Do we need to update PNG94 to PNG2020?

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51st Association of Surveyors of Papua New Guinea Congress, Alotau, 3-5 May 2017

Does PNG94 have a use by date?

PNG94 is now 23 years old (reference epoch)

Users of precise GNSS (and even handheld GPS) are seeing differences between GPS coordinates (WGS 84 or ITRF2008) and PNG94.

With improvements to GNSS (e.g. QZSS and SBAS), orbit models and software, 10 cm positioning accuracy using a smartphone is likely by 2025. GNSS Positioning is in ITRF not PNG94!

This difference is due up to 1.8 m of tectonic plate movement in PNG since 1994 (secular deformation between 1994 and 2017) and

821 M_w 5.0 and larger earthquakes since 1994 (<30 cm deformation)

28 M_w 7.0 and larger earthquakes since 1994 (metre level deformation)

3 M_w 8.0 earthquakes since 1994 (several metre deformation)

Significant distortions now in the PNG94 network that now exceed many surveying tolerances.

Increasingly difficult to use site velocity model to estimate PNG94 coordinates

The future of positioning circa 2030

multi-GNSS
+ augmentation (e.g. SBAS)
+ indoor positioning (e.g. Locata)
+ miniature inertial sensors

real-time
precise broadcast
orbits

4D GIS in the cloud

real-time positions

mm

active transformation model

accurate

real-time information currency

centralised data
+ clone

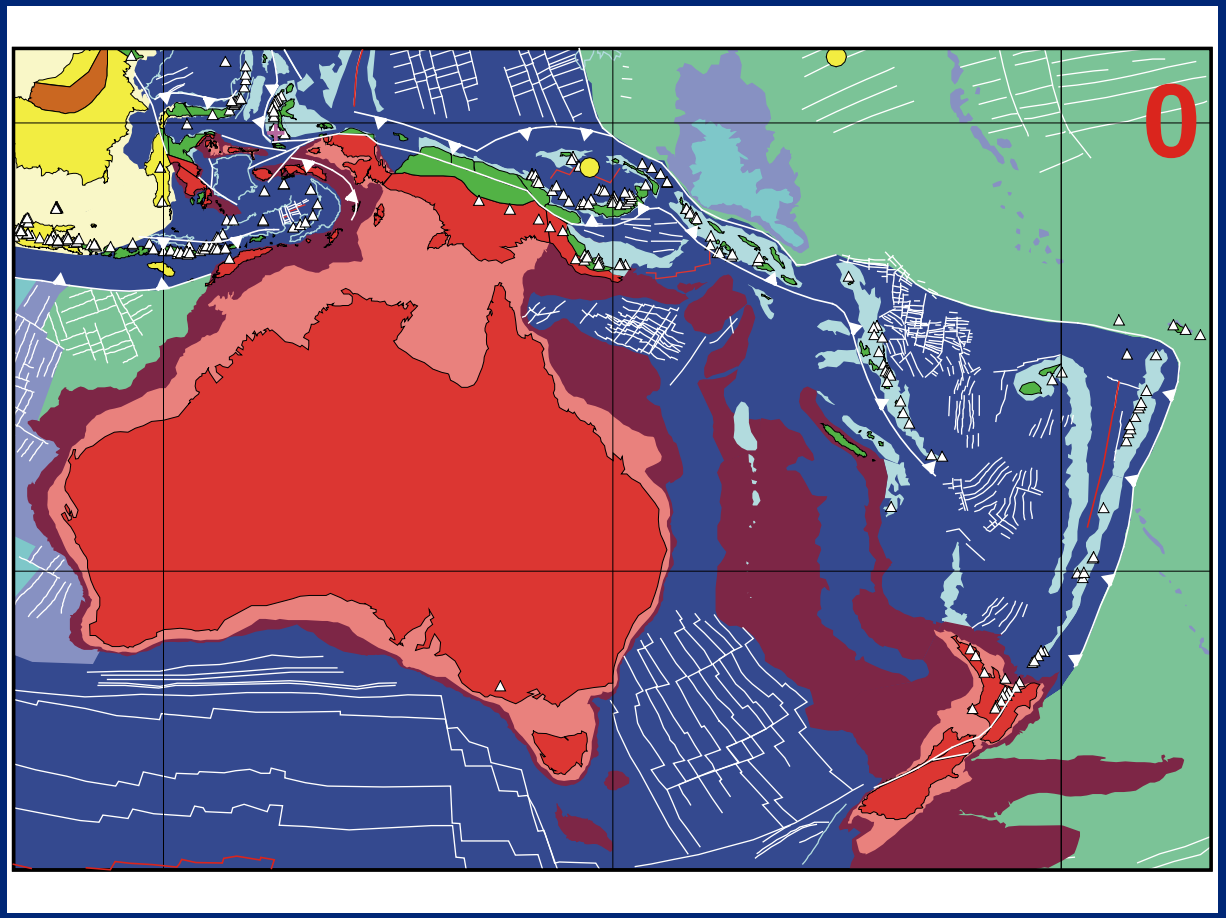
authoritative

ubiquitous

5G/6G wireless
and satellite comms.
(e.g. Beidou, Galileo)

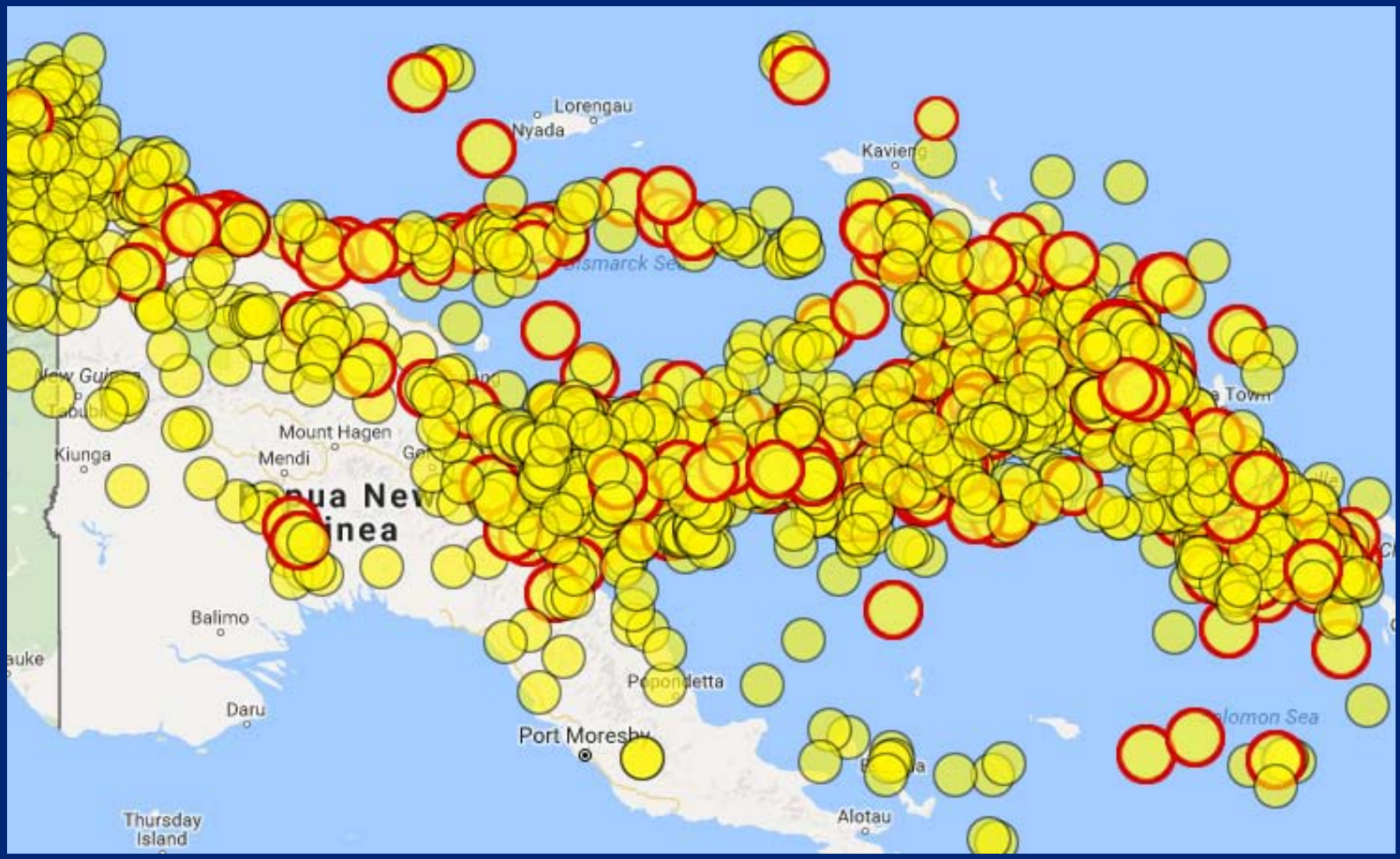
mm/cm accurate real-time personal positioning and navigation – everywhere - No need for explicit use of "coordinates"!

Movement of Australian and PNG tectonic plates



Hall, R. 2002. Journal of Asian Earth Sciences, 20 (4), 353–434.

Magnitude 5+ Earthquakes since 1994

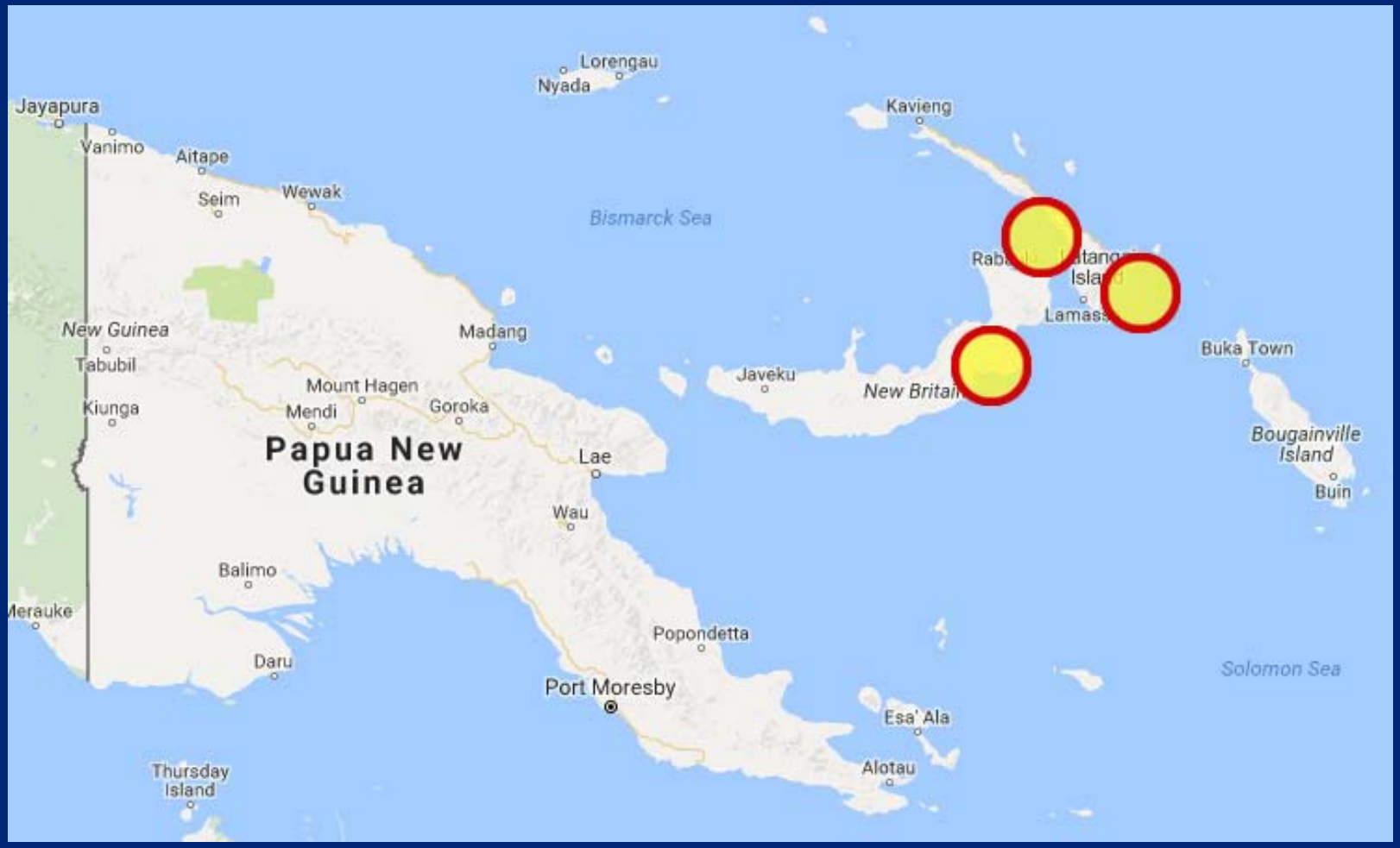


821 Magnitude 5 and greater earthquakes between 1994 and 2017 can typically result in 10 – 30 cm surface deformation

Magnitude 7+ Earthquakes since 1994

28 Magnitude 7 and greater earthquakes between 1994 and 2017 can typically result in 1 – 2 metres of surface deformation

Magnitude 8 Earthquakes since 1994



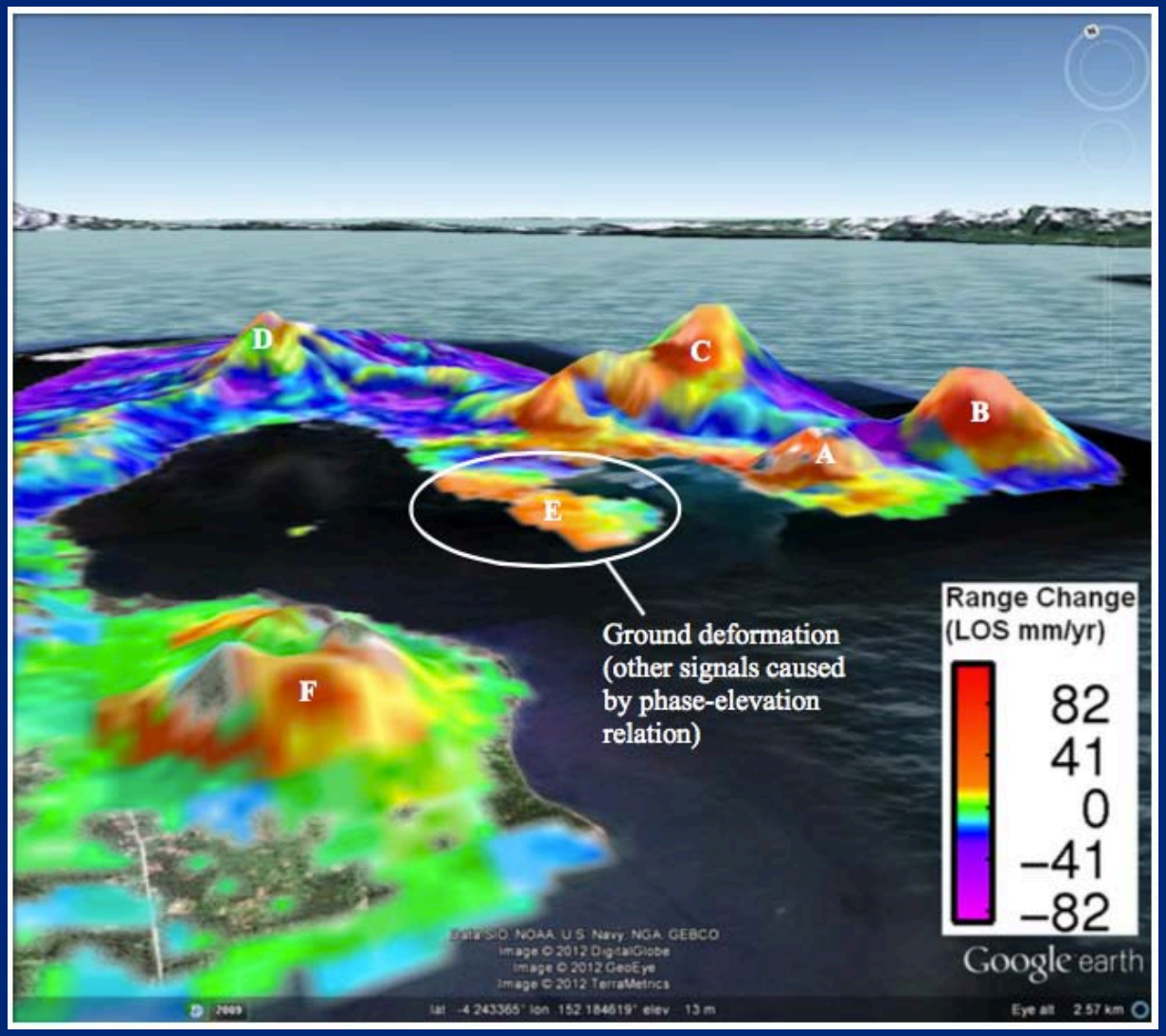
Three Magnitude 8 and greater earthquakes between 1994 and 2017 can typically result in 7-10 metres of surface deformation

Seismic deformation – M_w8.0 Weitin Fault November 2000

M_w 7.8 earthquake surface deformation

M_w 7.8 earthquake surface deformation

Deformation from volcanic activity



Rabaul Caldera

Romeyn and Garthwaite 2012

Volcanic activity – Rabaul 1994

Twin volcanic eruptions of Vulcan (L) and Tavurvur (R), Rabaul, September 1994

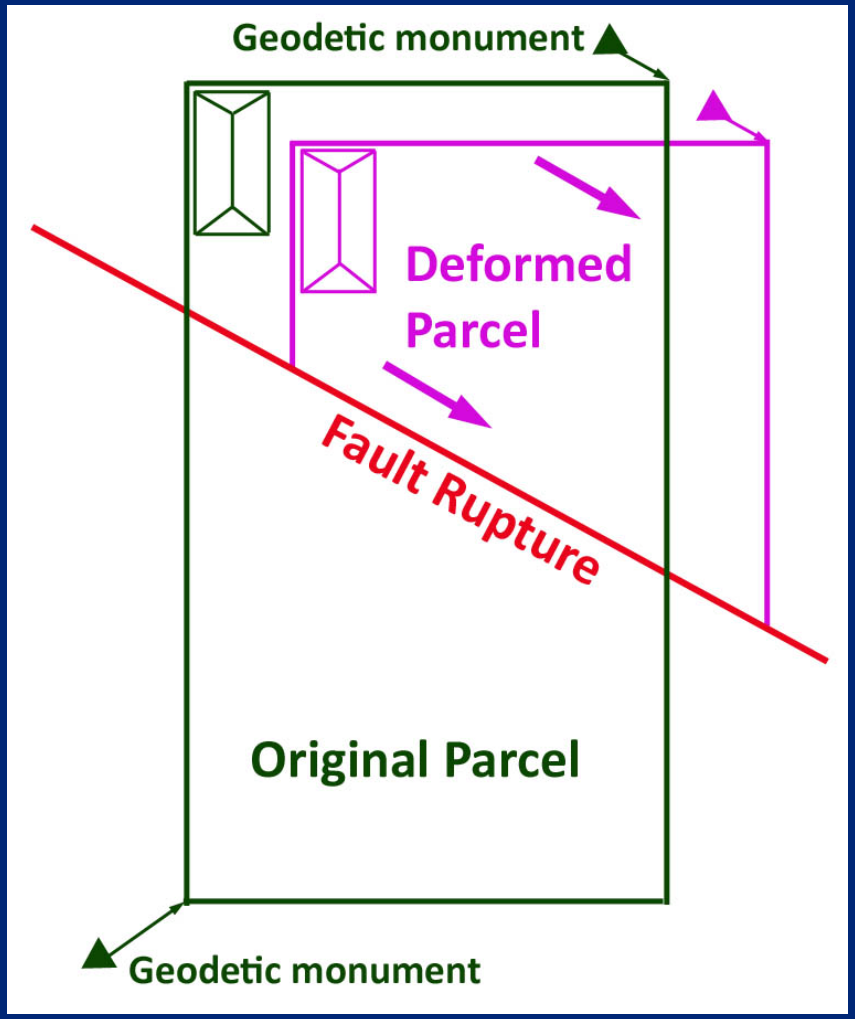
Volcanic activity – Rabaul 2006

Tavurvur eruption - 2006

Seismic deformation and cadastral boundaries

Kaikoura earthquake, New Zealand, 14/11/16

Earthquake effect on cadastral boundaries and coordinates



Cadastral boundaries may need to be redefined (new dimensions) after earthquake to maintain principle of occupational boundaries

and so, coordinates require change after earthquake to reflect spatial reality

Other motivations for an update to PNG94

Other motivations / factors

Australia adopting GDA2020 (ITRF2014 at epoch 2020.0) during 2017
(PNG and Australian share a maritime border just off PNG Coast in Torres Strait)

Indonesia geocentric datum (IGRS2013 = ITRF2008 at epoch 2012.0)
(Indonesia and PNG share a monumented land border near 141 deg E)

Sharing of spatial data across international boundaries (e.g. for road infrastructure projects between Vanimo and Jayapura) – requires little or no offset due to different reference epoch of ITRF

Agreement of a common epoch for border monument surveys (Indonesia and Papua New Guinea)

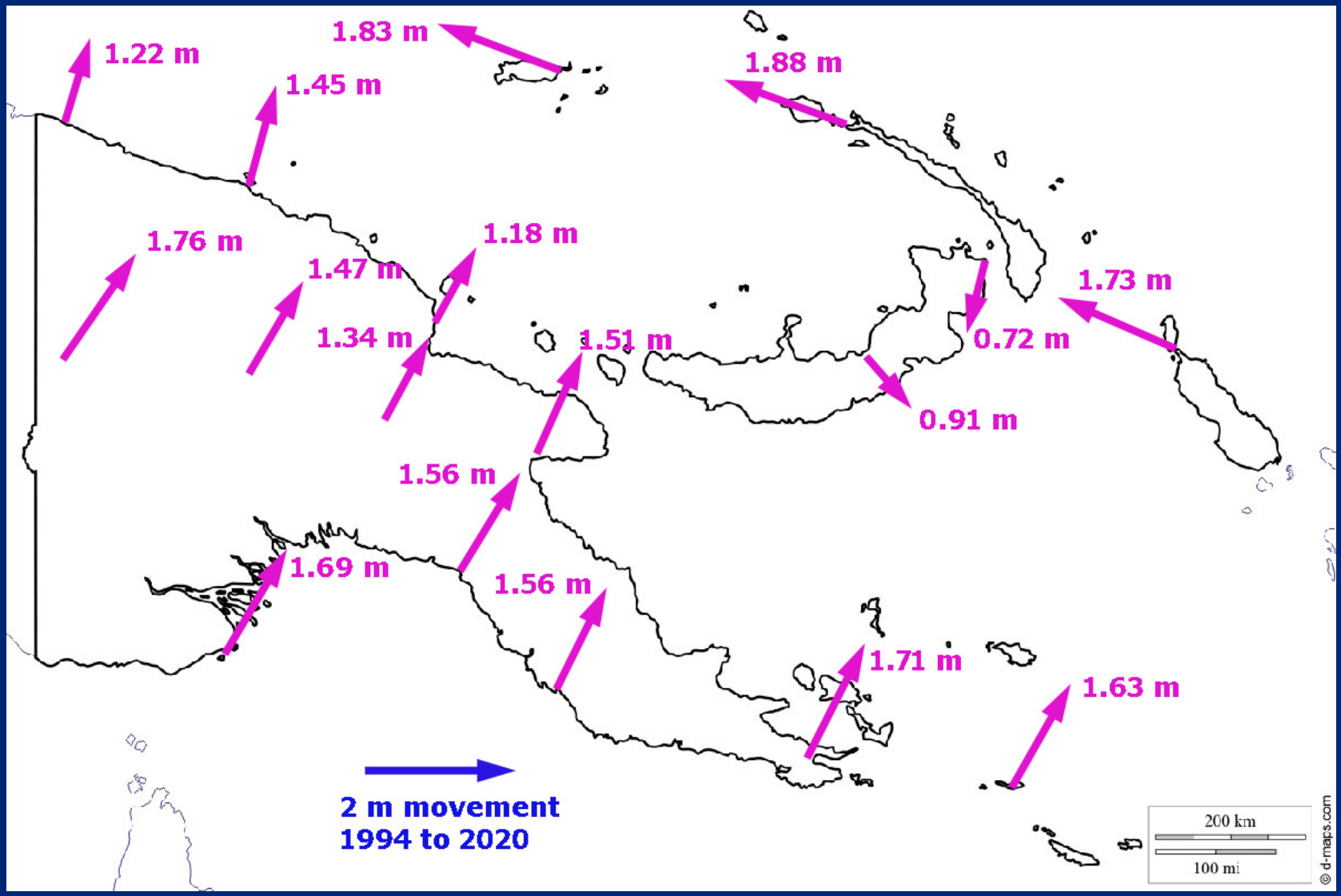
Considerations for PNG2020

Datum will be ~1.8 m offset from PNG94, so care needed not to mix datasets

Will require a transformation grid (e.g. NTv2). A 7 parameter transformation cannot be used due to large number of rapidly moving tectonic plates and complex seismic deformation over 26 years.

Considerations for legislation changes and regulations.

PNG94 difference from ITRF and WGS84 in 2020



How PNG2020 can be realised

GPS reobservation campaign of zero and 1st order geodetic network in PNG. (Office of Surveyor General – Geodetic Section)

1st order control locations: Government compounds (provincial govt., LLG, Dept. of Works), universities, schools, airports, ports, mining and oil and gas operations.

Continuously operating GPS (CORS) at each major provincial capital to support surveys. Currently only Port Moresby, Lae and Rabaul have CORS. Situation unchanged in 17 years!

Construction of CORS at each major provincial capital to support local GNSS surveys and DCDB updates. This aspect could be run by the private sector as a subscription service to surveyors. RTK corrections by radio link or mobile data.

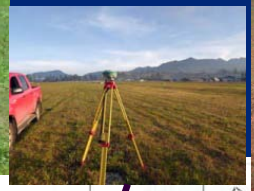
Computation of ITRF2014 coordinates at epoch of measurement

Time series analysis to estimate station velocities and epoch 2020.0 coordinates (1st January 2020) and uncertainties

PNG Fiducial (zero order) geodetic network

Site ID	Site Name	Monument number	PNG94 Latitude	PNG94 Longitude	PNG94 Ellipsoidal Height
MORE	NMB TOWER GPS	PSM 15832	-9°26'02.76968"	147°11'12.20017"	116.610
AIAM	AIAMBAK	PSM 9550	-7°20'51.81934"	141°16'01.44646"	95.465
MIS1	BWAGAOIA AIR	PSM 9195	-10°41'19.90490"	152°49'58.93878"	87.456
GOKA	GOROKA	PSM 9833	-6°04'53.07151"	145°23'30.44618"	1664.580
ALT2	GURNEY	PSM 9538	-10°18'37.50877"	150°20'18.09080"	94.871
KAVI	KAVIENG AIR	PSM 9513	-2°34'53.06528"	150°48'22.53578"	78.828
KIKO	KIKORI AIRPORT	PSM 5583	-7°25'24.65305"	144°14'55.76611"	88.965
MAD1	MADANG	GS 15495	-5°12'41.28824"	145°46'56.19305"	73.293
MANU	MANUS SECOR	PSM 9522	-2°03'02.29337"	147°21'37.63577"	129.751
MEND	MENDI	PSM 3507	-6°08'36.73422"	143°39'22.16540"	1815.154
9799	UNITECH SPORTS	PSM 9799	-6°40'16.96985"	146°59'52.37457"	130.389
VANI	VANIMO DOPPLER	PM 63/1	-2°41'05.28039"	141°18'15.65564"	80.516
NM34	WANKKUN	PSM 15029	-6°08'52.07208"	146°04'52.44226"	510.015
WUVU	WUVULU ISLAND	PSM 15456	-1°44'07.59465"	142°50'10.07846"	79.056









PNG2020 implementation

Repeat GNSS observations on all geodynamics stations to provide sufficient data for precise site velocity model in PNG

Gridded site velocity and seismic patch model for PNG, to enable PPP and Auspos solutions to be propagated to epoch 2020.0 and to facilitate GNSS post-processing within ITRF using input PNG2020 coordinates. Potential for a PNGPos positioning service for surveyors

Tide Gauge observations and connections to improve geoid model and develop offset models for Chart Datum, LAT and CDW height datums

Geodynamics studies in PNG

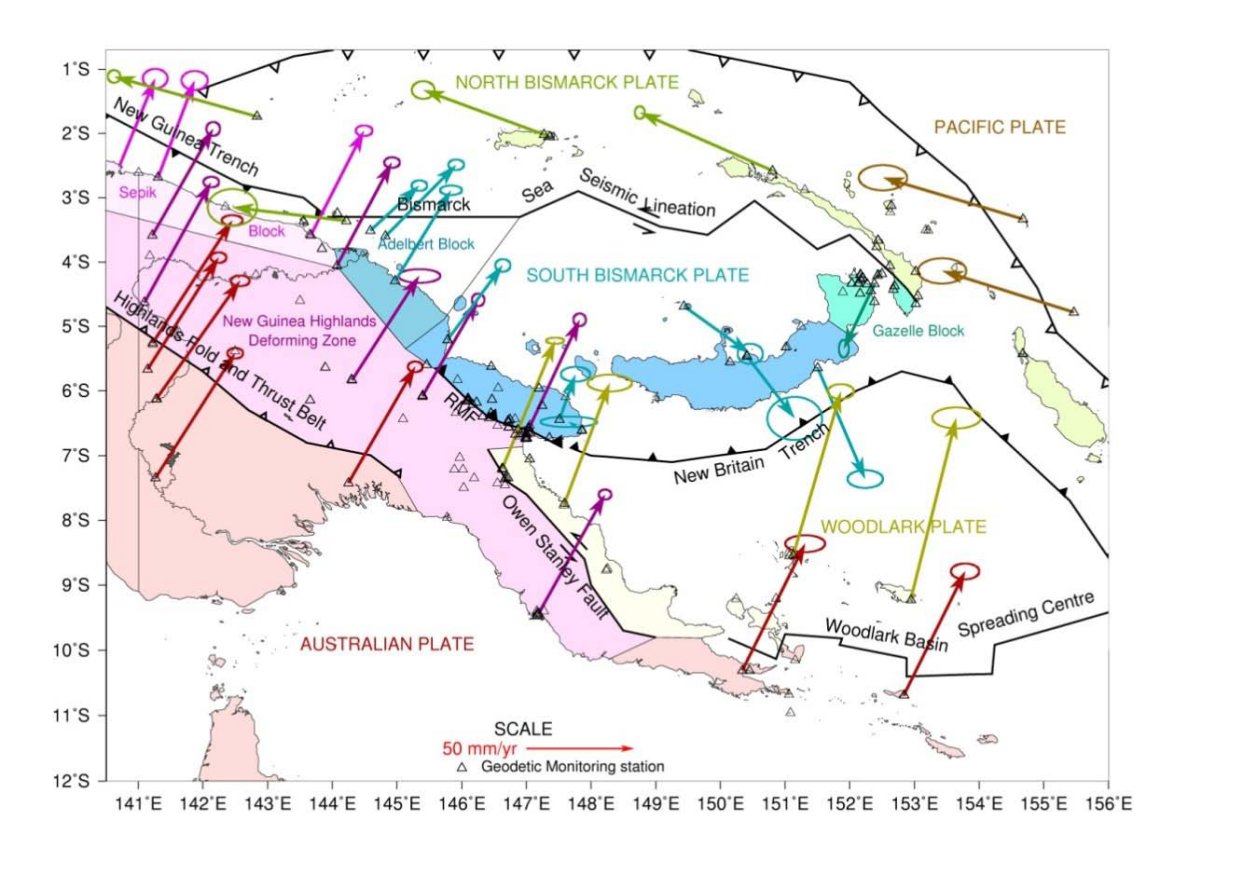
GPS campaigns to monitor plate tectonics in PNG:

UNSW and NMB (1990-1994)
RPI and UCSC (USA)
UniTECH and RVO (1993-2001)

ANU (RSES Geodynamics) (1996-2008)

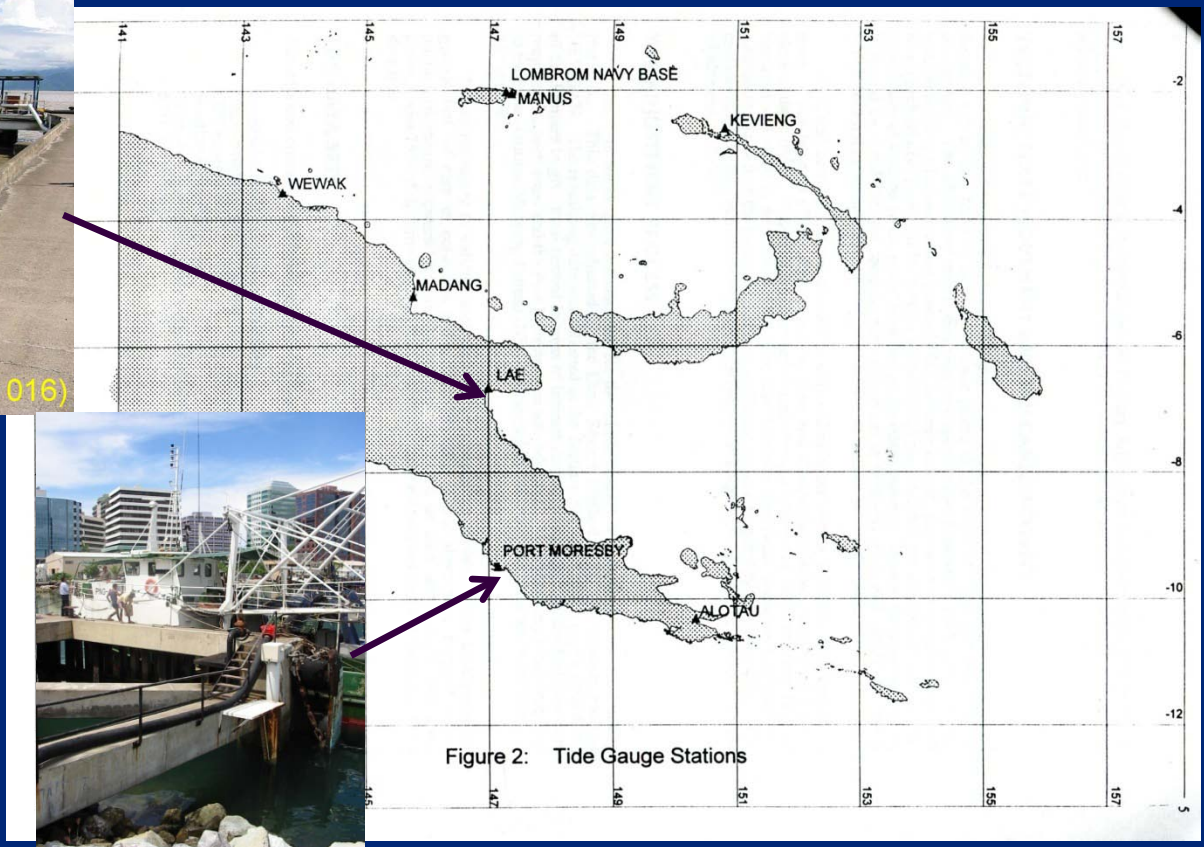
GNS-New Zealand (2009-2013)

Airport Geodetic Survey (PNGASL – AAM- ALS) (2013-)



Funding required to develop site velocity model for PNG to support 15 mm precision at 1σ

Tide Gauge GPS Connections



GNSS observations on tide gauge (TG) network around PNG (and smaller islands) is an urgent priority!

GNSS and TG crucial for monitoring sea level changes and land uplift

New PNG2020 “MSLoid”model

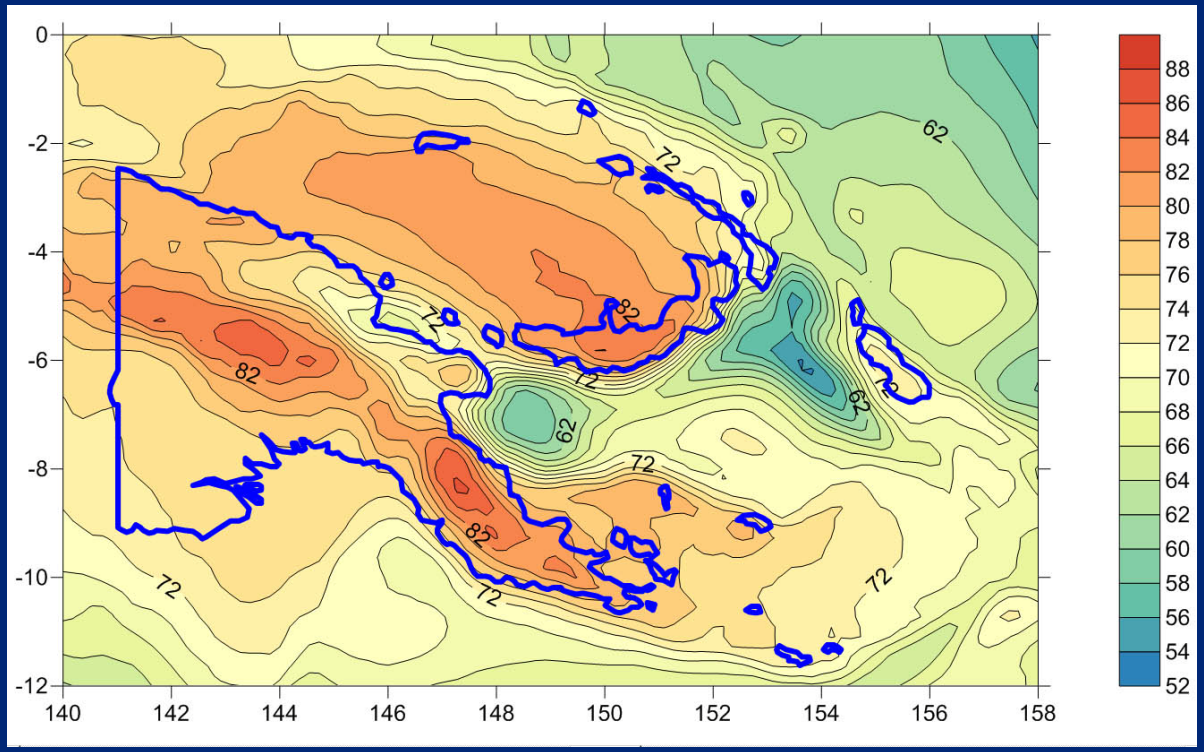
could be based on EGM2020 model to be released in 2020, or current EGM2008 model

consider the fit to observed MSL at wide network of tide gauges around PNG (typically global model is offset by 0.8 to 1.5 m in PNG)

2.5’ grid of N values

Precision 0.1 m 1σ

ASCII, Leica, Topcon and Trimble formats for use in GNSS and GIS



PNG08 geoid model (still provisional after 6 years of use!)

Other considerations …..

Insufficient (almost zero) funding from national government to fund geodetic infrastructure. The period between 2011 and 2013 was productive but there has been no activity since 2014. Geodetic section currently does not have capacity to process GPS data due to computing issues and lack of funds.

Vandalism of geodetic infrastructure by raskols and landowners

Inadvertent destruction of geodetic control by construction

Unreliable power supply and internet for active CORS operation

New PNG datum must be home grown

PNG Geodetic staff should receive state-of-art training in GNSS processing, time-series analysis and deformation modelling. – Attend RFIP workshops (FIG and IAG) – Assistance from Pacific Island state academics.

In conjunction with PNG Unitech, – graduate and post-graduate programs in linkage with Lands Dept.

Requires funding and support from PNG Government

PNG2020 Delivery

Government Gazette – coordinates of zero order monuments

Coordinate information for PSMs on web

(ideally OSG web-site, or ASPNG if OSG site not operational)

Geodetic Registries (EPSG/IOGP and ISO TC 211) for datum and projection specifications

Transformation grids from PNG94 to PNG2020

ITRF2014 site velocity model

A working plan suggestion

1. Forming a PNG2020 working group to kick start the new datum (Led by the Office of the Surveyor General - Policy Formulation) (include Survey Community Representative/s - Private & Govt)

2. Technical expertise in the field of Geodesy, GNSS/GPS & datum delivery)

3. Network our PNG expertise in datum construction.

4. Restructure and empower the Geodetic Survey Staff to put together Internal Dept Budget for Data Collection.

Tinani and thank you