2016 - Chatham Island Local Tie Survey

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Contents

Executive Summary

The Chatham Islands are located approximately 800 east of Christchurch, New Zealand. The Owenga site is located in the south west corner of the main island along Waitangi Wharf-Owenga Rd near the Waitangi Wharf. The survey was completed between 1 June – 3 June 2016.

The purpose of the survey was to determine the relationship between a relocated DORIS antenna (OWFC), its reference mark, the relocated REGINA continuously operating reference station (OWMG) and the station's antenna reference point (ARP). The reference mark for the previous DORIS antenna (OWEC) was also included the survey. The previous REGINA site (OWNG) is no longer accessible.

The following report documents the technical aspects of the survey.

Acknowledgements

Land Information New Zealand (LINZ) would like to acknowledge Geoscience Australia (GA) for their support and assistance during this survey. The survey would have not been possible without their advice and equipment.

1. Introduction

This report accompanies the SINEX file computed as part of the local tie survey. Below are the high level steps in our approach for the observation and computation:

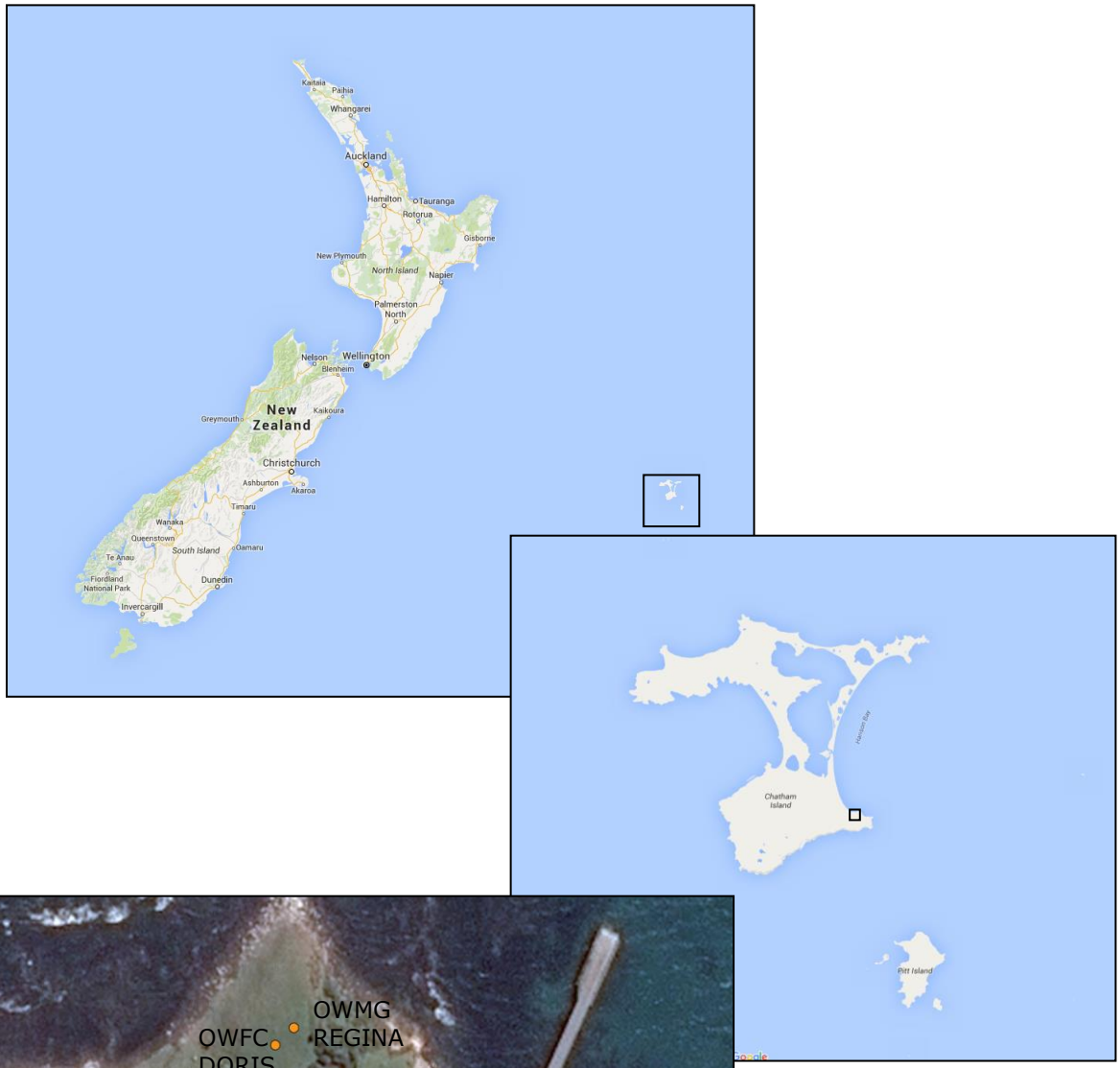
- The calibration of all geodetic instrumentation including: total station instruments, fixed height mounts and reflectors
- The observation of a vertical geodetic network by application of geodetic levelling (in our case specifically EDM height traversing) to survey marks at the site.
- The observation of a three dimensional geodetic network by conventional terrestrial geodetic observations, including angles and distances to survey marks established at the site.
- The observation of a Global Navigation Satellite System (GNSS) network on suitable survey marks at the site
- The reduction of terrestrial geodetic observations, including the correction of observations for instrument and target bias, set reduction and atmospheric effects
- Analysis of GNSS observations to derive GPS only coordinate estimates and associated geocentric covariance (VCV) matrix
- Least squares (minimally constrained) adjustment of all observations, including the terrestrial observations and the coordinates/covariance matrix calculated from the GNSS observations.
- The generation of a SINEX file of the stations of interest (ie: those with DOMES)

This report assumes that the reader has an understanding of the basic concepts of geodetic surveying and does not detail or justify the approach taken.

2. Site Description

The Chatham Islands are located approximately 800 east of Christchurch, New Zealand. The Owenga site is located in the south west corner of the main island along Waitangi Wharf-Owenga Rd near the Waitangi Wharf.

The Owenga site hosts a tsunami monitoring tide gauge, a DORIS antenna and REGINA CORS.



GLOBAL/IERS DESIGNATION
OWEC 50253M002
OWEC 50253S001
OWFC 50253S002
OWFC 50253M003
OWMG 50253M004
OWNG 50253M001

Table 2.1 List of survey marks with DOMES at the Chatham Islands site

3. Instrumentation

The following section provides the specification and calibration procedures of the equipment used in the June 2016 survey.

3.1. TOTAL STATION

3.1.1. Total Station

Leica TDRA6000 (S/N 362969)

Specification

- EDM (infrared) distance standard deviation of a single measurement: 0.6 mm + 1 ppm;
- Angular standard deviation of a mean direction measured in both faces: 0.15mgon (0.5”);
- Last calibrated by the National Measurement Institute – Australia on 21 July 2015

3.1.2. Auxiliary Equipment

Kestrel 5500 Weather Meter (S/N 2111309) recorded the temperature, pressure and humidity during the survey.

Specification

- Temperature: Accuracy ± 0.5 °C
- Pressure: Accuracy ± 1.5 mbar
- Relative Humidity: Accuracy ± 2%

3.2. SETUP AND CENTERING EQUIPMENT

3.2.1. Optical Plummet

A Leica FG-L30 (S/N: 609048) zenith and nadir optical plummet was used to centre and level all instruments and target set-ups.

3.2.2. Targets and Reflectors

The standard target kit includes:

4 x Leica GPH1P Precision Prisms
4 x Leica Tribrach
4 x Leica GZR3 Prism Carriers with Optical Plummets

- Leica GPH1P prisms have an offset of approximately 0.0000m

3.3. LEVELLING

3.3.1. Levelling Instruments

Refer to section 3.1.1 for description of Total Station.

3.3.2. Levelling Rods

- A fixed height stainless steel rod with Leica style bayonet mount was used with a bi-pole for stability (ARGN3).
- A levelling stub (#3)

3.4. TRIPODS

4x Wooden Tripods
1x Leica GLS14 Mini reflector pole (S/N 403427)

3.5. GNSS UNITS

Survey grade Trimble receivers and antennae were used during the survey.

3.5.1. GNSS Receivers

SITE	SERIAL NO.	DESCRIPTION
OWEC_RM/ OWFC 50253M003	04401187	TRIMBLE 5700
OWN5	022026074	TRIMBLE 5700
OWMG_ARP	5340K46072	TRIMBLE NETR9

Table 3.1: List of GNSS receiver information

3.5.2. GNSS Antennae

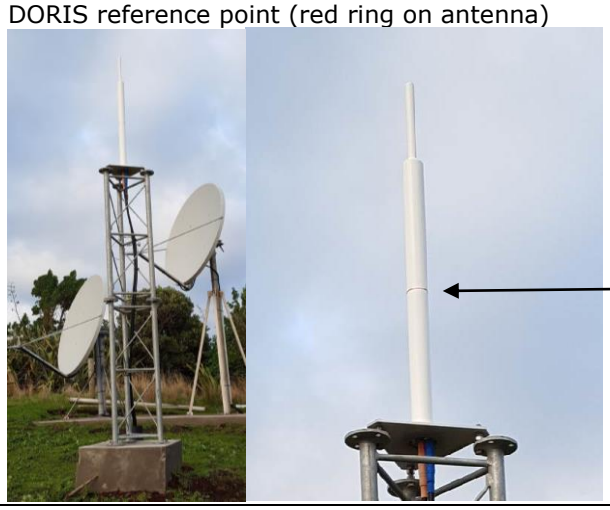
SITE	SERIAL NO.	TYPE
OWEC_RM/ OWFC 50253M003	12621960	TRM41249.00 NONE
OWN5	12652401	TRM41249.00 NONE
OWMG_ARP	5406354937	TRM59800.00 NONE

Table 3.2 List of GNSS antennae information

4. Network Measurement

4.1. GROUND NETWORK

4.1.1. Listing

SITE	ADJUSTMENT REFERENCE	DESCRIPTION
OWEC 50253M002	OWEC_RM	 DORIS marker, pin located in concrete plinth
OWEC 50253S001		Former DORIS reference point (red ring on antenna)
OWFC 50253S002	OWFC	DORIS reference point (red ring on antenna) 
OWFC 50253M003	OWFC_RM	Stainless steel pin located in concrete plinth underneath permanent DORIS beacon 
OWN1	OWN1	12mm stainless steel grouted into a 20mm iron tube
OWN2	OWN2	12mm stainless steel grouted into a 20mm iron tube
OWN3	OWN3	12mm stainless steel grouted into a 20mm iron tube
OWN4	OWN4	12mm stainless steel grouted into a 20mm iron tube
OWN5	OWN5	12mm stainless steel grouted into a 20mm iron tube

OWN6	OWN6	Iron spike
OWMG 50253M003	OWMG	CORS reference mark a stainless steel pin a concrete plinth 
	OWMG_ARP	CORS antenna reference point 
OWNG 50253M001		Former CORS site stainless steel pin in concrete plith – now buried under approx. 0.8m of soil and metal

Table 4.1 Description of network

4.1.1. Map of Survey Network

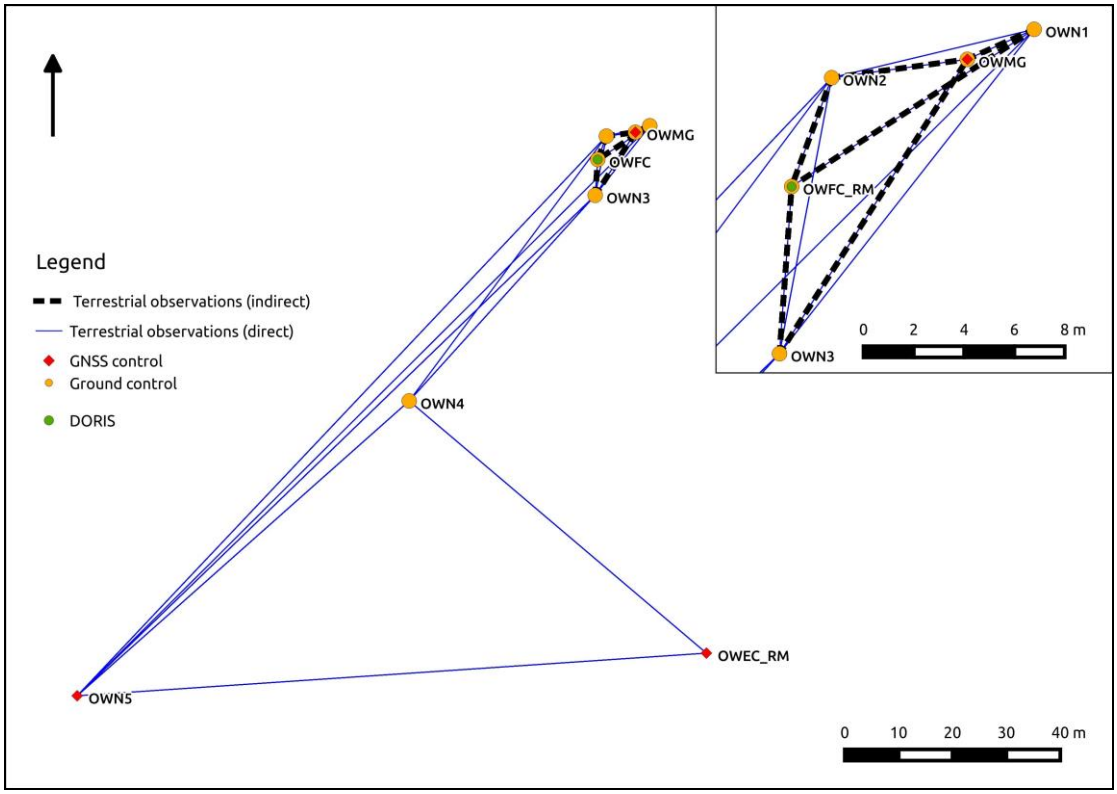


Figure 4.2: The terrestrial network showing the ground control

5. Observations

5.1. TERRESTRIAL NETWORK SURVEY

A precise EDM traverse was conducted between all ground control marks on site (refer Figure **4.1**).

Five sets of face left/face right observations were completed and recorded at each ground control mark. Horizontal angles, slope distances and zenith distances were recorded. .

The temperature, pressure, and relative humidity were recorded every 30 minutes or when there was a noticeable change in the weather. These observations were interpolated to the times of observation to calculate ppm corrections to the observed distances.

5.2. PRECISE LEVELLING

Precise levelling was conducted between all the ground control marks using the EDM Height Traversing technique (Johnston et al, 2002). Height difference observations were made using a Leica TDRA6000 Total Station to a prism mounted on a fixed height stainless steel prism pole (approximately 1.5m in height).

Atmospheric conditions (temperature, pressure, and relative humidity) were recorded every 30 minutes.

Levelling loops covering all monuments in the survey network were completed in both directions (Figure **6.1**). Each instrument set-up involved reading five rounds of face left/face right observations to a single prism set-up over two marks. The levelling observations zenith and slope distances were reduced to determine change of height with between marks.

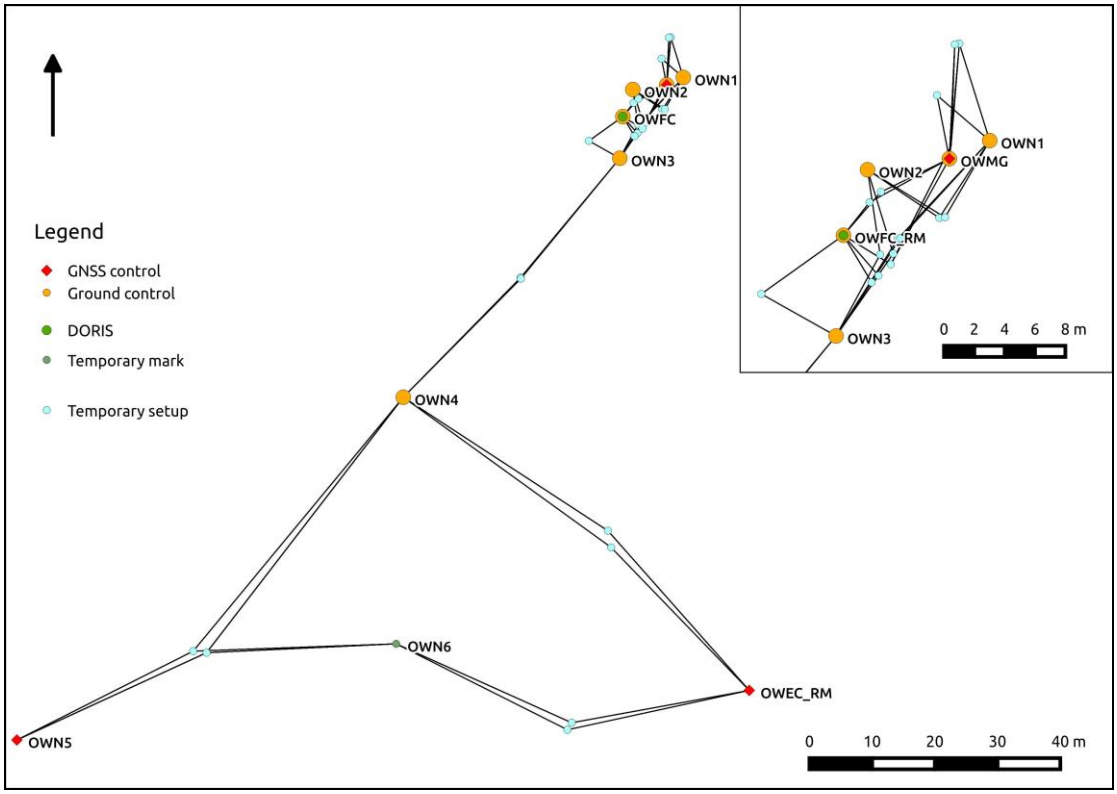


Figure 5.1: Precise levelling network, observed two way height differences

5.3. GNSS

At least 16 hours of GNSS observations were collected at the OWMG, OWEC and OWN5.

5.3.1. GNSS Receivers

SITE	ADJUSTMENT REFERENCE	DATA START (YY:DDD:SSSSS)	DATA END (YY:DDD:SSSSS)	DESCRIPTION
OWEC 50253M002	OWEC_RM	16:152:05790	16:152:69900	TRIMBLE 5700
OWMG	OWMG_ARP	16:152:00000	16:152:86370	TRIMBLE NETR9
OWN5	OWN5	16:152:07230	16:152:71430	TRIMBLE 5700

Table 5.1: List of GNSS receivers and observation times

5.3.2. GNSS Antennae

SITE	ADJUSTMENT REFERENCE	DATA START (YY:DDD:SSSSS)	DATA END (YY:DDD:SSSSS)	DESCRIPTION	
OWEC 50253M002	OWEC_RM	16:152:05790	16:152:69900	TRM41249.00	NONE
OWMG	OWMG_ARP	16:152:00000	16:152:86370	TRM59800.00	NONE
OWN5	OWN5	16:152:07230	16:152:71430	TRM41249.00	NONE

Table 5.2 List of GNSS antennae and observation times

5.4. INDIRECT OBSERVATIONS

5.4.1. Horizontal Position

The horizontal reference points for the GNSS antenna and DORIS beacon were determined using the indirect technique to avoid disturbing the antennae. At least three symmetrically opposite pairs were observed on each antenna including observations to ground control marks within the rounds. The horizontal angles pairs were averaged. The averaged horizontal angles from the three reference marks were intersected within the adjustment to determine the horizontal position of the antenna reference points of the DORIS beacon and GNSS antenna.

This method assumes that the antennae have been manufactured to be perfectly symmetrical.

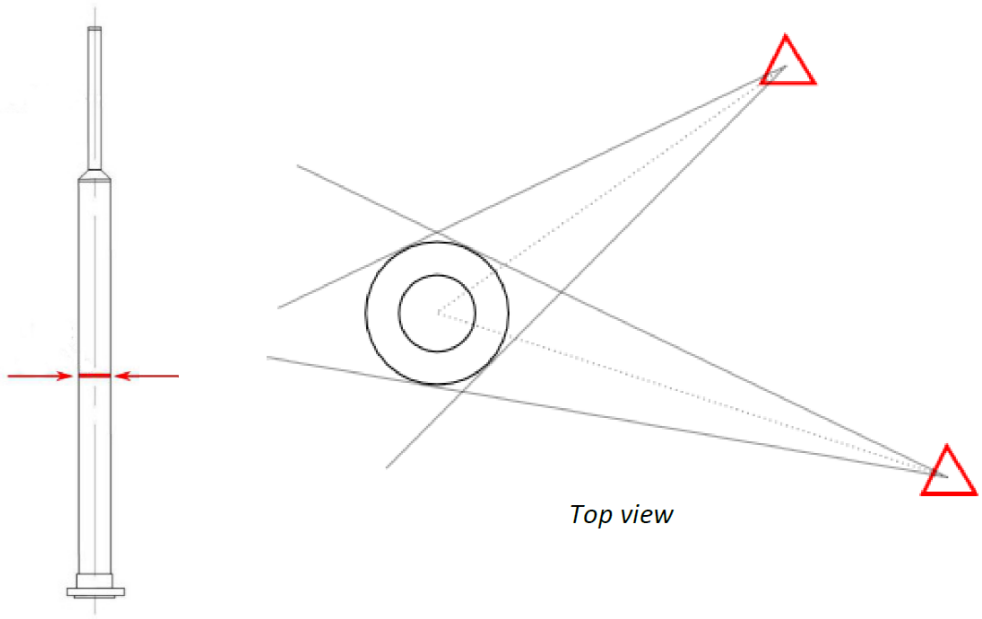


Figure 5.4 Diagram of the antenna reference point for the DORIS beacon (Donal. T., 2012)

5.4.2. Vertical Position

The vertical position of the DORIS beacon and GNSS antenna were determined using the precise EDM heighting technique. Their heights were determined relative to at least two other reference marks within the network.

The vertical reference position of the DORIS beacon was calculated by averaging the heights determined to the top and bottom of the red ring (antenna reference point). The distance to the reference line was measured by the total station in reflectiveless mode.

The vertical position of the antenna reference point for the GNSS antenna was determined by averaging the observation to the levelling stub that was place of the outer left and right edges of the antenna. This method assumes the difference between the antenna reference point (ARP) and top

of choke ring (TCR) is manufactured to the factory specifications of 0.1080m for the TRM59800.00 antenna.

5.4.3. Target Height Determination

Obtaining the correct height of the targets used in the leveling was an important step in the survey as any uncertainty in the target heights would be transferred into the vertical positions of the DORS and GNSS antennae.

The height of instrument were determined using the reuger heighting technique (Reuger and Brunner, 1981). The technique involves the observation of one round of face left/face right vertical angles to specific graduations on a levelling staff (in this case 0.8, 1.2, 1.6 and 2.0m) placed on a survey mark. This technique works best when the mid-graduations of the levelling staff are approximately horizontal from the instrument trunion axis.

$$H = \frac{S_2 \cot Z_1 - S_1 \cot Z_2}{\cot Z_1 - \cot Z_2}$$

Figure 5.4: Formula for the total station instrument heighting technique where Sn are the staff readings, Zn are the zenith angles (Rueger and Brunner, 1981).

The height of the each target relative to the instrument height was then determined using the EDM levelling technique. The instrument height and target height relative to the instrument were combined to obtain a value for the target heights. This was repeated and the averaged value was used.

TARGET	DETERMINED HEIGHTS
Stub	0.1603m
Fixed height pole	1.5668m
GLS14 mini pole	0.2005m

Table 5.1: Determined target heights used within the survey

6. Data Analysis and Results

6.1. DATA PRE-PROCESSING

6.1.1. Terrestrial data reductions

The horizontal angle, slope distance, and zenith angle observations were reduced using software writtenby LINZ to average observation sets and apply corrections for atmospherics and target offsets. This software outputs the reduced observations into a format compatible the snappy adjustment software (Section **6.3**).

6.1.1. Levelling

The raw observations were reduced using the same process described in 6.1.1. The levelling observations were reduced further using levelling reduction script to derive the change in heights between survey marks. The software outputs the reduced observations into a format compatible the snappy adjustment software (Section **6.3**)

6.2. GNSS

6.2.1. Analysis Software

The GNSS data analysis was undertaken using the Bernese GPS Processing Software Version 5.2 within the AUSPOS online data processing facility. An International Terrestrial Reference Frame 2008 (ITRF 2008) solution was minimally constrained in a regional solution.

The AUSPOS processing report specifies that "Coordinate constraints are applied at the Reference sites with standard deviation of 1mm and 2mm for horizontal and vertical components respectively" and "IGS08 station coordinates and velocities mapped to the mean epoch of observation."

6.3. COMBINED LEAST SQUARES ADJUSTMENT

The software and associated versions used to calculate this solution are list below and are available at http://github.com/linz

python-linz-geodetic 1.7.0-1
python-linz-adjustment 2.5.0-1
python-numpy 1:1.8.2-0ubuntu0.1
python-scipy 0.13.3-1build1

The data was processed using a Land Information New Zealand least squares adjustment package called snappy (survey network adjustment programme in python https://github.com/linz/python-linz-adjustment). The software is able to calculate instrument and target heights within the control network using the observations and height differences provided by the EDM levelling. Within the adjustment the temporary levelling points (TP##) are assigned an arbitrary fixed coordinate above which the instrument height is calculated. This approach is used as the horizontal location of these points are not observed.

The combined adjustment is minimally constrained by the OWMG_ARP, OWN5 and OWEC_RM AUSPOS ITRF2008 coordinates and their associated uncertainties

downweighted by a factor of 10. The downweighting is to avoid the GPS observations influencing the total station observations which have a greater relative accuracy.

reweight_observation_type GX 10.0
reweight_observation_type HA 1.2
reweight_observation_type LV 1.9
reweight_observation_type SD 1.5
reweight_observation_type ZD 1.9

6.4. SINEX FILE GENERATION

The SINEX file name is 50253_LNZ_2016-152.snx is generated by the LINZ snappy software.

ADJUSTMENT REFERENCE	CODE USED WITHIN SINEX	DOMES	DESCRIPTION
OWMG_ARP	MGRP		OWENGA REGINA ARP
OWFC	OWFC	50235S003	OWENGA DORIS ARP
OWFC_RM	FCRM	50253M003	OWENGA DORIS RM
OWEC_RM	ECRM	50253M002	OWENGA DORIS RM
OWMG	OWMG	50253M004	OWENGA REGINA RM

Table 6.1: Points and marks within SINEX file

Sum of squared residuals: 979.262750
Number of parameters: 112
Number of observations: 1117
Degrees of freedom: 1005
Standard error of unit weight 0.9871

Summary of residuals

Type	*NRes*	*RMS*
AZ	*1*	*0.0000*
GX	*5*	*0.9731*
HA	*307*	*1.0062*
HD	*0*	*1.0000*
LV	*454*	*0.9468*
SD	*179*	*0.9944*
ZD	*179*	*1.0198*

6.5. DISCUSSION OF RESULTS

6.5.1. Results

YEAR	OWFC 50253M003 TO…	Δ EAST (M)	∂(MM)	Δ NORTH (M)	∂(MM)	Δ UP (M)	∂(MM)
2016	OWEC 50253M002 (RM)	31.8369	2.0	-88.1983	0.1	0.1285	0.2
ECCENTRICITY							
2016	OWFC 50253S003 (ARP)	-0.0023	0.1	-0.0015	0.1	2.4332	0.1

YEAR	OWMG 50253M004 TO …	Δ EAST (M)	∂(MM)	Δ NORTH (M)	∂(MM)	Δ UP (M)	∂(MM)
2016	**OWFC 50253M003 (RM)**	-6.2732	0.2	-5.9170	0.2	-0.3394	0.1
ECCENTRICITY							
2016	**OWMG (ARP)**	0.0003	0.1	0.0004	0.1	2.0352	0.2

Table 6.2: Vectors between point and marks of interest

The 2mm standard error in the east component between OWFC and OWEC is due to the uncertainty in the orientation provided by the GPS observations to OWMG_ARP, OWN5 and OWFC_RM.

OWMG
Marker->ARP Up Ecc. (m) : 002.0352
Marker->ARP North Ecc(m) : 000.0004
Marker->ARP East Ecc(m) : 000.0003

OWFC
Marker->ARP Up Ecc. (m) : 002.4332
Marker->ARP North Ecc(m) :-000.0015
Marker->ARP East Ecc(m) : -000.0023

6.5.2. Comparison with Previous Surveys

There are no previous surveys to these sites.

7. Planning Aspects

It is not advisable to undertake future surveys during April to September due to limited day light and increased rain fall during these month.

Logistical Notes:

Cargo:
Ensure the cargo handlers are notified of additional cargo at least a week in advance. It was approx. 150kgs at $3.50 per kg. Should be paid for at the Air Chatham's office for both the to and from flights.

If cargo is on the same flight it should be able to be picked up from the Air Chatham's office the next day at 8am. You should check that it is booked on for the return trip. Fish get priority so they may not be able to get it on to the same flight.

Land owner contact details:

OWEC is now located on land owned by the Chatham Island Food Company. It may not be available in the future.
Chatham Island Food Company (Delwyn Tuanui)
+64 3 3050 572
delwyn@chathamislandfood.com

OWMG and OWFC is on land owned by Alfred Preece
Alfed Preese
+64 3 3050 267
awpreece@xtra.co.nz

8. References

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