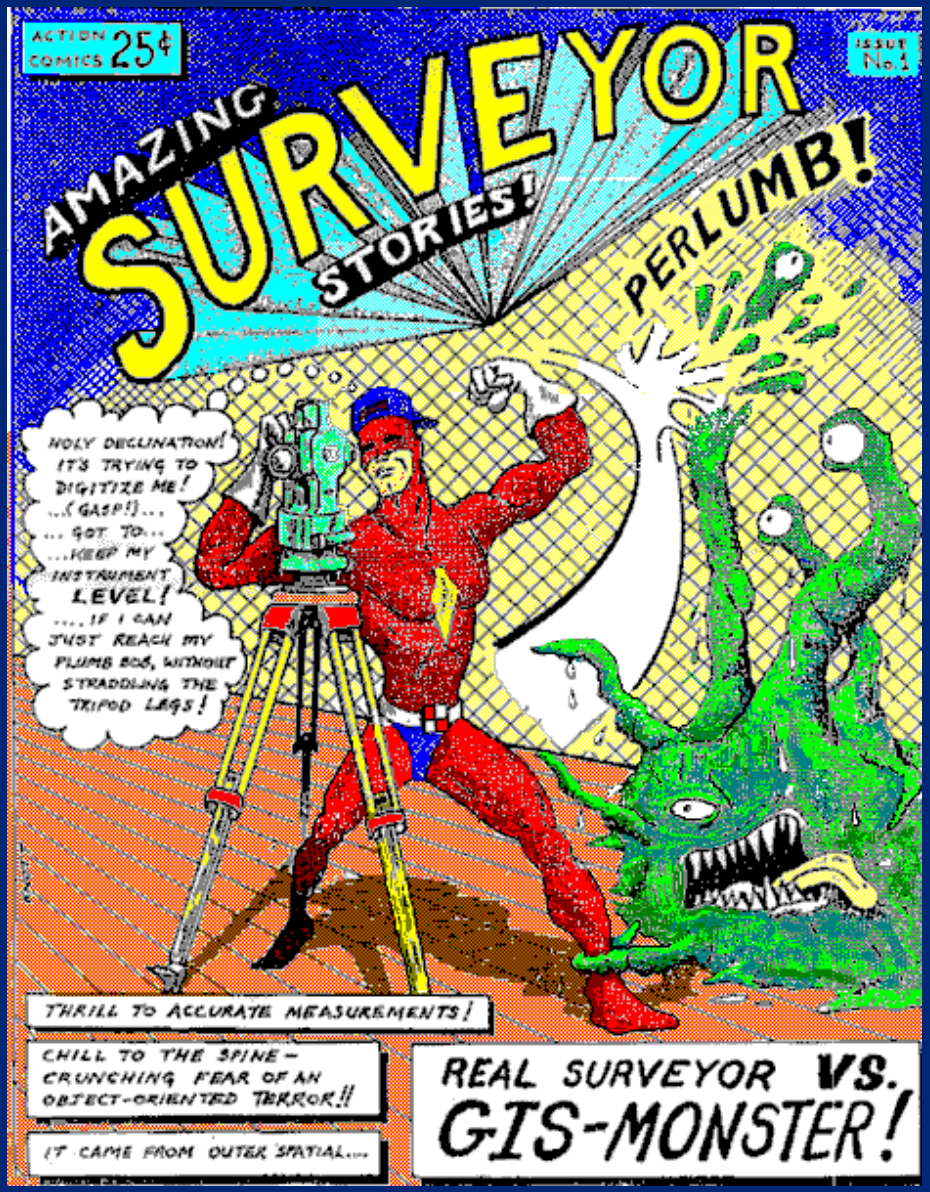
MSL elevation (epoch 20??) – Use Ausgeoid09/later + sea level rise model
(e.g. 2020 MSL will be ~150 mm above AHD71 at +3mm/yr rate)

Future kinematic EGM model (model of change of W_0 as function of time)

Future patch EGM model (model of episodic & seasonal changes of W_0)

Mean Dynamic Topography (MDT) model – open ocean

MDT patch model – localised estuary & fluvial discharge / seasonal effects



QUT student, 1999

Thank You