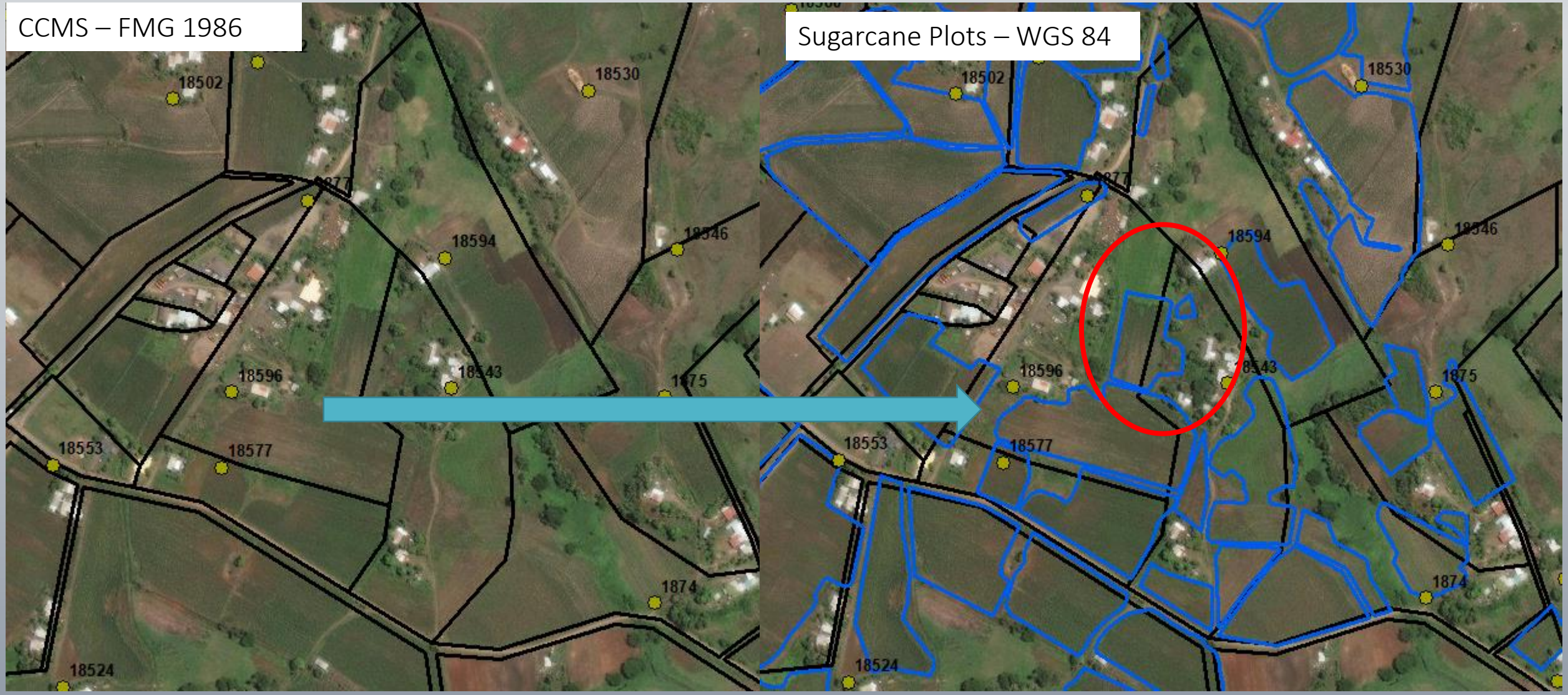
Updating Fiji's maritime boundary

Supervisor: Professor Don Grant and Simon Fuller

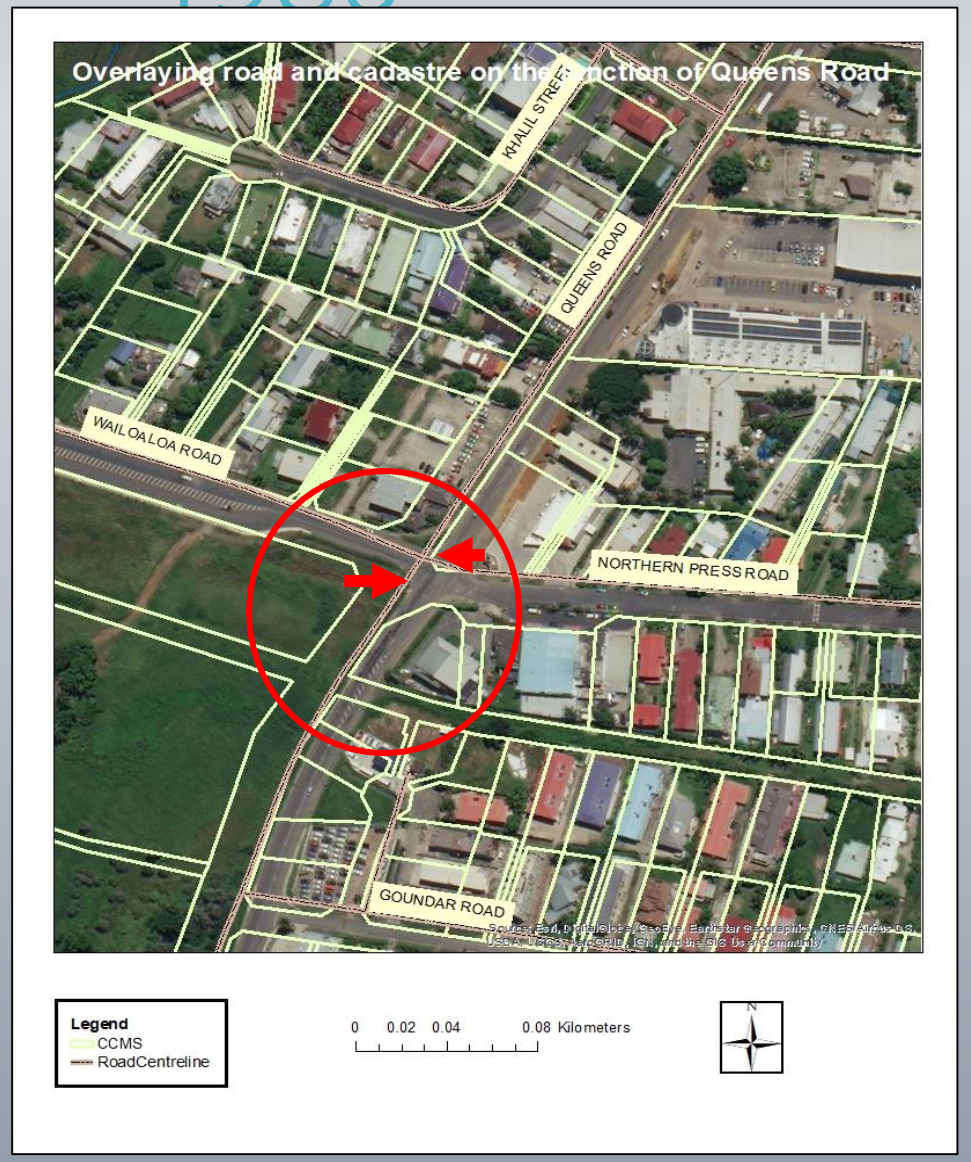
Name:Vasiti Soko

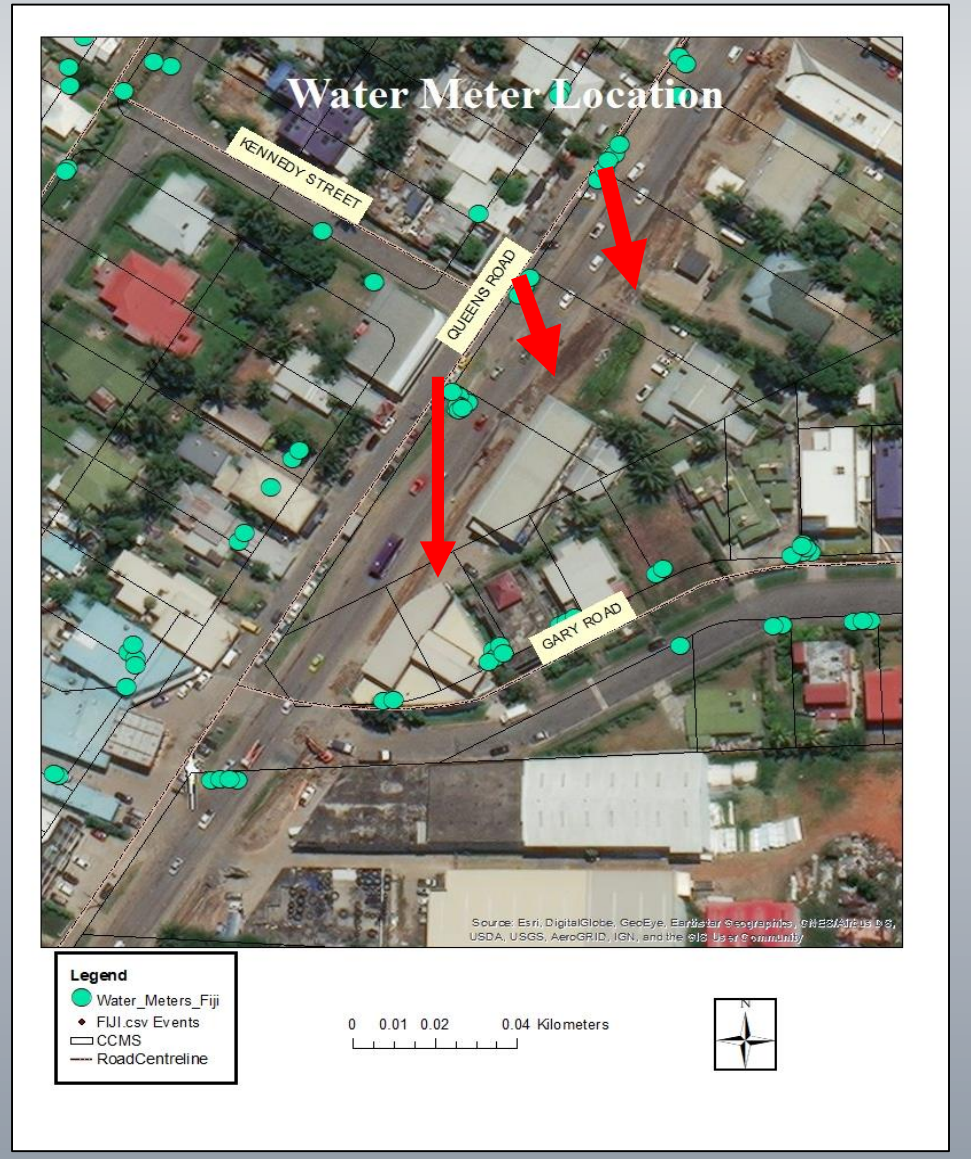
Vasiti.soko@gmail.com

Why ? Current Issues with FMG 1986



Why? More example on issues with FMG 1986

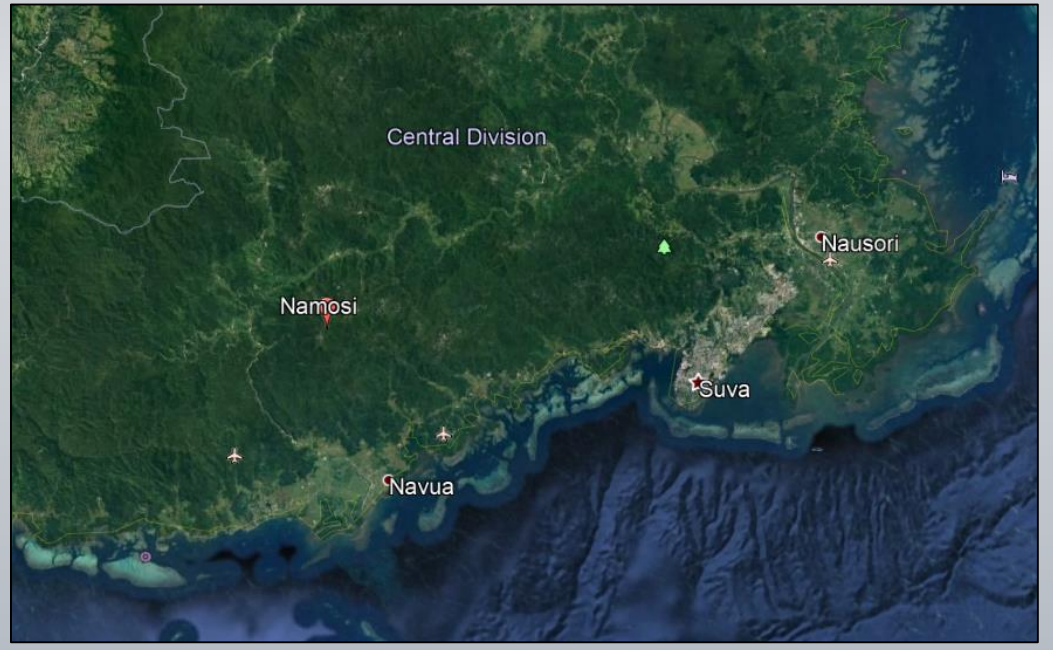




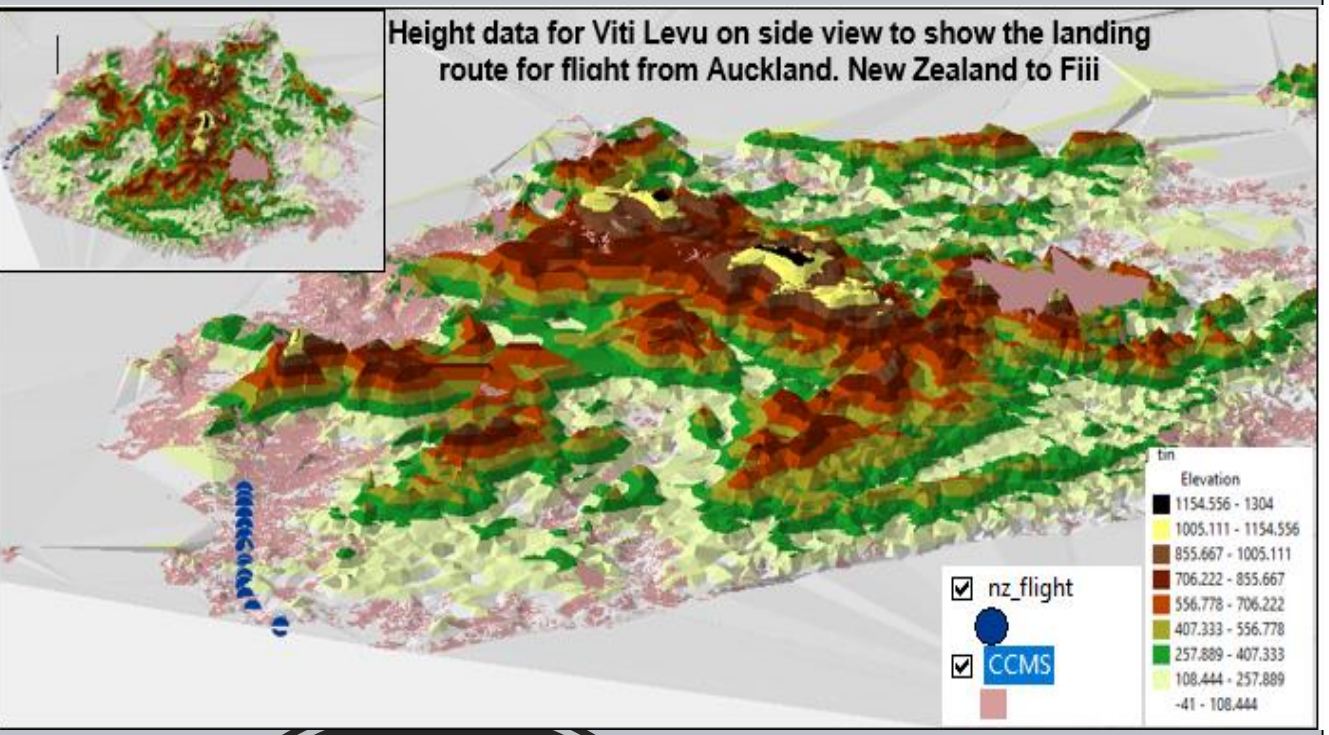
Current situation with CAAF

Map 1

Map 2



Visual Reporting Point (VRP) are user's waypoint marked on aeronautical charts. Clearly the shift is substantial. This shift is well outside the tolerances for air navigation. Such data proves the why CAAF cannot use FGD 1986 data in their system.



Air Navigation tolerance accuracy

Length/distance/dimension	Publication resolution	Integrity classification
Airway segment length	1/10 km or 1/10 NM	routine
Distance used for the formation of an en-route fix	1/10 km or 1/10 NM	routine
Terminal arrival/departure route segment length	1/100 km or 1/100 NM	essential
Distance used for the formation of a terminal and instrument approach procedure fix	1/100 km or 1/100 NM	essential
Runway and FATO length, TLOF dimensions	1 m or 1 ft	critical
Runway width	1 m or 1 ft	essential
Displaced threshold distance	1 m or 1 ft	routine
Clearway length and width	1 m or 1 ft	essential
Stopway length and width	1 m or 1 ft	critical
Landing distance available	1 m or 1 ft	critical
Take-off run available	1 m or 1 ft	critical
Take-off distance available	1 m or 1 ft	critical
Accelerate-stop distance available	1 m or 1 ft	critical
Runway shoulder width	1 m or 1 ft	essential
Taxiway width	1 m or 1 ft	essential
Taxiway shoulder width	1 m or 1 ft	essential

Figure 6. ICAO -Length, distance and dimension Fiji's CAAF requirement

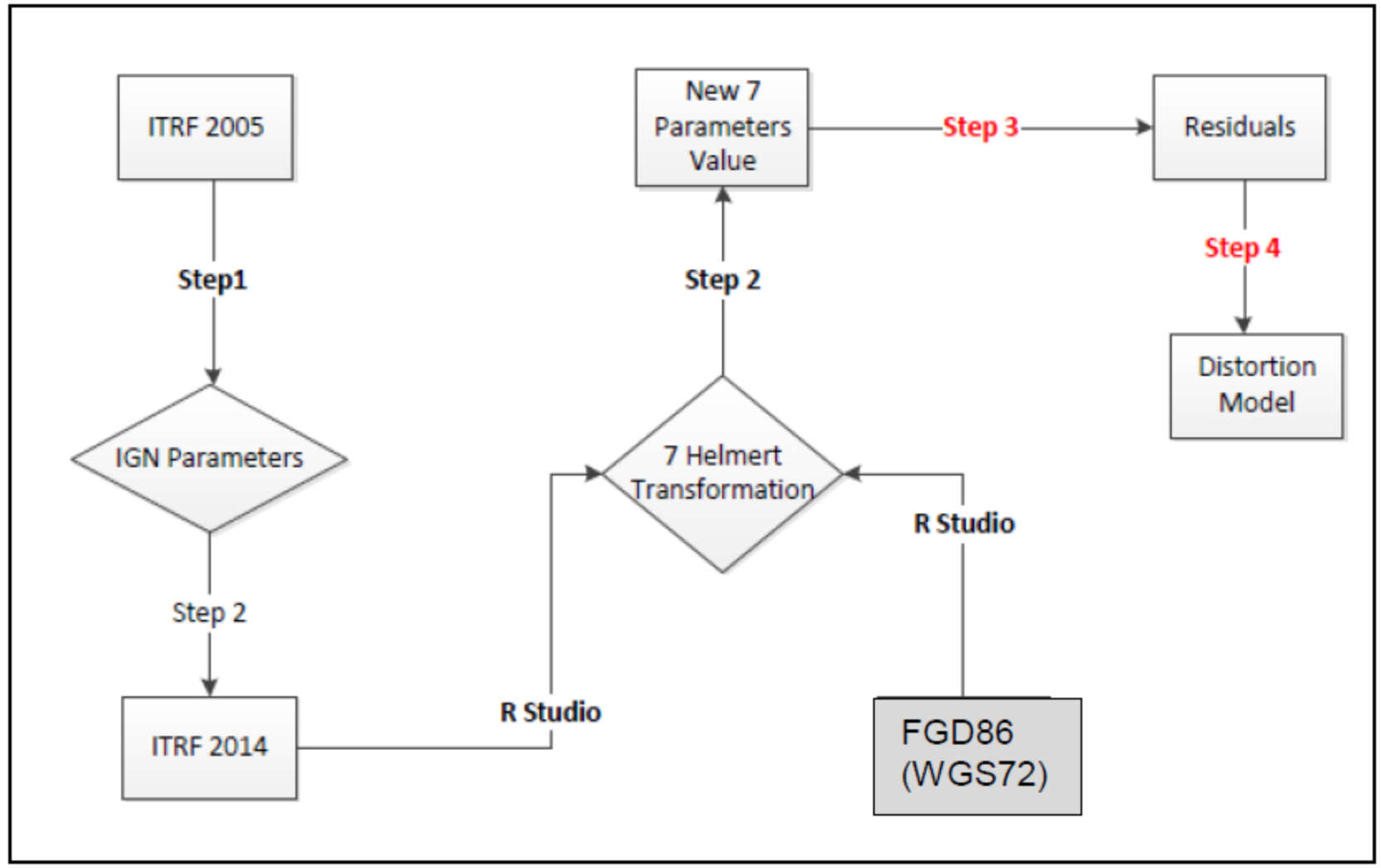
STANDARDS FOLLOWED BY OTHER COUNTRY Survey Tolerance: Land management

Map Scale	Application	0.2mm plot accuracy on the ground	minimum survey tolerance
1:1,000,000	International maps	200m	~70m
1:250,000	Aeronautical charts	50m	~20m
1:100,000	small scale topographical maps	20m	~5m
1:50,000	cadastral index maps	10m	~3m
1:10,000	town maps	2m	~0.5m
1: 2,500	urban service maps	0.5m	~0.1m
1:1,000	urban cadastral maps	0.2m	~0.05m
1: 500	construction site plans	0.1m	~0.1m

Mapping plot accuracy and survey tolerance Stanaway, F (2004)

To more fun stuff

Methodology



ITRF solutions

ITRF2014 is the latest realization of the International Terrestrial Reference System. It uses as input data time series of station positions and Earth Orientation Parameters (EOPs) provided by the Technique Centres of the four space geodetic techniques (VLBI, SLR, GNSS and DORIS) (http://itrf.ign.fr/ITRF_solutions/2014).

Transformation parameters from ITRF2014 to past ITRFs.

SOLUTION	Tx	Ty	Tz	D	Rx	Ry	Rz	EPOCH
UNITS---------->	mm	mm	mm	ppb	.001"	.001"	.001"	
	.	.	.	.	.	.	.	
RATES	Tx	Ty	Tz	D	Rx	Ry	Rz	
UNITS---------->	mm/y	mm/y	mm/y	ppb/y	.001"/y	.001"/y	.001"/y	
ITRF2008	1.6	1.9	2.4	-0.02	0.00	0.00	0.00	2010.0
rates	0.0	0.0	-0.1	0.03	0.00	0.00	0.00	
ITRF2005	2.6	1.0	-2.3	0.92	0.00	0.00	0.00	2010.0
rates	0.3	0.0	-0.1	0.03	0.00	0.00	0.00	

Updating Fiji maritime boundary ITRF 2005 – ITRF 2015

ITRF 2005						
Stations	X	y	z	dYears-08	dYears-2014	diffDate
CIKI	-6090792.049	-128369.460	-1882863.375	22/07/08	1/01/10	-1.447
EKUBU	-6045006.477	248381.185	-2012567.046	22/07/08	1/01/10	-1.447
KAMA	-6128129.150	-891.801	-1763104.872	22/07/08	1/01/10	-1.447
KIAS	-6125127.814	96598.283	-1770426.001	22/07/08	1/01/10	-1.447
LAUT	-6075194.581	270923.908	-1917189.421	22/07/08	1/01/10	-1.447
MANF	-6071340.246	307355.462	-1923860.422	22/07/08	1/01/10	-1.447
NAKO	-6069393.370	74300.738	-1952865.790	22/07/08	1/01/10	-1.447
NASA	-6092446.183	69059.233	-1880371.303	22/07/08	1/01/10	-1.447
OVAL	-6078392.577	126360.602	-1923939.748	22/07/08	1/01/	
QELE	-6129224.759	-89303.143	-1756463.885	22/07/08	1/01/	
QILO	-6141289.697	-4173.006	-1717003.079	22/07/08	1/01/10	-1.447
SESE	-6106871.908	158732.363	-1828960.537	22/07/08	1/01/10	
SAIL	-6108966.715	182311.733	-1818366.920	22/07/08	1/01/10	
SOLE	-6219743.211	324285.635	-1371182.671	22/07/08	1/01/10	
SUVA	-6060677.228	166617.195	-1973761.328	22/07/08	1/01/10	
TAVE	-6101703.045	8527.734	-1852331.734	22/07/08	1/01/10	
ULUI	-6119100.790	62728.212	-1792699.464	22/07/08	1/01/10	
UNAV	-6060202.220	-129071.485	-1978127.158	22/07/08	1/01/10	
VADA	-6078942.227	247703.323	-1908644.924	22/07/08	1/01/10	
YAWI	-6105774.604	260113.907	-1819818.890	22/07/08	1/01/10	-1.447

www.ltrf.ensg.ign.fr

ITRF2005	RATES
2.6	0.3
1	0
-2.3	-1
0.92	0.03
0	0
0	0
0	0

ITRF2014

xNew	yNew	zNew
-6090792	-128369.46	-1882863
-6045006	248381.183	-2012567
-6128129	-891.8021	-1763105
-6125128	96598.2815	-1770426
-6075195	270923.907	-1917189
-6071340	307355.46	-1923860
-6069393	74300.7369	-1952866
-6092446	69059.2318	-1880371
[illegible]393	126360.6	-1923940
-6129225	-89303.143	-1756464
-6141290	-4173.007	-1717003
-6106872	158732.361	-1828961
-6108967	182311.732	-1818367
-6219743	324285.633	-1371183
-6060677	166617.194	-1973761
-6101703	8527.73319	-1852332
-6119101	62728.2105	-1792699
-6060202	-129071.49	-1978127
-6078942	247703.322	-1908645
-6105775	260113.905	-1819819

Helmert Transformation parameters

4.2.4 7 Helmert Transformation Parameters

The below descriptions are adopted from Geographic Information Systems Stack Exchange (2015) where the formula used was also extracted from to calculate the seven helmert parameters.

The script included three kinds of transformation:

1. Translation displayed by vector of displacement in meters
2. Scale factor given in parts per million (ppm)
3. Rotation where x'=x - rz*y +ry*z,

   y'=y – rx *z+ rz*x,

   z' = z- ry*x + rx*y

Geodetic coordinates (x,y,z) and (x', y', z') is a linear function related to the parameters [cx,cy,cz, +s, (1+s)*rx (1+s)*ry,(1+s)*rz] = [b1, b2, b3…,b7), where b are the helmert transformation estimates that is also using the standard ordinary least square algorithm. Therefore converting the x,y,z to x',y'z' into three separate rows of data for the seven independent variables as per below table

1, 0, 0, x.0,z,-y;x'

0, 0, 1, z, -x, 0; y'

0, 0, 1, z, -x, 0; z'

x- geodetic Cartesian coordinates

C – displacement in meters

S - scale in ppm

r- rotation in arcseconds.

```
helmert.fit <- function(x, xp) {
  x.d <- data.frame(matrix(apply(x, 2,
                                 function(y) matrix(c(1,0,0,y[1],0,y[3],-y[2],
                                                      0,1,0,y[2],-y[3],0,y[1],
                                                      0,0,1,y[3],y[2],-y[1],0),
                                                    nrow=3)), ncol=7, byrow=TRUE))
  x.d
  x.d$y <- as.vector(xp)
  names(x.d) <- c("cx", "cy", "cz", "s", "rx", "ry", "rz", "y")
  rownames(x.d) <- outer(c("x","y","z"), 1:ncol(x), paste, sep="") # `ncol(x)` was
  fit <- lm(y ~ . - 1, data=x.d)
  #
  # Convert the solution back to (cx, cy, cz, s, rx, ry, rz) in standard
  # units of measurement (ppm for `s` and arcseconds for `rx`, `ry`, `rz`).
  #
  parameters <- coef(fit) * c(1,1,1,1,60*60*180/pi*c(1,1,1))
  s1 <- parameters["s"]
  parameters <- parameters / c(1,1,1,1,s1,s1,s1)
```

Outcome of the transformation

John and Hu: FGD (WGS 72) - ITRF2005						
tx	**ty**	**tz**	**rx**	**ty**	**tz**	**s**
-7.0295	-22.1185	-10.1505	0.1139	-0.3325	0.2573	-1.4227
FGD 86(WGS 72) - ITRF2014						
-5.437	-23.33	-10.18	-0.151	0.3485	-0.314	-1.191
Difference						
-1.5927	1.2083	0.0307	0.2653	-0.681	0.5716	-0.2315

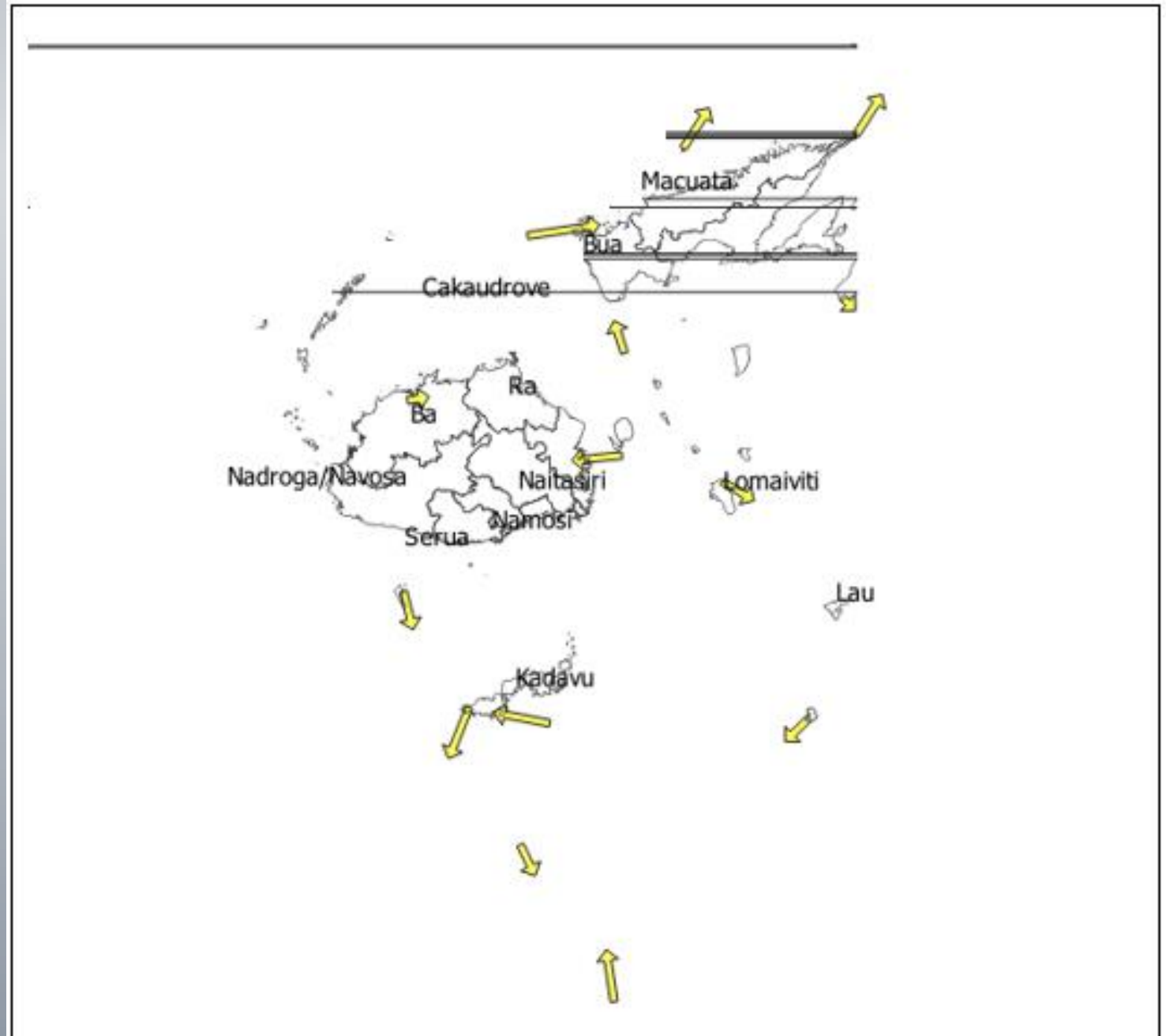
Residuals from between ITRF 2005 and ITRF 2014

Residuals between the two sets of coordinates that is FGD86 (WGS72) - ITRF2005 and FGD86 (WGS 72)-ITRF2014 were calculated to identify the difference.

Difference is minimal when moving from one ITRF to another. For Fiji GIS Users, moving datasets from a dynamic reference frame to another would have minimal impact on GIS datasets and accuracy as opposed to moving from a static datum to a dynamic datum.

	Residuals (mm)		
CIKI	0.005	0.013	-0.017
EKUB	0.007	0.012	-0.018
KAMA	0.005	0.014	-0.017
KIAS	0.005	0.014	-0.018
LAUT	0.008	0.006	-0.016
MANF	0.007	0.013	-0.019
NAKO	0.006	0.013	-0.018
NASA	0.006	0.013	-0.018
OVAL	0.006	0.013	-0.018
QELE	0.005	0.014	-0.017
QILO	0.005	0.014	-0.018
SESE			
SAIL			
SOLE	0.002	-0.033	-0.016
SUVA	0.006	0.013	-0.018
TAVE	0.005	0.013	-0.017
ULUI	0.005	0.014	-0.018
UNAV	0.005	0.007	-0.021
VADA	0.006	0.013	-0.018
YAWI	0.006	0.013	-0.019

Fiji Maritime Boundary Distortion Map in QGIS



Conclusion

Lessons Learnt

- More survey marks on land, to observe for 24 hours, at the same time and at the same day in 2 different years.
- Difference in the 2 datum not fully understood by local GIS users

Many organizations spend substantial amounts acquiring a data set without giving any thought to how it will be maintained.

References

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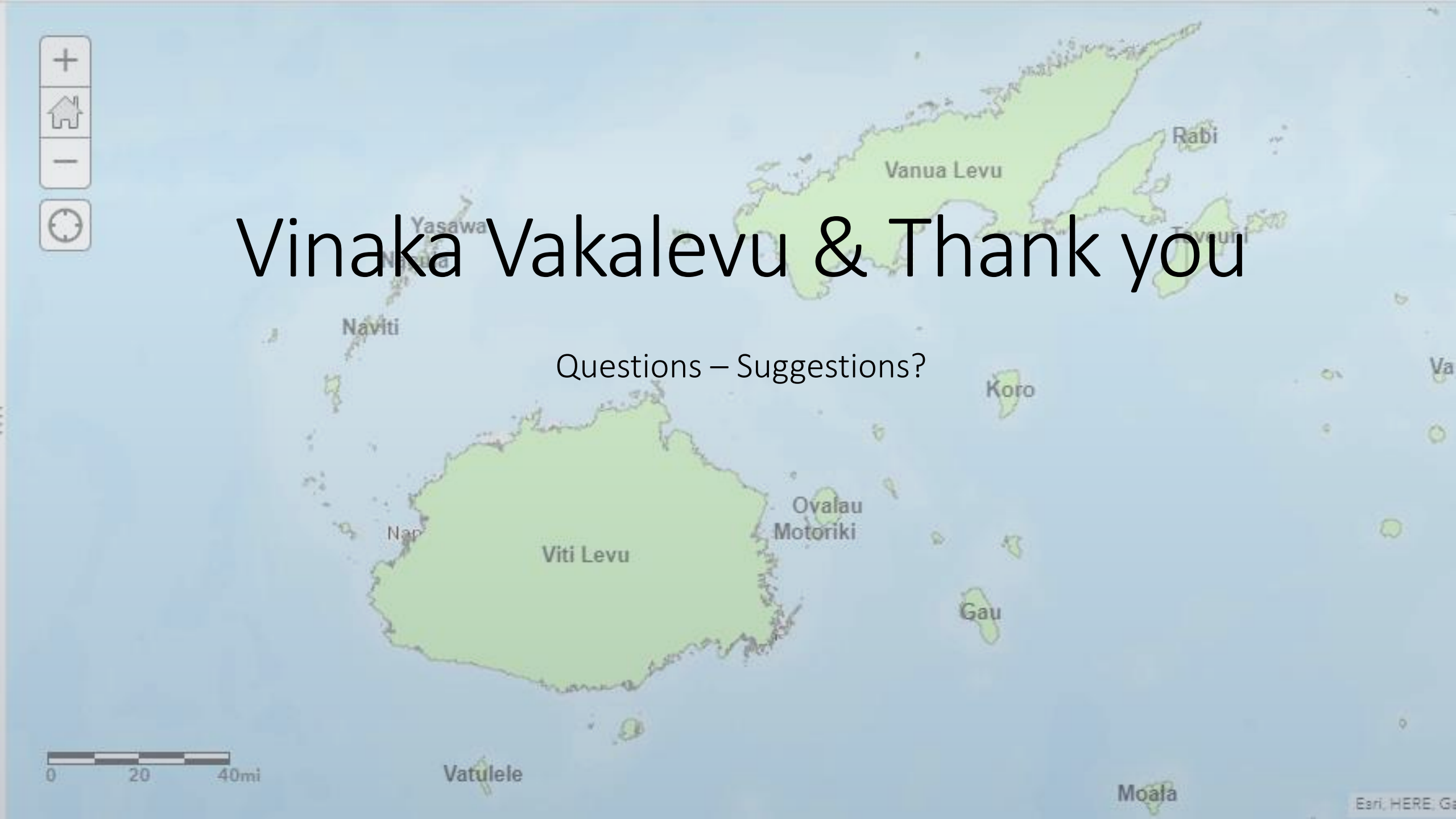
- Fiji Geospatial Users
- Fiji Airports Authority
- Sugarcane Industry



Vinaka Vakalevu & Thank you

Questions – Suggestions?