Australian Government
Geoscience Australia

Pacific Community
Communauté du Pacifique

GNSS CORS in the Pacific

FIG References Frame in Practice Seminar

Operational Aspects of GNSS CORS Technical Workshop

Holiday Inn, Suva - Fiji

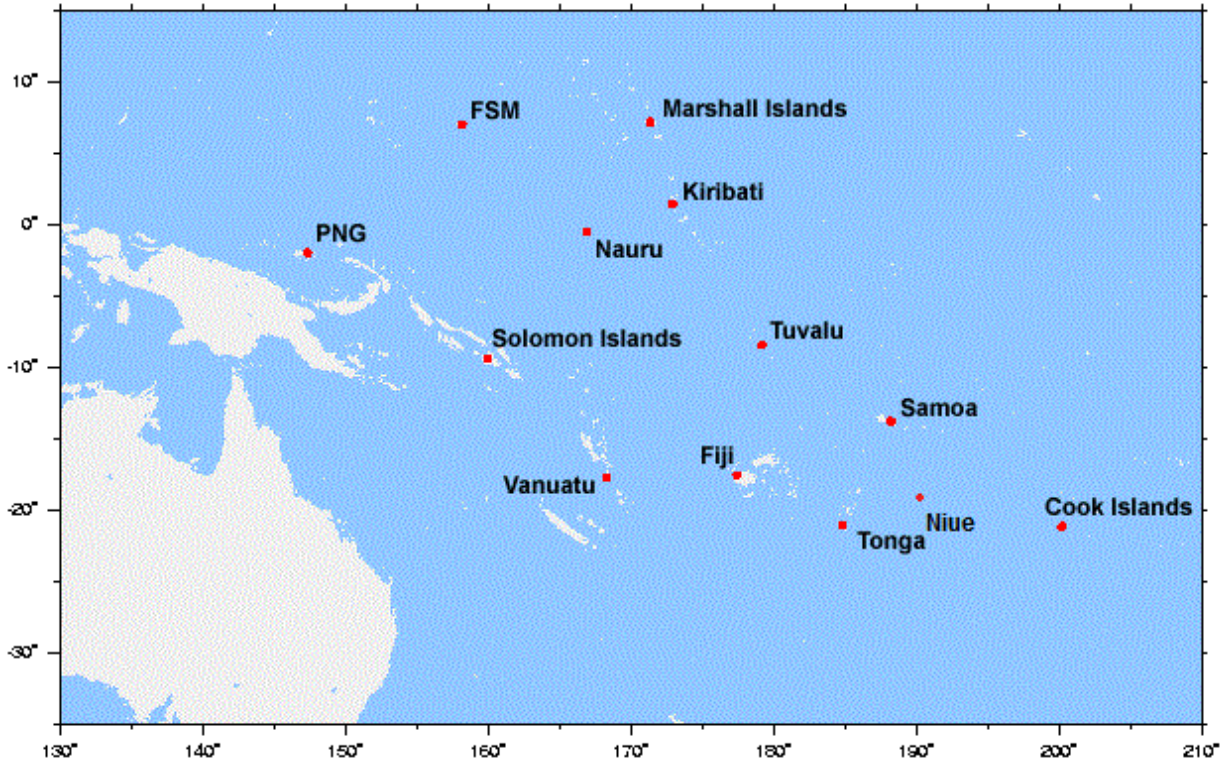
PGSC Partnership Desk, GEM Division, Pacific Community (SPC)

National Geodesy & GNSS Networks Team, Geoscience Australia

18 September 2018

REGIONAL NETWORKS

- **SPRGN** – South Pacific Regional GNSS Network
  - 14 GNSS COR Stations
  - 13 Pacific Island Countries
  - Managed by GA, with the assistance of local government Lands & Survey or Weather offices



REGIONAL NETWORKS

Australian Government
Geoscience Australia

Pacific Community
Communauté du Pacifique

- **SPRGN** – South Pacific Regional GNSS Network

REGIONAL NETWORKS

Australian Government
Geoscience Australia

Pacific Community
Communauté du Pacifique

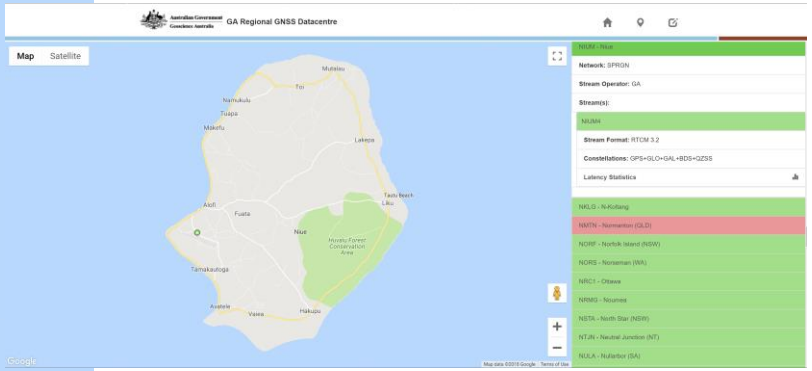
- **SPRGN** – South Pacific Regional GNSS Network

REAL TIME GNSS NETWORK

- AUSCORS NTRIP Broadcaster
- Geoscience Australia (GA) provides 1 Hz data streaming from our Global Navigation Satellite System (GNSS) stations throughout Australia, Antarctica and the Pacific, with a mean latency of below 2 seconds.

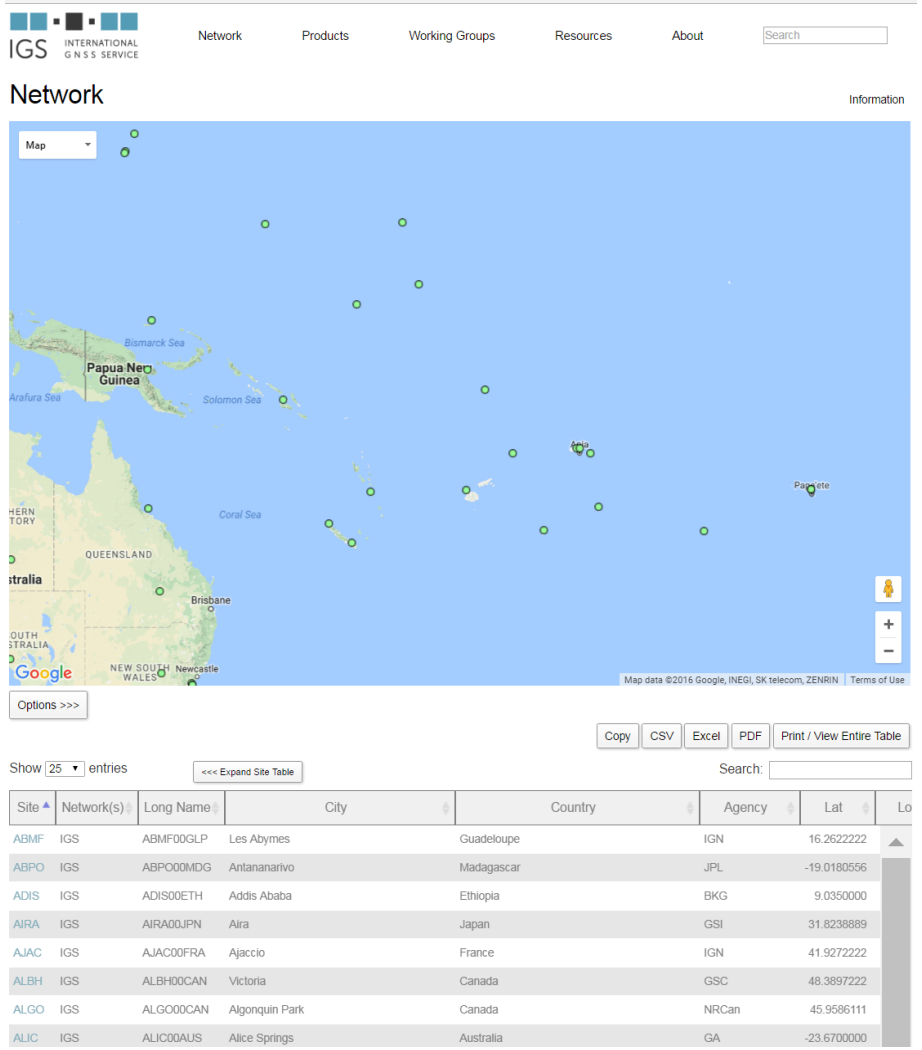
The SPRGN GNSS CORS network was established primarily for scientific research, in particular the monitoring of crustal deformation and tectonic motion.

Real-time data is an additional benefit of these networks

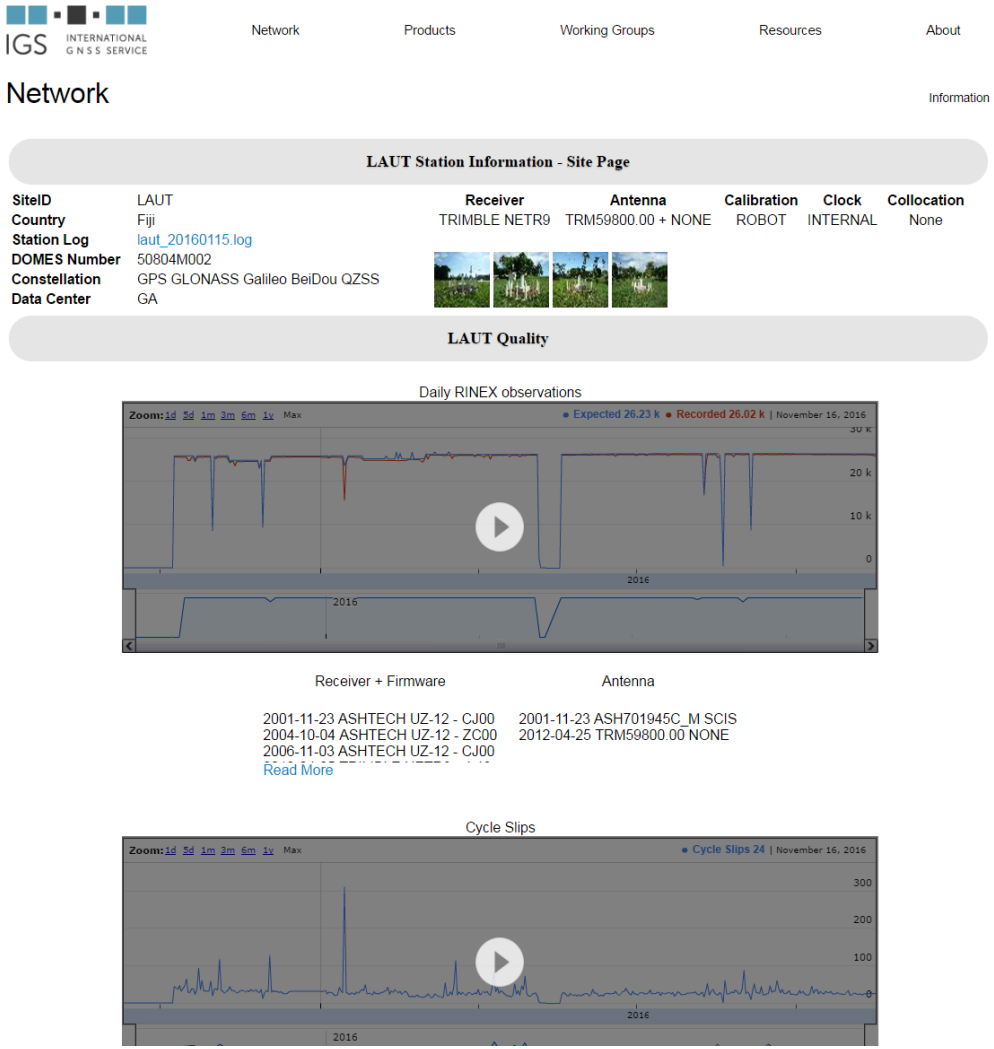


GNSS STATION (CORS) – LAUTOKA, FIJI.

- IGS Network



http://www.igs.org/network



http://www.igs.org/igsnetwork/network_by_site.php?site=laut

COSPPac

Climate and Oceans Support Program in the Pacific

Australian Government Bureau of Meteorology

Australian Government Geoscience Australia

Pacific Community Communauté du Pacifique

The **Pacific Sea Level & Geodetic Monitoring Project (PSLGMP)**, operates under the Climate and Oceans Support Program in the Pacific (COSPPac). It is a continuation of the 20-year South Pacific Sea Level and Climate Monitoring Project (SPSLCMP) since 1991

Comprises of a tide gauge network component, and geodetic monitoring component (GNSS CORS)

- To monitor sea level over a long time period, vertical crustal movement of the earth needs to be accounted for, to provide an absolute reading from the tide gauge

Geodetic monitoring component is maintained by Geoscience Australia

- Providing a Long term height time series of data
- Providing a Long term GNSS CORS data
- In a consistent, accurate, global geocentric terrestrial reference frame – ITRF2008
- Meeting accuracy requirements to match the expected sea level rise determined from over a century previous global tide gauge measurements of 1mm/annum

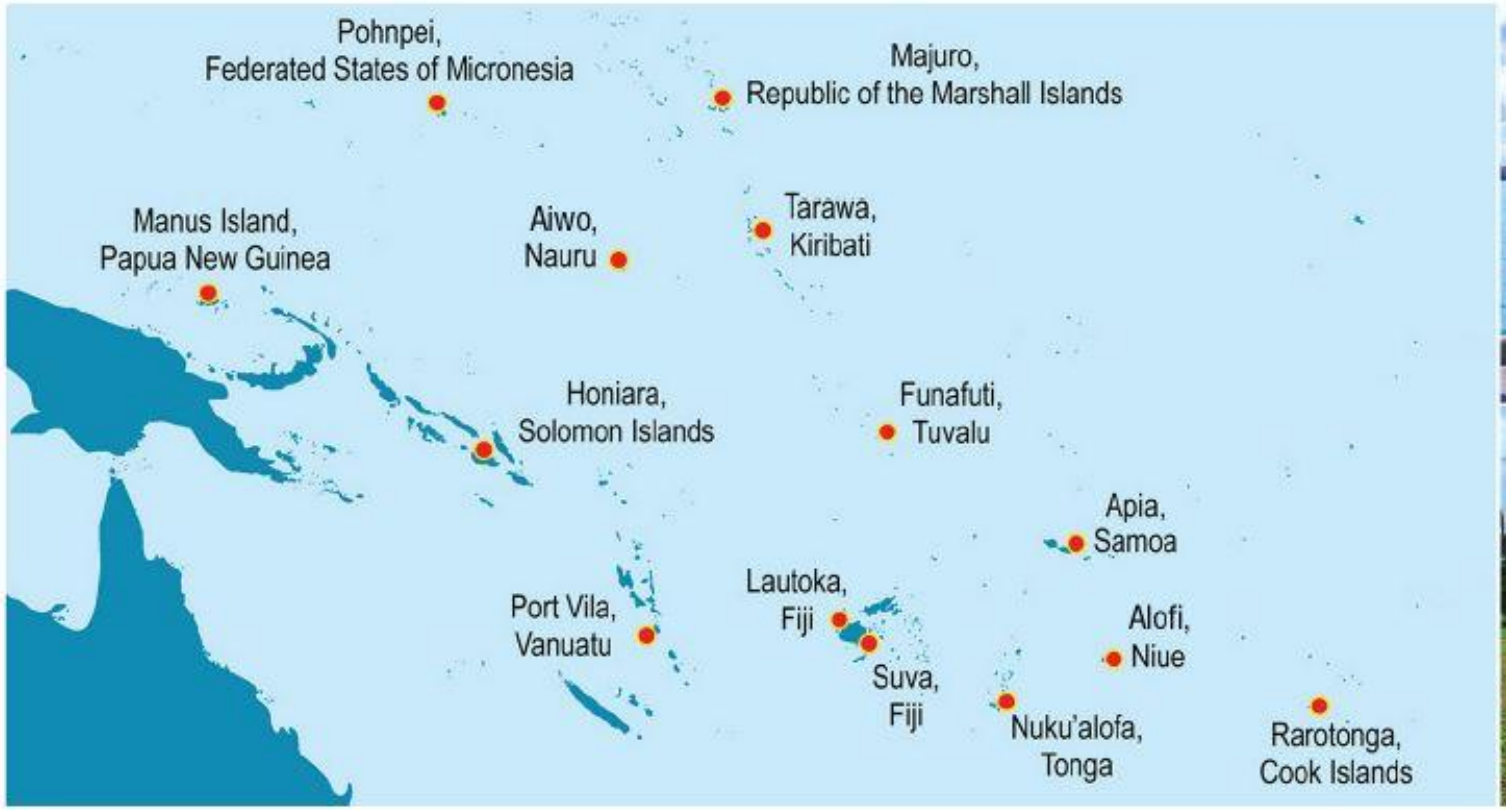
PACIFIC SEA LEVEL & GEODETIC MONITORING PROJECT

Pacific Community
Communauté du Pacifique

Earth Monitoring: Permanent GNSS CORS

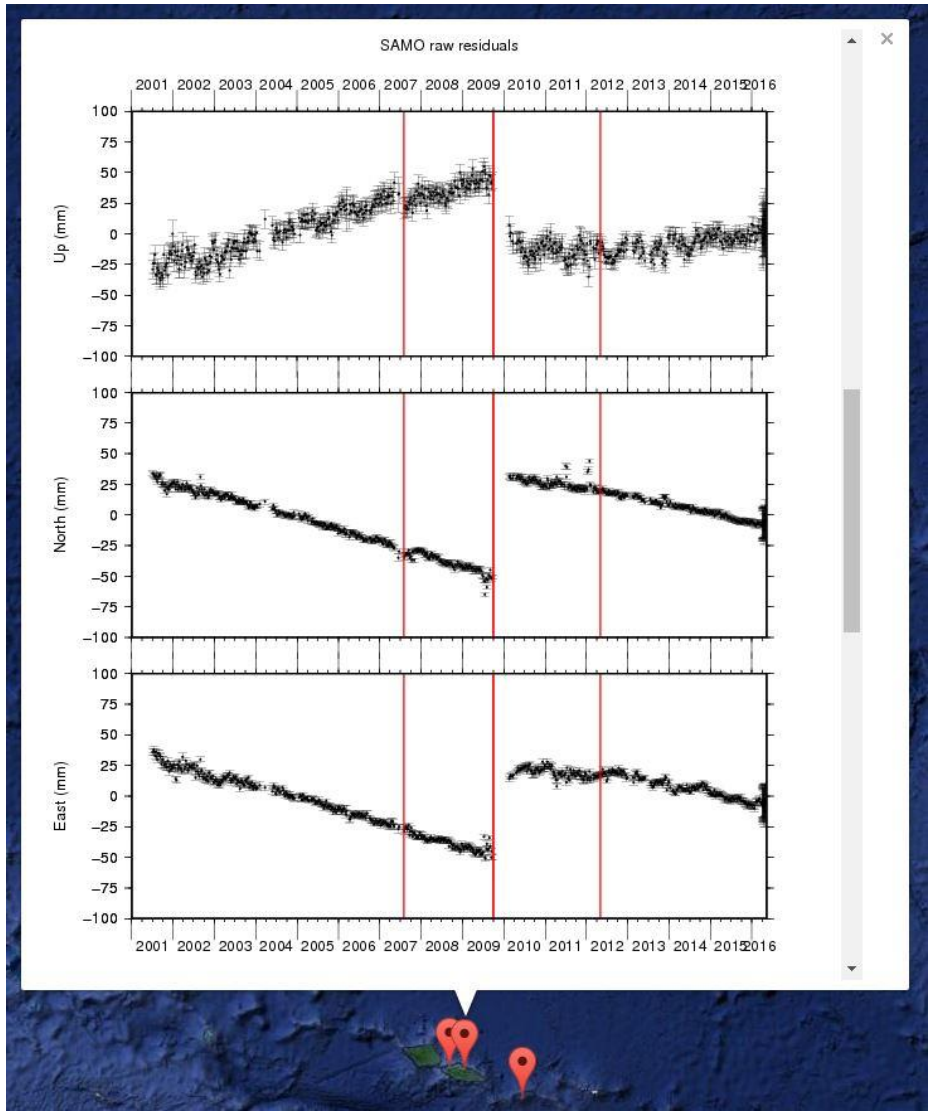
Sea Level Monitoring: Permanent SEAFRAME station with continuous monitoring of instantaneous sea level

Co-Location of this equipment at 13 sites in the region:



PACIFIC SEA LEVEL & GEODETIC MONITORING PROJECT

Pacific Community
Communauté du Pacifique



Geodetic Coordinates and Velocities (ITRF2008)

Position: longitude (degrees minutes seconds), latitude (degrees minutes seconds), height (GRS80, metres)
Velocity: East, North, Height (metres per year), Coordinate Epoch

```
MAC1 2 50135M001 C 158 56 8.9906 -54 -29 -58.2991 -6.8214 -0.0113 0.0318
-0.0025 01-Jan-15

MAC1 3 50135M001 C 158 56 8.9906 -54 -29 -58.2992 -6.8203 -0.0113 0.0318
-0.0025 01-Jan-15

MAC1 4 50135M001 C 158 56 8.9897 -54 -29 -58.3004 -6.8166 -0.0114 0.0318
-0.0025 01-Jan-15

MAC1 5 50135M001 C 158 56 8.9894 -54 -29 -58.3006 -6.8117 -0.0114 0.0318
-0.0025 01-Jan-15
```

Station Events

```
MAC1 1 27-Jun-95 receiver change

MAC1 2 25-Mar-98 EQ M8.1 - Balleny Islands region

MAC1 3 23-Dec-04 EQ M8.1 - north of Macquarie Island

MAC1 4 22-Jun-12 EQ M5.7 - Macquarie Island region

MAC1 1 23-Dec-04 EQ M8.1 - north of Macquarie Island
```

Estimated Discontinuities

```
Offset: MAC1 50135M001 2 to MAC1 50135M001 3 is -0.0000 -0.0041 0.0011 East,
North, Up (metres)

Offset: MAC1 50135M001 3 to MAC1 50135M001 4 is -0.0164 -0.0369 0.0038 East,
North, Up (metres)

Offset: MAC1 50135M001 4 to MAC1 50135M001 5 is -0.0047 -0.0064 0.0048 East,
North, Up (metres)
```

Useful links

RINEX data used in this computation.

Full SINEX format solution files.

```
Last updated: Monday, 31 October 2016 3:17:30 PM EST
```

PACIFIC SEA LEVEL & GEODETIC MONITORING PROJECT

GNSS CORS Data Access

Australian Government
Geoscience Australia

GA Regional GNSS Datacentre

AUSCORS NTRIP Broadcaster

Geoscience Australia (GA) provides 1 Hz data streaming from our Global Navigation Satellite System (GNSS) stations throughout Australia, Antarctica and the Pacific. The data is distributed via the AUSCORS Ntrip Broadcaster. Access to the data is free, however a username and password is required. The real-time data is made available through an RTCM standard transmitted over the Internet using the NTRIP (Network Transport of RTCM via Internet Protocol).

To connect you will need:

- Username and password,
- NTRIP client and internet access,
- Connection details.

Register for an Account

Connection Details

Host Domain	auscors.ga.gov.au
Port	2101

PACIFIC SEA LEVEL & GEODETIC MONITORING PROJECT

Pacific Community
Communauté du Pacifique

GNSS CORS Data Access

Index of /geodesy-outgoing/gnss/data

[parent directory]

Name	Size	Date Modified
campaign/		5/16/13, 12:00:00 PM
Creative_Commons_Copyright_Authorisation.txt	748 B	11/15/12, 1:00:00 PM
daily/		1/2/18, 1:00:00 PM
GA_NTRIPCaster_Info.txt	3.6 kB	1/18/13, 1:00:00 PM
GNSS_data_Readme.txt	4.7 kB	11/4/12, 1:00:00 PM
highrate/		1/1/18, 1:00:00 PM
hourly/		1/1/18, 1:00:00 PM
sprgn/		1/2/18, 1:00:00 PM

ftp://ftp.ga.gov.au/geodesy-outgoing/gnss/

Index of /geodesy-outgoing/gnss/data/highrate/2018/18001/23/

[parent directory]

Name	Size	Date Modified
00na001x00.18d.Z	248 kB	1/1/18, 1:00:00 PM
00na001x15.18d.Z	213 kB	1/1/18, 1:00:00 PM
00na001x30.18d.Z	251 kB	1/1/18, 1:00:00 PM
00na001x45.18d.Z	235 kB	1/2/18, 1:00:00 PM
02na001x00.18d.Z	110 kB	1/1/18, 1:00:00 PM
02na001x15.18d.Z	103 kB	1/1/18, 1:00:00 PM
02na001x30.18d.Z	98.5 kB	1/1/18, 1:00:00 PM
02na001x45.18d.Z	102 kB	1/2/18, 1:00:00 PM
alby001x00.18d.Z	258 kB	1/1/18, 1:00:00 PM
alby001x15.18d.Z	257 kB	1/1/18, 1:00:00 PM
alby001x30.18d.Z	245 kB	1/1/18, 1:00:00 PM
alby001x45.18d.Z	237 kB	1/2/18, 1:00:00 PM
alic001x00.18d.Z	202 kB	1/1/18, 1:00:00 PM
alic001x15.18d.Z	200 kB	1/1/18, 1:00:00 PM
alic001x30.18d.Z	181 kB	1/1/18, 1:00:00 PM
alic001x45.18d.Z	183 kB	1/2/18, 1:00:00 PM
anda001x00.18d.Z	220 kB	1/1/18, 1:00:00 PM
anda001x15.18d.Z	218 kB	1/1/18, 1:00:00 PM
anda001x30.18d.Z	214 kB	1/1/18, 1:00:00 PM
anda001x45.18d.Z	194 kB	1/2/18, 1:00:00 PM

ftp://ftp.ga.gov.au/geodesy-outgoing/gnss/data/highrate/2018/

Index of /geodesy-outgoing/gnss/data/sprgn/2018/

[parent directory]

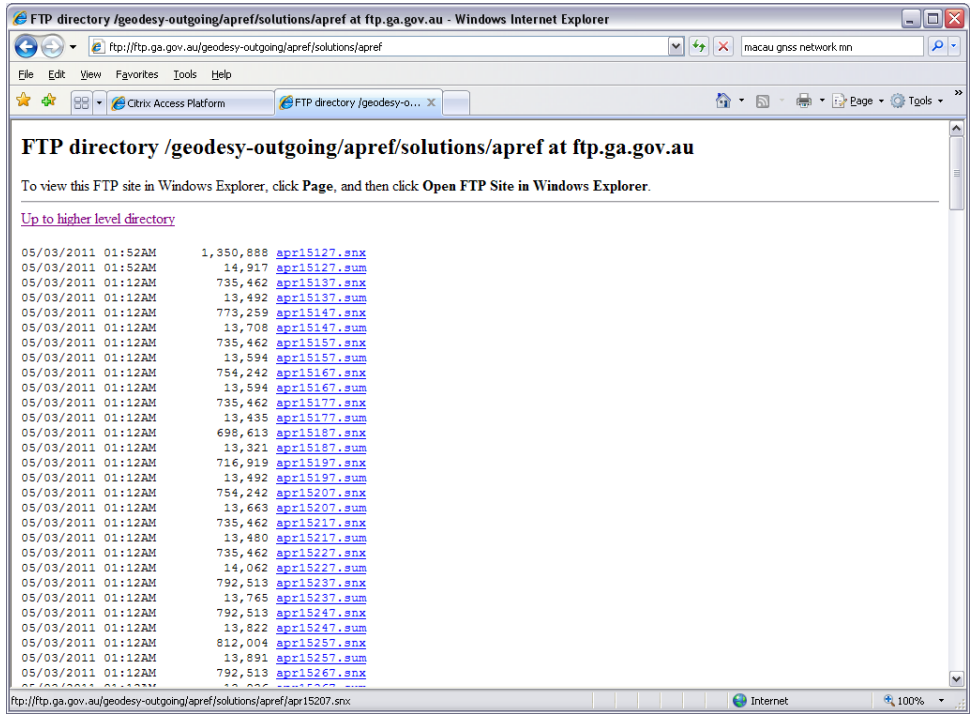
Name	Size	Date Modified
18001/		1/2/18, 1:00:00 PM
18002/		1/3/18, 1:00:00 PM
18003/		1/4/18, 1:00:00 PM
18004/		1/5/18, 1:00:00 PM
18005/		1/6/18, 1:00:00 PM
18006/		1/10/18, 1:00:00 PM
18007/		1/10/18, 1:00:00 PM
18008/		1/10/18, 1:00:00 PM
18009/		1/10/18, 1:00:00 PM
18010/		1/11/18, 1:00:00 PM

ftp://ftp.ga.gov.au/geodesy-outgoing/gnss/data/sprgn/2018

PACIFIC SEA LEVEL & GEODETIC MONITORING PROJECT

Pacific Community
Communauté du Pacifique

Weekly SINEX Files



Weekly station coordinates

ITRF2008 Cartesian Coordinates (X,Y,Z) @ 22/06/2011

00NA 59975M001	-4073662.2922	4712064.7447	-1367874.4683
01NA 59974M001	-4084823.4609	4702026.6604	-1369125.8453
02NA 59973M001	-4078496.4549	4711380.1330	-1355915.1332
20NA 59972M001	-4050985.3396	4212133.7934	-2547954.8094
21NA AUM000184	-4048578.9364	4210151.5056	-2554917.6069
ADEL AUM000008	-3926936.9094	3461614.4215	-3631644.2263
ALBU AUM000009	-4324312.5655	2817311.0325	-3735264.7605
ALBY 50191M001	-2441714.5963	4629128.5358	-3633363.2024

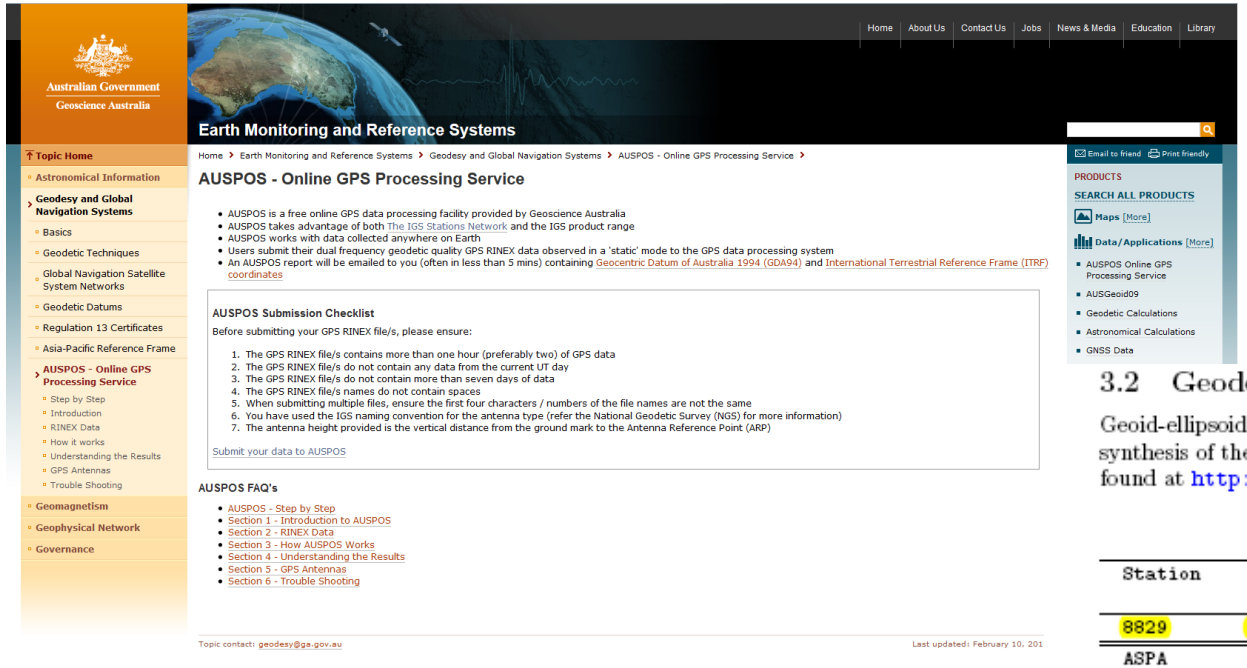
Weekly station performance

Total number of stations: 303

Station	#Days	Weekday 0123456	Repeatability (mm) N	E	U
00NA 59975M001	7	XXXXXXX	0.48	1.18	1.87
01NA 59974M001	7	XXXXXXX	0.54	1.61	5.80
02NA 59973M001	7	XXXXXXX	0.79	1.95	3.59
20NA 59972M001	7	XXXXXXX	0.41	1.29	2.00
21NA AUM000184	7	XXXXXXX	0.61	1.65	0.98
ADEL AUM000008	7	XXXXXXX	1.28	1.19	4.02
ALBU AUM000009	7	XXXXXXX	1.64	0.98	5.10
ALBY 50191M001	7	XXXXXXX	1.62	2.87	4.30
ALIC 50137M001	4	XXXX	0.28	1.26	1.47
ANDA 59971M001	7	XXXXXXX	0.64	0.87	1.74
ANTW AUM000010	7	XXXXXXX	1.47	0.83	3.70
APOL AUM000011	7	XXXXXXX	1.44	1.44	7.61
APSL AUM000012	7	XXXXXXX	3.27	1.23	5.96
ARMD AUM000143	7	XXXXXXX	0.60	1.42	2.74
ARTU 12362M001	5	XXXXX	3.16	2.20	3.20
ASPA 50503S006	7	XXXXXXX	2.39	2.88	12.17
AUCK 50209M001	7	XXXXXXX	1.27	1.66	4.47
AUKT 50216M001	7	XXXXXXX	1.63	1.66	4.81
BAIR AUM000015	7	XXXXXXX	1.14	1.06	5.46
BAKO 23101M002	7	XXXXXXX	2.97	3.40	10.00
BALN AUM000180	7	XXXXXXX	0.40	1.24	3.82
BAN2 22306M003	7	XXXXXXX	2.74	2.94	7.17
BBOO 59997M001	7	XXXXXXX	0.62	0.80	1.46
BDLE 50196M001	7	XXXXXXX	1.73	2.46	2.46
BDST 59981M001	7	XXXXXXX	0.80	1.43	2.86

PACIFIC SEA LEVEL & GEODETIC MONITORING PROJECT

Pacific Community
Communauté du Pacifique



Home › Earth Monitoring and Reference Systems › Geodesy and Global Navigation Systems › AUSPOS - Online GPS Processing ›

Number of RINEX files 1 ▼	Submit RINEX using ◉ upload ○ ftp	
File Name	Height (m)	Antenna Type
Choose File No file chosen	0.0000	DEFAULT(NONE) ▼
Your Email Address:		

submit | start over

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

3.2 Geodetic, GRS80 Ellipsoid, ITRF2008

Geoid-ellipsoidal separations, in this section, are computed using a spherical harmonic synthesis of the global EGM2008 geoid. More information on the EGM2008 geoid can be found at http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm2008/

Station	Latitude (DMS)	Longitude (DMS)	Ellipsoidal Height(m)	Derived Above Geoid Height(m)
8829	-18 14 55.15475	178 06 07.97027	59.744	3.114
ASPA	-14 19 33.93487	-170 43 20.77496	53.603	20.979
AUCK	-36 36 10.22511	174 50 03.78953	132.704	97.771
CORM	-36 51 55.54545	175 44 58.40878	170.256	135.958
FALE	-13 49 55.95936	-171 59 58.30917	47.534	9.674
KOUC	-20 33 31.28498	164 17 14.41583	84.139	23.692
KTIA	-35 04 08.14239	173 16 23.19787	127.460	89.116
LAUT	-17 36 31.72253	177 26 47.69241	89.684	31.724
NIUM	-19 04 35.49319	-169 55 37.44949	89.719	59.100
NORF	-29 02 36.04074	167 56 19.79789	159.020	112.175
SAMO	-13 50 57.14873	-171 44 18.32831	76.798	39.557
TONG	-21 08 40.96854	-175 10 45.17531	56.315	3.745
WARK	-36 26 03.87585	174 39 46.00782	111.288	75.851
WHNG	-35 48 13.56175	174 18 52.44164	172.805	135.377

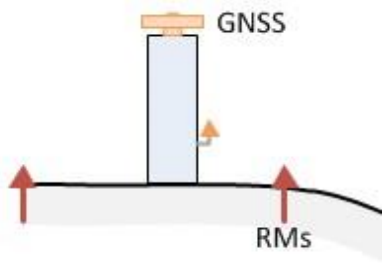
AUSPOS 2.0 Job Number: # 7656
User: andrick at sopac org

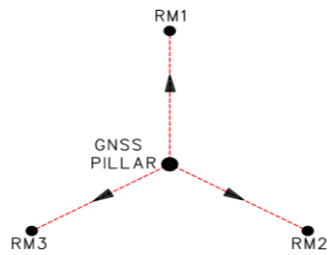
3

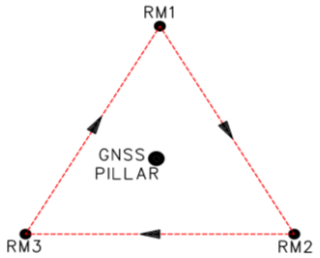
©Commonwealth of Australia (Geoscience Australia) 2012

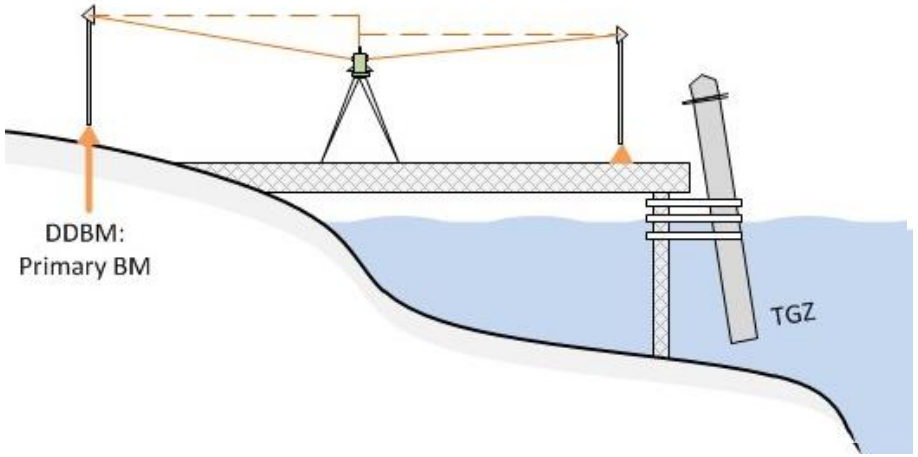
PACIFIC SEA LEVEL & GEODETIC MONITORING PROJECT

- Increasing the confidence of measurements:
  - Local deformation of equipment



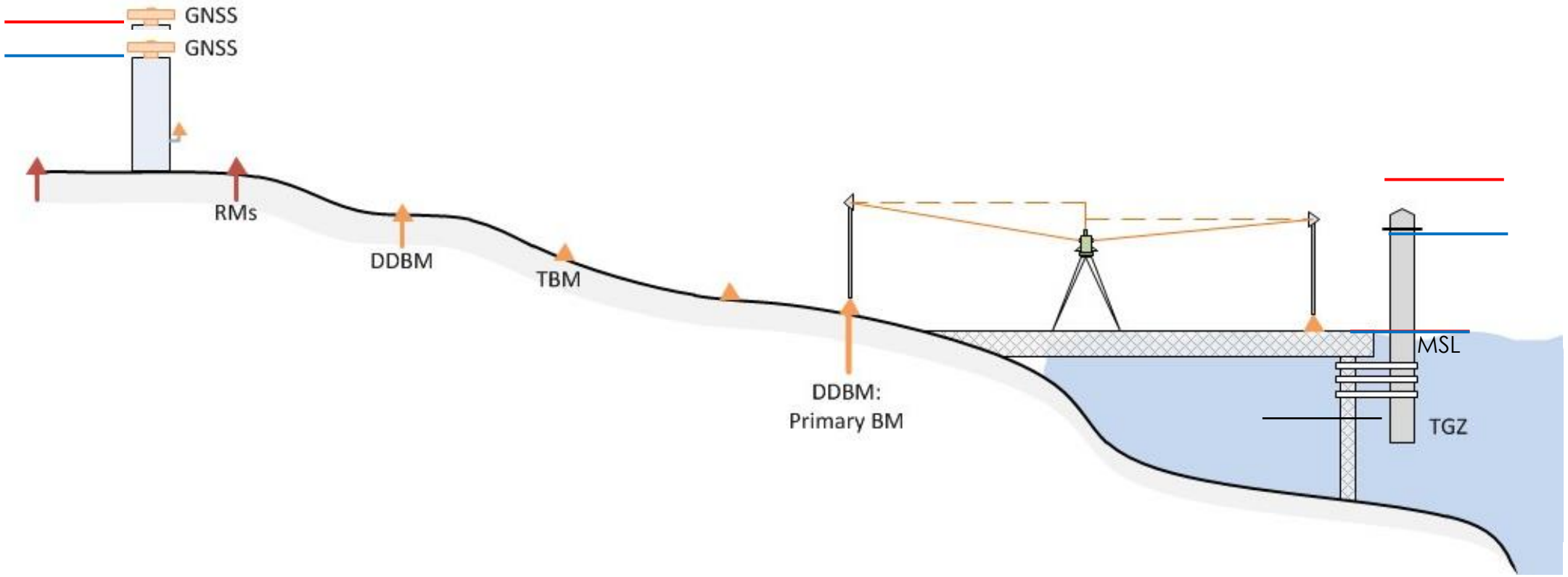






PACIFIC SEA LEVEL & GEODETIC MONITORING PROJECT

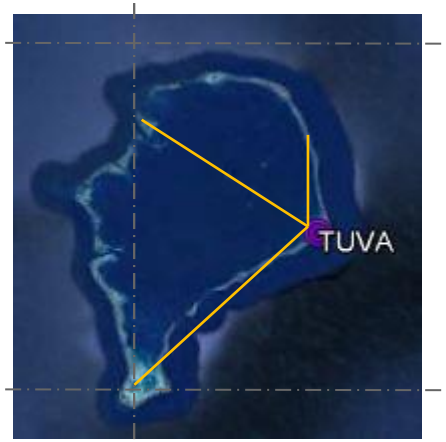
- Increasing the confidence of measurements:
  - Validation of tide gauge readings



We can measure the movement of the land using GNSS CORS

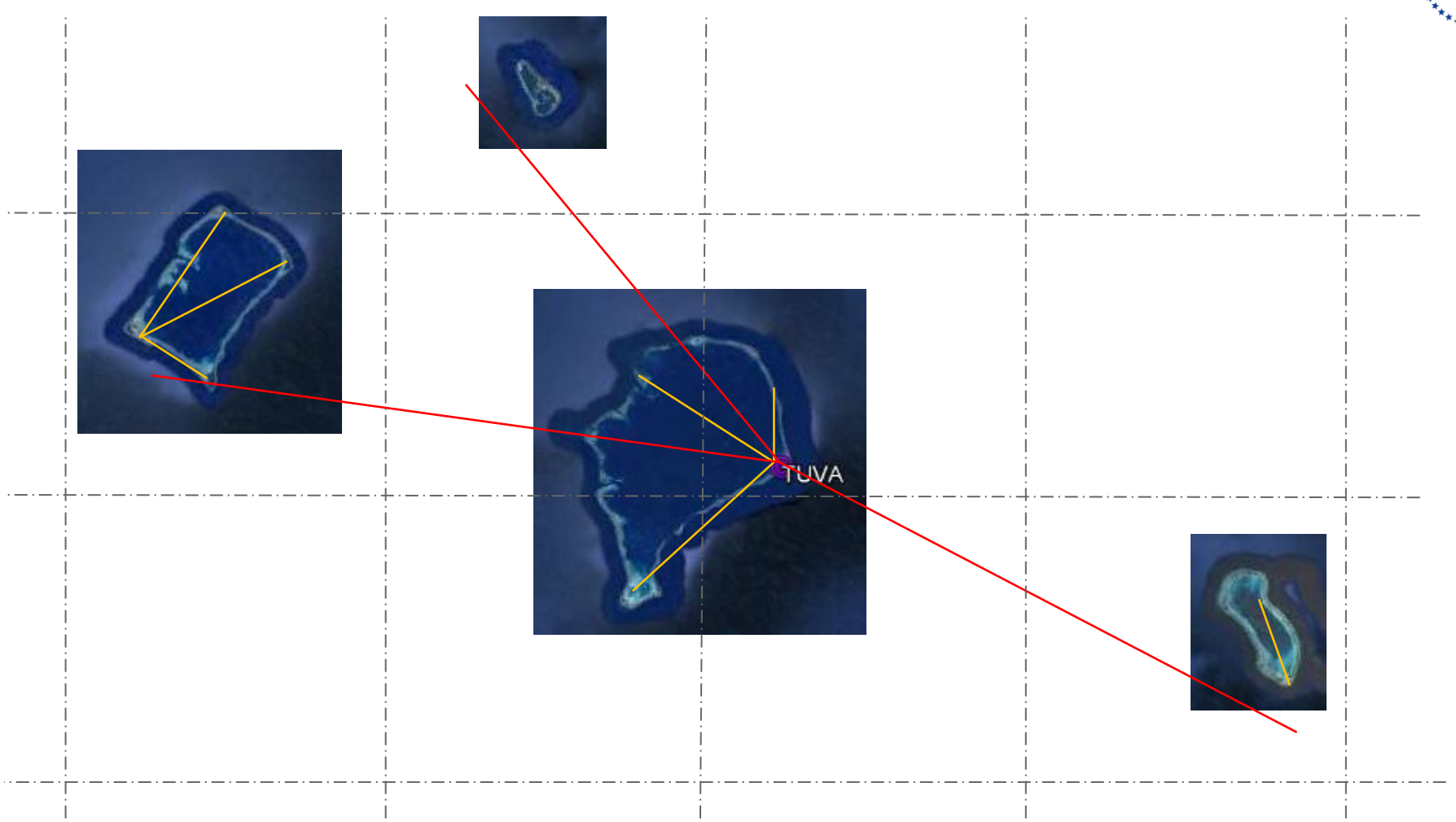
BENEFITS OF GNSS CORS TO LOCAL SURVEYING

- A local GNSS CORS site can provide the opportunity to preform accurate baseline measurements when the user only has 1 geodetic quality GNSS receiver available.

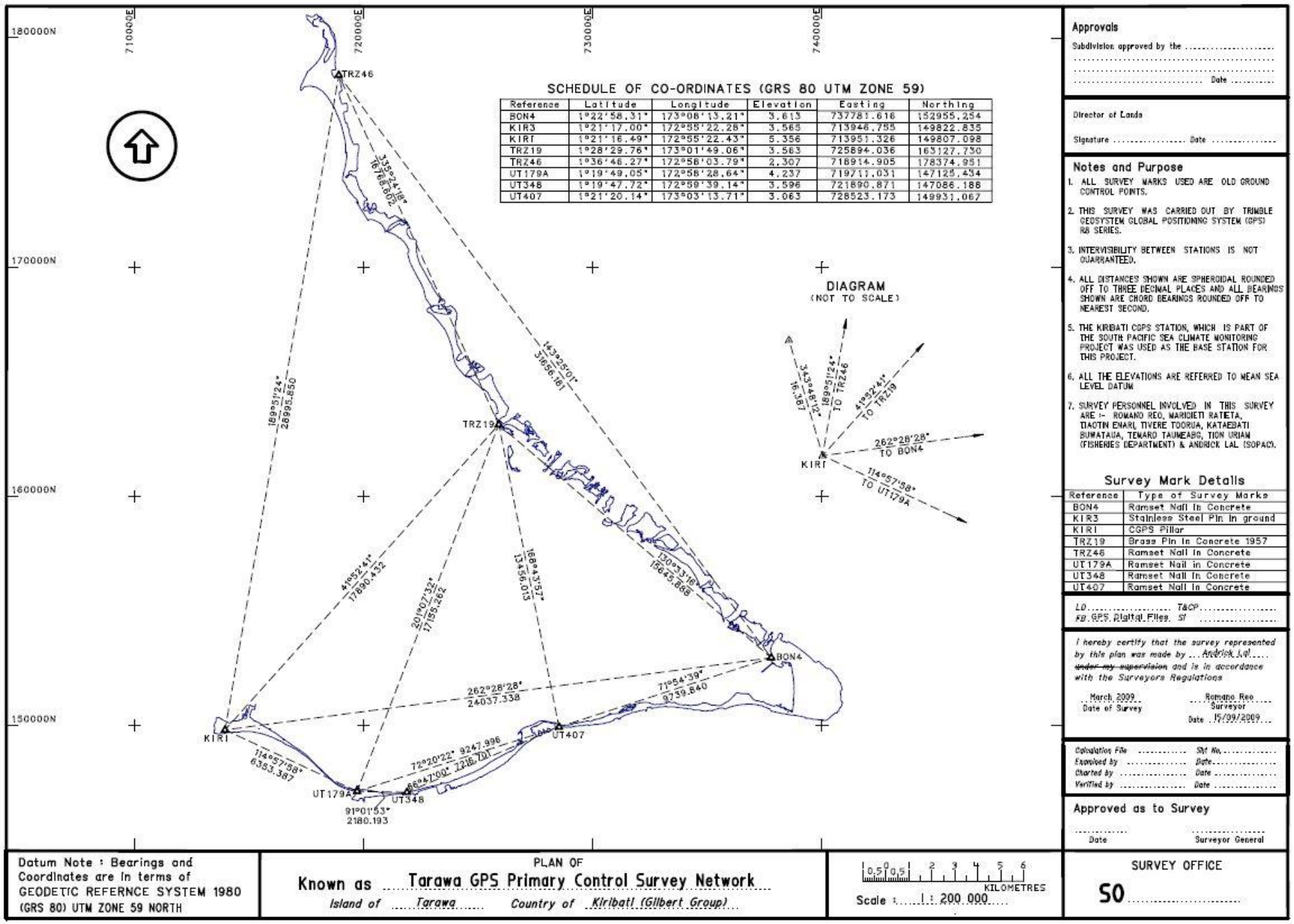


Having observations from a permanent reference station available will allow local Lands & Survey departments to update their current network of survey control from a Local coordinate system onto the International Terrestrial Reference Frame [currently ITRF2008].

BENEFITS OF A GNSS CORS TO LOCAL SURVEYING



The distance & azimuth between parts of the country that may once have been known to only a low accuracy, can now be measured to the mm



SCHEDULE OF CO-ORDINATES (GRS 80 UTM ZONE 59)

Reference	Latitude	Longitude	Elevation	Easting	Northing
BON4	1°22'58.31"	173°08'13.21"	3.613	737781.616	152955.254
KIR3	1°21'17.00"	172°55'22.28"	3.565	713946.755	149822.835
KIRI	1°21'16.49"	172°55'22.43"	5.356	713951.326	149807.098
TRZ19	1°28'29.76"	173°01'49.06"	3.563	725894.036	163127.730
TRZ46	1°36'46.27"	172°58'03.79"	2.307	718914.905	178374.951
UT179A	1°19'49.05"	172°58'28.64"	4.237	719711.031	147125.434
UT348	1°19'47.72"	172°59'39.14"	3.596	721890.871	147086.188
UT407	1°21'20.14"	173°03'13.71"	3.063	728523.173	149931.067

DIAGRAM
(NOT TO SCALE)

Approvals

Subdivision approved by the .....
.....
.....
..... Date .....

Director of Lands

Signature ..... Date .....

Notes and Purpose

1. ALL SURVEY MARKS USED ARE OLD GROUND CONTROL POINTS.
2. THIS SURVEY WAS CARRIED OUT BY TRIMBLE GEOSYSTEM GLOBAL POSITIONING SYSTEM (GPS) R8 SERIES.
3. INTERVISIBILITY BETWEEN STATIONS IS NOT GUARRANTEED.
4. ALL DISTANCES SHOWN ARE SPHEROIDAL ROUNDED OFF TO THREE DECIMAL PLACES AND ALL BEARINGS SHOWN ARE CHORD BEARINGS ROUNDED OFF TO NEAREST SECOND.
5. THE KIRIBATI CGPS STATION, WHICH IS PART OF THE SOUTH PACIFIC SEA CLIMATE MONITORING PROJECT WAS USED AS THE BASE STATION FOR THIS PROJECT.
6. ALL THE ELEVATIONS ARE REFERRED TO MEAN SEA LEVEL DATUM
7. SURVEY PERSONNEL INVOLVED IN THIS SURVEY ARE :- ROMANO REO, MARIOIETI RATIETA, TIAOTIN ENARI, TIVERE TOORUA, KATAEBATI BUWATAUA, TEWARO TAUMEABO, TION URIAN (FISHERIES DEPARTMENT) & ANDRICK LAL (SOPAC).

Survey Mark Details

Reference	Type of Survey Marks
BON4	Ramset Nail In Concrete
KIR3	Stainless Steel Pin In ground
KIRI	CGPS Pillar
TRZ19	Brass Pin In Concrete 1957
TRZ46	Ramset Nail In Concrete
UT179A	Ramset Nail In Concrete
UT348	Ramset Nail In Concrete
UT407	Ramset Nail In Concrete

LO..... T&CP.....
FB GPS Digital Files SI .....

I hereby certify that the survey represented by this plan was made by ... Andrick Lal ... ~~under my supervision~~ and is in accordance with the Surveyors Regulations

March 2009 — Date of Survey
Romano Reo — Surveyor
Date 15/09/2009

Calculation File ..... Sht No. .....
Examined by ..... Date .....
Charted by ..... Date .....
Verified by ..... Date .....

Approved as to Survey

..... Date
..... Surveyor General

Datum Note : Bearings and Coordinates are in terms of GEODETIC REFERNCE SYSTEM 1980 (GRS 80) UTM ZONE 59 NORTH

PLAN OF
Known as Tarawa GPS Primary Control Survey Network
Island of Tarawa Country of Kiribati (Gilbert Group)

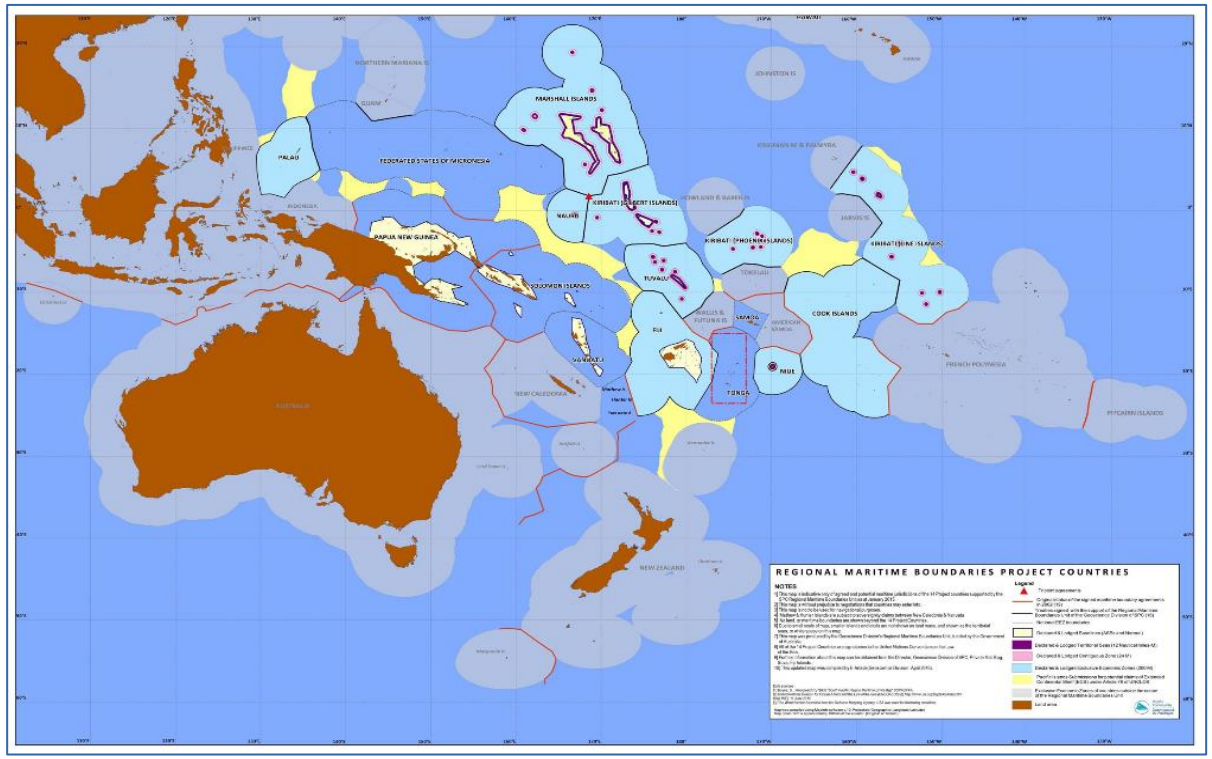
0.5 0 0.5 1 2 3 4 5 6 KILOMETRES
Scale : 1 : 200 000

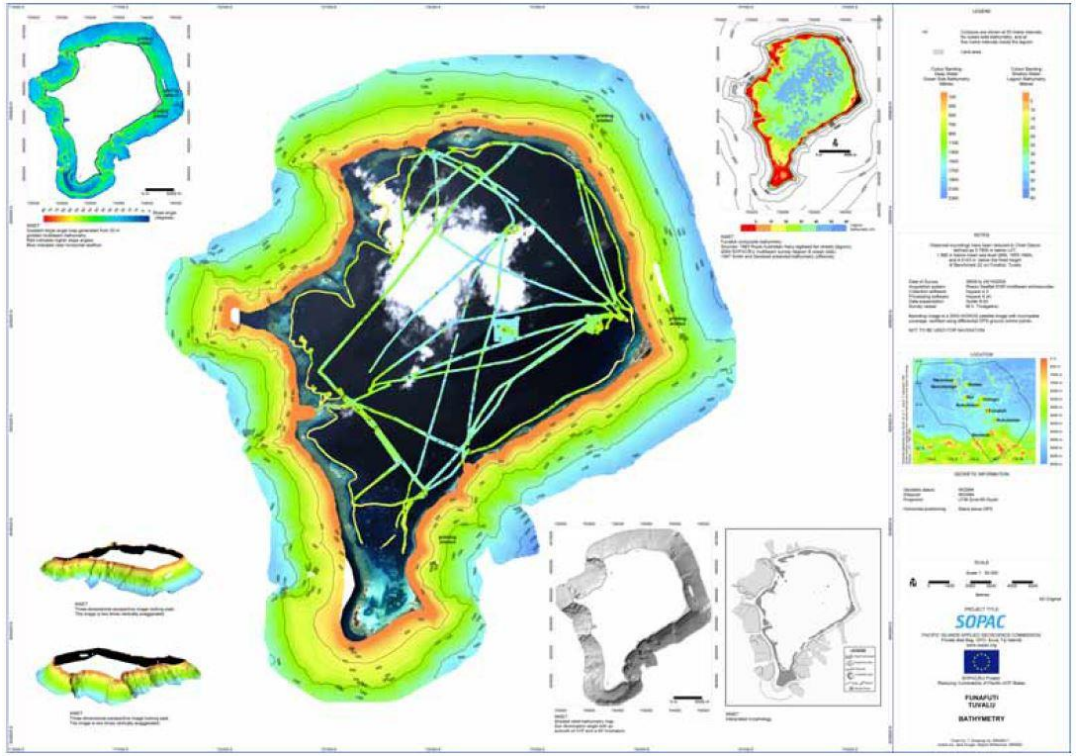
SURVEY OFFICE
SO .....

Pacific Community
Communauté du Pacifique

BENEFITS OF A GNSS CORS TO LOCAL SURVEYING

- Local & Regional Benefits:
  - Strong local coordinated network is necessary for infrastructure and asset management.
  - Provide a common reference between local data sets (sea floor mapping, land surveys, aerial photography) & allowing various GIS applications
  - Integration of data sets across the region (fisheries, maritime boundaries, large scale environmental monitoring, disaster management)





CHALLENGES OF GNSS CORS

Pacific Community
Communauté du Pacifique

- Power Supply
- Data Storage (Local Server -> Cloud)
- Communications (internet)
- Good Coordination with Local Contact
  - Infrastructure and asset management.

Questions?

Vinaka