42nd Association of Surveyors PNG Congress, Holiday Inn, Port Moresby 9th-12th July 2008

How to bring PNG94 into a project

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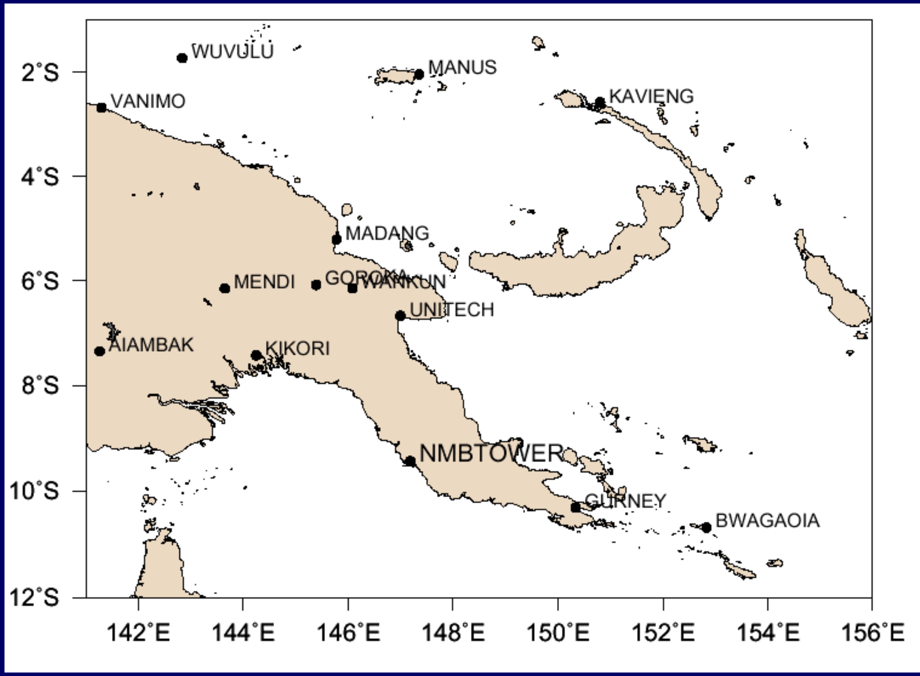
PNG94 fiducial network

14 Stations around PNG surveyed by GPS between 1992 and 1994

Same realisation as GDA94 in Australia

Accurate to 5 cm

Offset from WGS84 >1.5m



Gazetted national geodetic datum for PNG

Densification of PNG94

ANU, Unitech & NMB GPS data needs to be collated to densify and validate PNG94

Preliminary listing prepared for ASPNG 42nd Conference

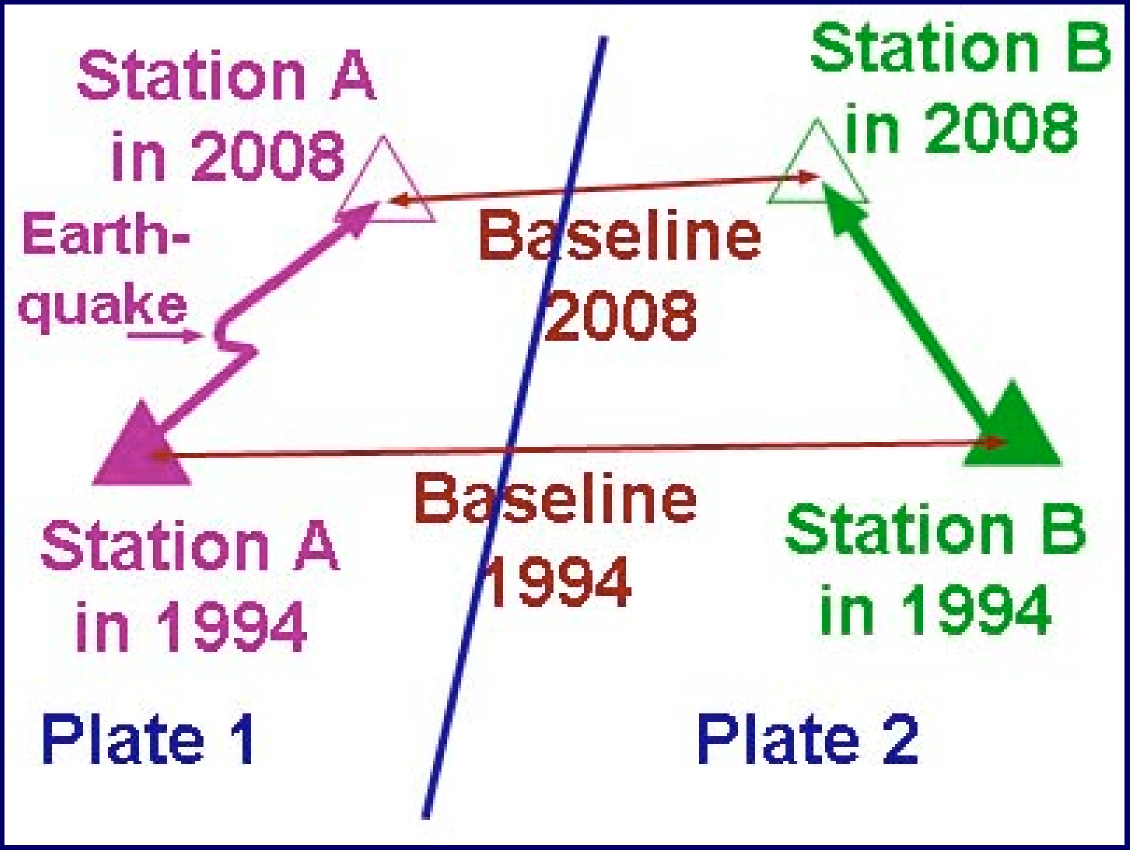
Funding required to process, reduce and document all stations (approx. 130 around PNG)

Coordinates and station info to be available from the web.

Need PNG based web host

NMB Geodetic Section need funding to observe additional stations and do tide gauge connections

Effect of tectonic deformation on survey baselines & PNG94

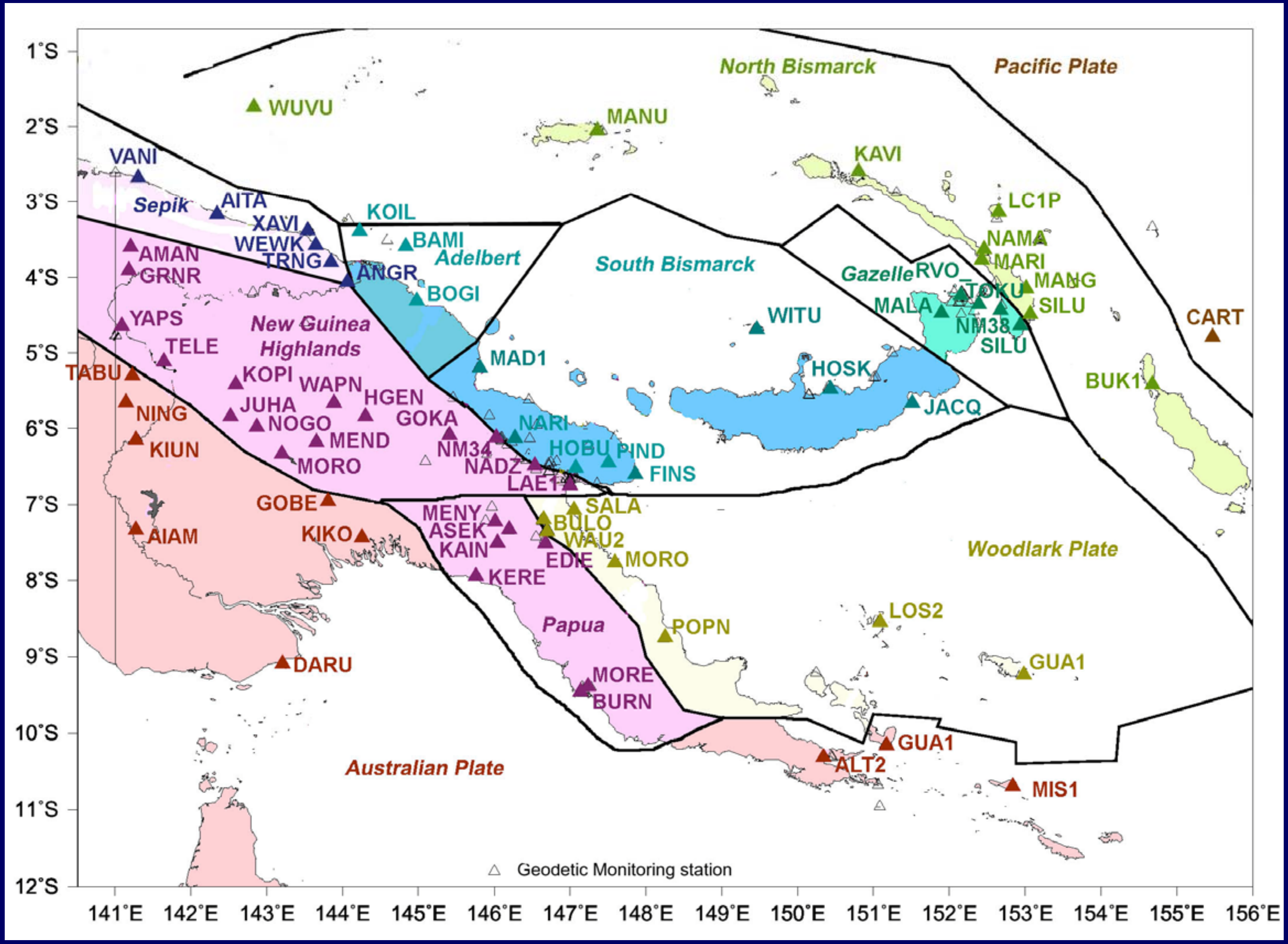


Need to use a model to get back to 1994 coordinates

The guiding principle is that PNG94 coordinates for any point should not change from where they were on 1/1/94

How do you bring quality PNG94 on to a project?

1. Find nearest validated PNG94 station ON THE SAME PLATE (< 50 km)



PNG94 1st order control listing - Provisional update 7th June 2008 (verification required)

Station location			PNG94 Ellipsoidal Coordinates			PNGMG94 Grid Coordinates			MSL	Site Velocity	
Location	GPS ID	NMB Reg. No.	Latitude	Longitude	Ellipsoid Height	Zone	Easting	Northing	RL	E m/yr	N m/yr
Aiambak	AIAM	PSM 9550	-7°20'51.8206"	141°16'01.4470"	95.52	54	529475.73	9187801.94	21.7	0.037	0.058
Alotau - Gurney Airport	ALT2	PSM 9538	-10°18'37.5094"	150°20'18.0912"	94.87	56	208478.37	8859053.57	16.3	0.031	0.058
Buka Airport	BUK1	PSM 4871	-5°25'34.3712"	154°40'08.4373"	73.25	56	684918.22	9399967.57	4.3	-0.059	0.031
Daru	DARU	AA 440/A	-9°05'15.5229"	143°12'27.1952"	80.28	54	742639.83	8994719.42	4.9	0.035	0.055
Finschhafen	FINS	PSM 19471	-6°36'55.4209"	147°51'17.6868"	74.24	55	594504.66	9268686.35	9.5	-0.006	0.004
Goroka - Airport	GOKA	PSM 9833	-6°04'53.0717"	145°23'30.4470"	1664.47	55	322023.98	9327531.64	1585.4	0.023	0.046
Hoskins - Airport	HOSK	PSM 9795	-5°28'00.4073"	150°24'31.6614"	101.35	56	212869.72	9395119.32	18.0	0.022	-0.027
Kavieng - Airport	KAVI	PSM 9513	-2°34'53.0660"	150°48'22.5361"	78.81	56	256077.96	9714464.61	2.7	-0.067	0.027
Kenabot - Lands Base	KENB	PSM 23342	-4°20'45.1168"	152°16'07.9951"	136.69	56	418875.65	9519602.79	63.2	-0.002	-0.041
Kerema - Catholic Mission	KERE	PSM 31703	-7°57'28.0191"	145°46'19.0726"	97.57	55	364647.58	9120168.45	21.5	0.030	0.052
Kikori - Airport	KIKO	PSM 5583	-7°25'24.6531"	144°14'55.7677"	88.93	55	196298.45	9178490.00	12.01	0.035	0.054
Kiunga - Airport	KIUN	PSM 9465	-6°07'37.9805"	141°16'41.2696"	103.27	54	530773.45	9322724.61	27.7	0.038	0.056
Lae - Unitech DSLS Base	LAE1	PSM 31107	-6°40'25.3661"	146°59'35.4668"	140.37	55	499246.79	9262320.80	67.12	0.026	0.052
Lae - Unitech Sports	9799	PSM 9799	-6°40'16.9707"	146°59'52.3754"	130.31	55	499765.91	9262578.60	57.06	0.026	0.052
Lake Kopiago - Airport	KOPI	PSM 17001	-5°23'09.0852"	142°29'42.1907"	1412.79	54	665650.98	9404480.51	1327.7	0.031	0.055
Losuia	LOSU	AA 583	-8°32'07.2596"	151°07'30.8181"	85.16	56	293644.60	9056016.40	6.1	0.021	0.071
Madang - Airport	MAD1	GS 15495	-5°12'41.2891"	145°46'56.1940"	73.27	55	365044.17	9423829.87	5.0	0.023	0.039
Manus - Lombrum Secor	MANU	PSM 9522	-2°03'02.2944"	147°21'37.6363"	129.77	55	540084.32	9773337.48	50.8	-0.065	0.027
Mendi	MEND	PSM 3507	-6°08'36.7344"	143°39'22.1658"	1815.08	54	793981.21	9320198.80	1732.6	0.029	0.047
Misima - Airport	MIS1	PSM 9195	-10°41'19.9049"	152°49'58.9388"	87.46	56	481741.61	8818417.91	13.1	0.030	0.055
Moro - Airport	MORA	PSM 17442	-6°21'44.9072"	143°13'46.0940"	917.86	54	746627.49	9296194.53	837.4	0.033	0.054
Mount Hagen - Airport	HGEN	PSM 3419	-5°49'55.7591"	144°18'23.7948"	1710.15	55	201725.79	9354636.51	1626.5	0.030	0.048
Nadzab - Airport	NADZ	ST 31024	-6°33'47.9879"	146°43'39.6541"	148.83	55	469894.96	9274514.88	77.4	0.024	0.056
Namatanai - Airport	NAMA	GS 19461	-3°39'58.5422"	152°26'06.1582"	114.96	56	437261.32	9594742.59	43.9	-0.061	0.001
Nogoli Hides - Helipad	NOGO	PSM 30041	-5°56'02.4348"	142°47'16.7455"	1340.20	54	697930.59	9343770.78	1257.5	0.032	0.054
Pomio	JACQ	PSM 9515	-5°38'42.9782"	151°30'19.6067"	151.55	56	334476.29	9375795.22	77.3	0.020	-0.053
Popondetta	POPN	PSM 9371	-8°46'09.6499"	148°14'00.3966"	187.53	55	635667.54	9030425.34	106.8	0.024	0.054
Port Moresby - NMB Base	MORE	PSM 15832	-9°26'02.7696"	147°11'12.2016"	116.74	55	520498.42	8957148.59	41.3	0.028	0.053
Rabaul - RVO Base	RVO_	RVO	-4°11'27.1915"	152°09'49.5108"	266.24	56	407190.52	9536723.33	191.9	0.007	-0.052
Tokua - Airport	TOKU	GS 9822	-4°20'27.7832"	152°22'45.8215"	82.05	56	431137.64	9520146.01	9.5	-0.010	-0.036
Vanimo - Doppler	VANI	PM 63/1	-2°41'05.2819"	141°18'15.6562"	80.59	54	533829.65	9703242.49	3.4	0.013	0.045
Wankkun - Pillar	NM34	NM/J/34	-6°08'52.0739"	146°04'52.4422"	509.98	55	398344.12	9320370.15	436.7	0.026	0.047
Wau - MCG Base New	WAU1	WAU1	-7°20'57.0996"	146°42'55.7613"	1224.79	55	468599.31	9187638.65	1144.5	0.025	0.056
Wewak - Airport	WEWK	PSM 15497	-3°35'02.5848"	143°40'00.1481"	83.91	54	796268.18	9603418.22	5.8	0.017	0.053
Wuvulu	WUVU	PSM 15456	-1°44'07.5951"	142°50'10.0781"	79.03	54	704257.66	9808081.66	2.4	-0.068	0.019

Horizontal Coordinates - Positional Uncertainty < 0.05m, Ellipsoidal Heights - Uncertainty < 0.10m, MSL RLs - Uncertainty < 0.5m (except Lae & Kikori < 0.10m)

* **Coordinates require verification by resurvey**

A preliminary update for PNG94 showing selected stations

2. Obtain VALIDATED PNG94 coordinates

3. Obtain PSM sketches, plans & reports

4. Choose positioning equipment

>10 km dual-frequency GPS (static)

<10 km single-frequency GPS (static)

<5 km single-frequency GPS (RTK)

<5 km line of sight: total stations

What if no station within 50 km?

Use AUSPOS or Precise Orbit

If station is within 50 km from project AND on same plate

Use minimum of two dual-frequency receivers and static post-processing to connect to PNG94

Can use OmniSTAR-HP, but multiple observations from cold start up required over two days to isolate outliers.

How long should I observe for?

Table 1. Occupation times for different baseline lengths (good observing conditions)

Baseline length	dual - frequency (minutes)	single - frequency (minutes)
0-5 km	15	30
5-10 km	20	40
10-20 km	30	60+ 50% chance
20-30 km	40	unlikely
30-40 km	50	
40-50 km	60	
> 50 km*	300	

** over 50 km requires PPP such as AUSPOS or precise orbit.*
If using AUSPOS start obs after 10:00 PNG Time if possible.

If bad conditions (nearby trees, high grass, buildings, towers, periods of bad DOP or SV availability, or if >400m elevation difference on baseline, then double the time

AUSPOS best to get 24 hrs obs for best result

Receiver setup

Check free memory (download, backup and delete old files)

Set all observables recorded

10 second epoch (30 sec for AUSPOS)

elevation mask 10° (5°-15°)

LiDAR control requires 0.5 - 1 second epoch

Clear any trees or branches nearby to improve sky visibility

Station and antenna setup

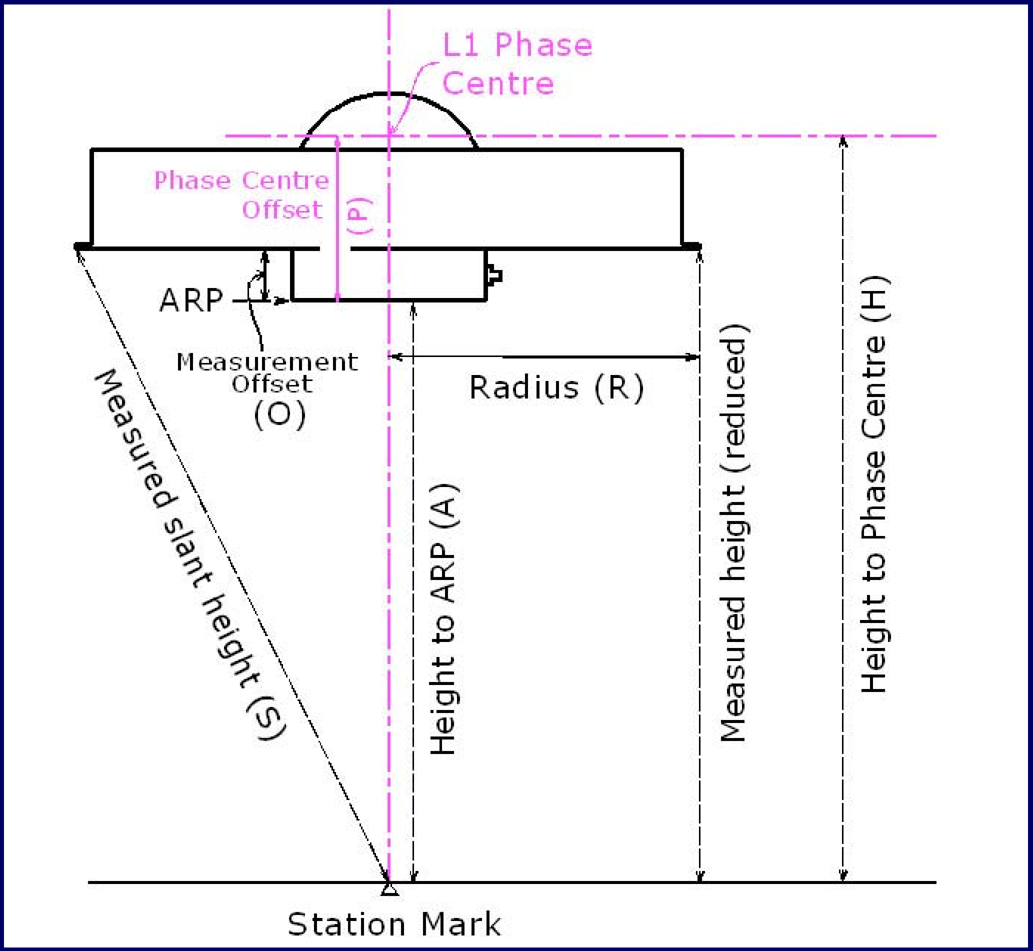
Check battery levels & eqpt.

Level and centre the antenna

Check centering with plumb-bob

measure antenna height (3 points)

kisim piksa



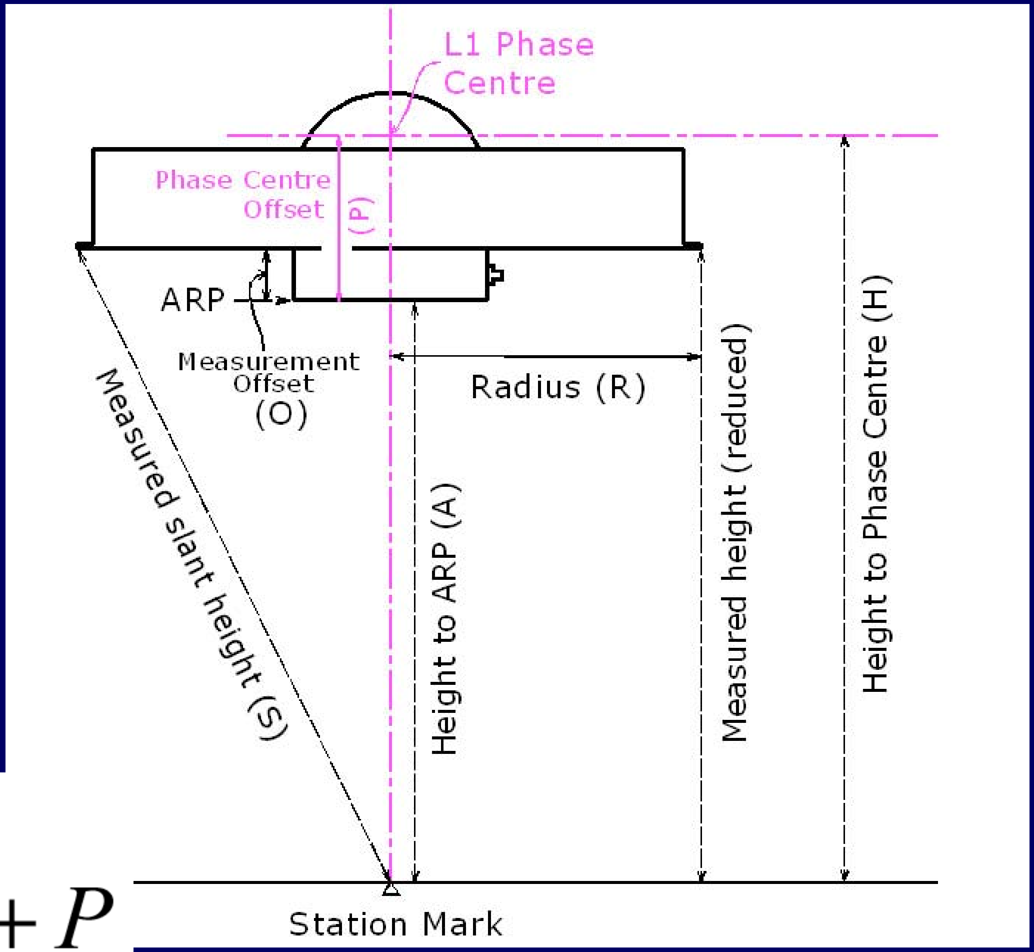
Site Log

GPS Occupation Log		Antenna sketch
Site ID or filename		show point where measurement
Station Name		to antenna is taken
Antenna type		
Antenna serial number		
Height measurement (start)		
Height measurement (end)		
Height to Phase Centre		
Date start		
Time start (PNG Time)		**Approximate position**
Time end (PNG Time)		Latitude
Date end		Longitude

Antenna heights (take care)

"Instrument height" is L1 antenna phase centre

"Antenna Reference Point (ARP)" is also commonly used



$$H = \sqrt{S^2 - R^2} - O + P$$

GPS data processing

Can use AUSPOS if no PNG94 reference station used, or for QA

Or use static baseline processing using carrier-phase observations

May need software to convert receiver raw data to RINEX (Receiver Independent Exchange Format) if different receivers used and for AUSPOS

AUSPOS http://www.ga.gov.au/bin/gps.pl

AUSPOS

Dual-frequency RINEX file required

Need 1 hr obs for +/- 20 cm

Need 6 hrs obs for +/- 2 cm

Should wait 2-3 days to get Rapid Orbit

Should wait 2-3 weeks to get Final Orbit

AUSPOS http://www.ga.gov.au/bin/gps.pl

GDA94 and ITRF report sent by email

Ignore GDA94 and ITRF needs to be converted to PNG94 using site velocity

Using a site velocity model?

Need to convert AUSPOS ITRF ellipsoid or cartesian coordinates to UTM (using geographical calculator)

The site velocity is the rate of change of coordinates due to overall tectonic movement (refer to Stanaway)

$$E_{PNGMG} = E_{UTM(ITRF)} + V_E(1994.0 - Y_M)$$

$$N_{PNGMG} = N_{UTM(ITRF)} + V_N(1994.0 - Y_M)$$

E_{PNGMG} and N_{PNGMG} are the PNG Map Grid Coords.

$E_{UTM(ITRF)}$ and $N_{UTM(ITRF)}$ are the ITRF/WGS84 UTM Coords at the time of measurement

V_E and V_N are site velocity components (Easting and Northing)

1994.0 and Y_M is the reference epoch and measurement epoch

Baseline Processing

Setup project (can use WGS84 & UTM parameters)

Zone 54 South between the Indonesian border and 144° E
Zone 55 South between 144° E and 150° E
Zone 56 South between 150° E and 156° E

Use EGM96 Geoid if available

Load raw or RINEX data

Enter known PNG94 coordinates and ellipsoid height for validated PNG94 reference station (set as fixed)

Leave ? for orthometric (MSL) height

Run the baseline processing

Baseline assessment

Should use “fixed” solution as “float” solution often unreliable for cm accuracy surveys

Shouldn’t use code solution for accurate surveys

L1 fixed or narrow lane fixed

L1/L2 fixed or ionospheric free fixed

If you get a float or code solution, reobserve the baseline for longer or improved conditions

RMS should be between 0.004 and 0.030

Reference variance ideally 1, but up to 10 OK

Ratio 1:n   the higher n is the better (>10)

Reobserve if outside tolerances

Observe new station from different station (compare)

Obtaining MSL values

Baseline processing or AUSPOS will give MSL values using the EGM96 geoid model if selected

If possible observe at a nearby 1st order MSL station (i.e. next to tide gauges) otherwise at any existing high order MSL station used as existing height datum

Compare EGM96 MSL with existing MSL. The difference is correction to be applied to all other EGM96 derived heights

Compare EGM96 MSL with existing MSL. The difference is correction to be applied to all other EGM96 derived heights

$$MSL_{local} = h - N_{EGM96} + c$$

$$c = MSL_{localdatum} - MSL_{EGM96}$$

EGM96 available on web if not built in to processing software, or use older PNG geoid model

Using RTK for control surveys

Should use post-processing for better reliability

RTK can be used for local < 5 km range control

Check that a geoid model is used in the system

Should not do RTK when DOP high or satellite availability is low

Before racing off, check the performance of the RTK by observing another fixed station first

Must do repeat measurement on different day at a different time of the day

Can use site calibration but geometry must be good (must span survey area)

Compute AGD66 transformations (if required)

Compare PNG94 values with existing AGD66 tabulated data from high order stations used for earlier surveys

Mean difference in Eastings and Northings for project area (PNGMG - AMG)

4 parameter - compute joins between stations on the two datums - compute swing and scale c hange as well as translation (or do least squares estimation)

Don't use any default software parameters if accuracy better than 5 metres is required

Setting up a project plane grid

Can't use PNGMG or AMG coordinates for engineering or cadastral surveys where ground distances are required

Scale factor of 1 often used with PNGMG/AMG coords
MUST NOT DO THIS OR BIG ERRORS WILL HAPPEN

Scale factor can be very different from 1, especially at high elevations near the central meridian

Choose a local origin at centre of project area (mean coordinates and height of project)

Use same azimuth and drop "sleeping" figures off PNGMG/AMG coordinates so they are more manageable

Can extend Plane grid 10 km away from datum or less if there are large elevation changes

Plane Grid conversions

$$E_{PLANE} = E0_{PLANE} + \frac{1}{k_p}(E_{PNGMG} - E0_{PNGMG}) \quad \text{(Eq. 4.11)}$$

$$N_{PLANE} = N0_{PLANE} + \frac{1}{k_p}(N_{PNGMG} - N0_{PNGMG}) \quad \text{(Eq. 4.12)}$$

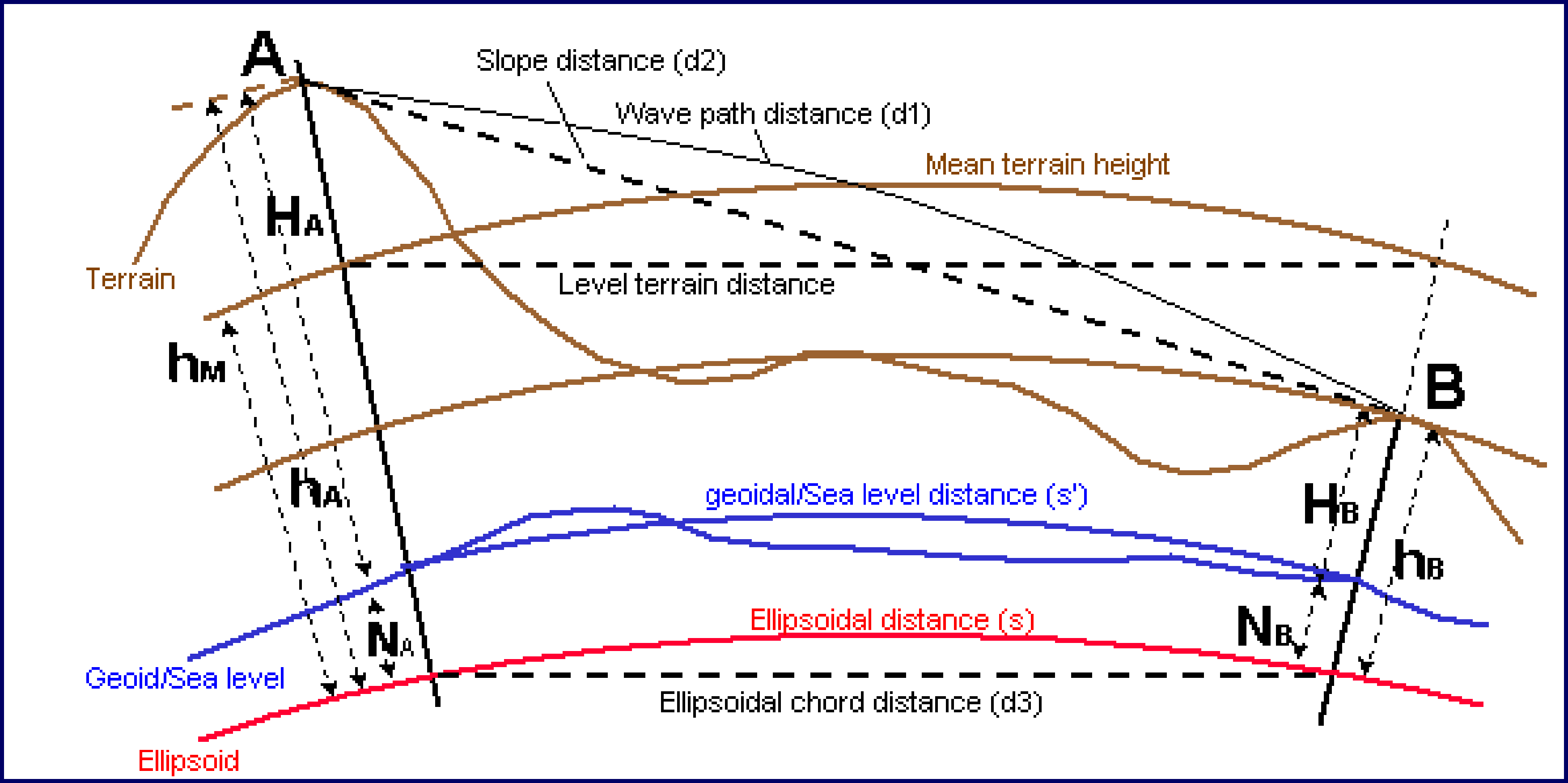
$$E_{PNGMG} = E0_{PNGMG} + k_p(E_{PLANE} - E0_{PLANE}) \quad \text{(Eq. 4.13)}$$

$$N_{PNGMG} = N0_{PNGMG} + k_p(N_{PLANE} - N0_{PLANE}) \quad \text{(Eq. 4.14)}$$

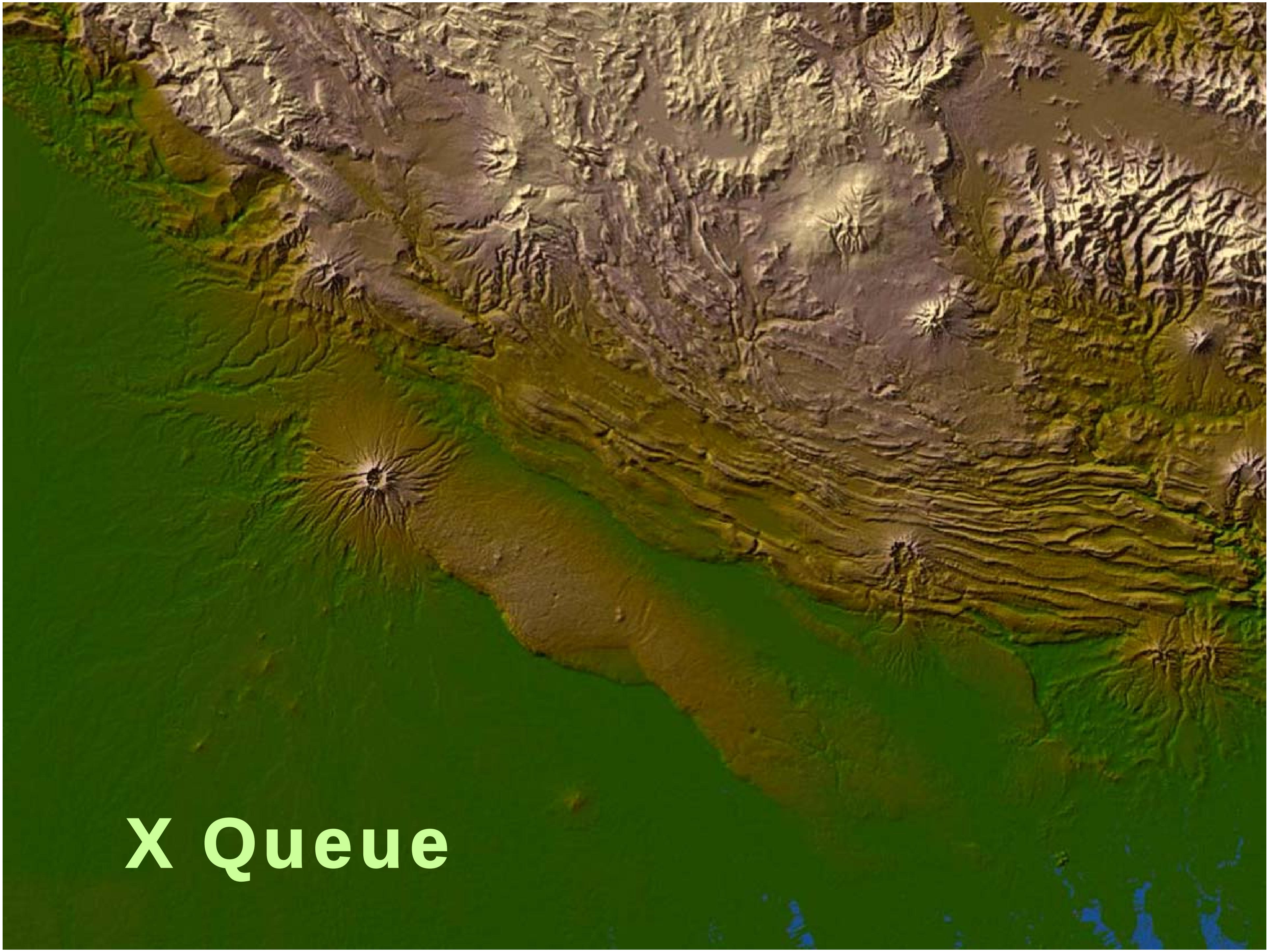
where,

E_{PLANE} & N_{PLANE} are the local plane coordinates
E_{PNGMG} & N_{PNGMG} are the PNGMG coordinates to be converted
$E0_{PLANE}$ & $N0_{PLANE}$ are the Plane coordinates of the Plane datum origin
$E0_{PNGMG}$ & $N0_{PNGMG}$ are the PNGMG coordinates of the Plane datum Origin
k_p is the is the combined PNGMG Grid and Height scale factor at the Plane Origin

Distances



A
Slope distance (d2)
Wave path distance (d1)
Mean terrain height
HA
Terrain
Level terrain distance
hM
B
hA
geoidal/Sea level distance (s')
HB
hB
Ellipsoidal distance (s)
NB
NA
Geoid/Sea level
Ellipsoidal chord distance (d3)
Ellipsoid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