



## LINZ Technical Tour -Geodetic recovery from the Canterbury earthquakes

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This presentation covers key points of the live demonstration of geodetic tools carried out during the FIG Technical Tour of LINZ.

### Introduction



- Two demonstrations: Landonline and PositioNZ-PP
- Show how geodetic coordinates can be generated after an earthquake by both surveyors and LINZ
- Show the deformation model in action

Two demonstrations are summarised in these slides. The first is a demonstration of the Landonline adjustment software, in particular how the deformation model is used to combined observations made at different times within an earthquake sequence. The second is a demonstration of the PositioNZ-PP service, an online GNSS processing service provided by LINZ. In particular, the demonstration shows how it can be used after an earthquake to calculate post-earthquake coordinates.



The first demonstration uses the Landonline system.

Landonline Adjustment Observations Grid				
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Landonline is the system that manages New Zealand's titles, cadastral and geodetic data. One of the modules within Landonline available to LINZ internal users, "Maintain Network", uses the least squares technique to calculate coordinates for survey marks (nodes). In this series of slides, we show how Landonline is able to combine observations that have been affected by different earthquakes to calculate a consistent set of coordinates. The "Manage Adjustment" function within the "Maintain Network" module has an "Observations" and a "Nodes" tab. We start with the Observations tab.

A very simple least squares adjustment has been set up, consisting of 4 GNSS vectors (dX,dY,dZ) and three marks. Two of the marks are Continuously Operating Reference Stations (CORS), the third is a passive control mark we are coordinating. This is real data collected by geodetic surveyors working under contract to LINZ and/or the Christchurch City Council. Take particular note of the date column (red box). Christchurch has been impacted by 5 significant earthquakes on the following dates: 4 September 2010, 22 February 2011, 13 June 2011, 23 December 2011 and 14 February 2016. So we have two vectors observed after the first earthquake and another two observed after the fourth earthquake. The survey mark would have been in a different position in 2013 than it was in 2010, so we might expect problems when combining these observations.

Landonline Adjustment Nodes Grid				
Landonline - Maintain Network - [CMN_502a - Manage Adjustment]		- • •		
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Performs the adjustment run				

Moving to the Nodes tab, we see the three marks. There are two CORS (WIG1 and MQZG) and the mark we are coordinating (BDTP). We hold the two CORS fixed.



Looking at the adjustment spatially, we see the vectors (blue lines), fixed marks (small blue circles) and the mark to be coordinated (small brown circle with number over the top).

Landonline Adjustment Residuals without Deformation Model														
Landonlin	e - Maintain Network - [CMN_S02a	a - Manage Adjustm	ent]											
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Error Multipl	er App	łv								Locate Obs	Amend Obs	Remove Ob	s Sort Obs	View Details
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We run the adjustment and examine the results. In particular, we notice that the Standard Error of Unit Weight (SEUW) is 8.7. We normally expect this to be about 1. We also notice that the residuals ("Res" column) are quite large – up to 17cm. This is much larger than we would normally expect for geodetic GNSS data. Given that the data is in Christchurch, and was observed at different points in the earthquake sequence, we conclude that it is likely that the mark has moved between the 2010 and 2013 observations.

🖄 CMN_S016 - Edi	t Adjustment Method Parameters			
- Adjustment Datale				
Adjustment Method	General geodetic network maint			
Software	LINZ Geodetic Adjustment Software			
Adjustment Type	Geodetic			
Status	Authoritative			
Description	General readetic network maintenance			
Description	Clemental geodelic metwork maintenance			
Adjustment Coeffici	ls			
Coefficient Code	Description	Default Value	New Value	
BRSW	BRSW Bearing swing ontions	BY CROSYS SET * 0.0		
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CNVG	CNVG Coordinate conversence tolerance (m)	0.0001		
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MAUB	MADE Max number of des	50000		
NOCD	NOCD inhibit generation of new coordinates	no		
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DACH	DACI/ Data Internet of the should for matrix optimisation	0.001		
RALV	RAL V Ref frame translation convergence tolerance (m)	0.001		
Incut	PCCL Calculate retraction coefficient	0.075		
IDECI	NUVL Default refraction coefficient	0.0/5		
RFCL	RFCL Reference trame calculation options			
RECO	KFCU Overnde reference trame coordinate systems	no		
RPCV	RPCV Ref frame scale/rot convergence tolerance (ppm)	1		
SPEC	SPEC Accuracy test specifications			
IVENU	VENU Vector errors as ENU components	Linke		

Landonline has the capability to incorporate a deformation model into an adjustment – which is in fact a requirement for adjustments being carried out to generate coordinates in terms of New Zealand Geodetic Datum 2000 (NZGD2000 is New Zealand's local reference frame). However, for the purposes of the demonstration, the deformation model had been turned off (set to "none").

🖄 CMN_5016 - E	dit Adjustment Method Parameters			
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status	Planoitauve			
Description	General geodetic network maintenance			
Adjustment Coeffi	dents	1		
Coefficient Code	Description	Default Value	New Value	
BRSW	BRSW Bearing swing options	BY_CRDSYS SET * 0.0		
BSCV	BSCV Bearing swing convergence tolerance (arc sec)	1		
CNVG	CNVG Coordinate convergence tolerance (m)	0.0001		
CRLF	CRLF DOS report format (CR+LF line terminator)	yes		
DBUG	DBUG Log file debug options	nothing		
DEFM	DEFM Deformation model definition	LINZDEF NZ2KDF04 2000 0		
TU:O	Teho flag agrilicance levela	35% 35% M/VL 0.2 0.001		
FNAD	FNAD Free net adjustment	no		
LIST	LIST Log file listing options	summary nodes residuals parameters		
MXCH	MXCH Maximum allowed coordinate change	1000		
MXIT	MXIT Maximum iterations	10		
MXND	MXND Max number of nodes	10000		
MXOB	MXOB Max number of obs	50000		
NOCD	NOCD Inhibit generation of new coordinates	no		
OPTF	OPTF Override matrix optimisation	no		
OPTT	OPTT Parameter threshold for matrix optimisation	50		
RACV	RACV Ref frame translation convergence tolerance (m)	0.001		
RCCL	RCCL Calculate refraction coefficient	no		
RCVL	HCVL Default refraction coefficient	0.0/5		
RFCL	RFCL Reference frame calculation options			
RFCO	RECO Overnde reference frame coordinate systems	no		
RPCV	RPCV Ref frame scale/rot convergence tolerance (ppm)	1		
SPEC	SPEC Accuracy test specifications			
13/CAULT	VENIL Vector error as ENIL components			

We now turn the deformation model on (by removing the value "none" so that the deformation model gets applied) and re-run the adjustment.

Landonline Adjustment Residuals with Deformation Model				
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●  ▶ 国家 ⋒   沙皮 Q @ @ ( 1 t t 2 2 2 2 1 1 1 1 1 1 1 1 1 1 1 1 1				
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Description Test earthquake deformation	Add Obs			
Observations         Nodes           Fiter Exclude by         All Vectors         Fiter OK?by         (None)           From Node Code From Node         To Node Code To Node Code To Node         Survey Number         Date         Type         Cadastral Class         Status         Length Exc. Em Mu8         Res 5d Res OK?         Measured. GFS           WIG1         CNS         BDTP         S5 48 50 17878         NPC10008, CCC. Post. Sec. reformat.         09 Sep 2010 00:000.         Vector Difference (XY2)         (None)         Autoritative.         2896         1.000         .0141         225 Bad         Measured. GFS           MQ25         McQueers Valley         BDTP         S5 48 50 17878         2013 00:00:00:00: Vector Difference (XY2)         (None)         Autoritative         16787         1.000         .0141         225 Bad         Measured. GFS           WQ31         WG1 CORS         BDTP         S5 48 50 17878         2013 10:00:00:00: Vector Difference (XY2)         (None)         Autoritative         16787         1.000         .0141         225 Bad         Measured GFS           WQ25         McGueens Valley         BDTP         S5 48 50 17878         2013 10:14 - EMS4 Replacing BDTP         26 Jul 2013 13:17:00         Vector Difference (XY2)         (None)         Autoritative         16787         1.000 <th>ent Type /</th>	ent Type /			
Image: Control of the second secon	► ew Details Cancel			
Redy				

We notice a significant improvement in the adjustment results. The SEUW has reduced from 8.7 to 1.62 and the largest residual from 17cm to 4cm. The deformation model is not perfect so it is likely that at least part of the remaining residual is due to uncertainties in the deformation model. However, the level of accuracy now being achieved is adequate for many spatial applications.

This demonstration has shown that by using a deformation model, data collected at various times in the earthquake sequence (or before the earthquake sequence started) can be used to generate accurate NZGD2000 coordinates. While this demonstration has used Landonline, there is free software called SNAP that can be used by non-Landonline users http://www.linz.govt.nz/data/geodetic-services/download-geodetic-software/snap-concord-downloads



The second demonstration uses the PositioNZ-PP online GNSS processing system.

# PositioNZ-PP - GNSS Post-processing service

Step 1/4: Setup job

Use this form to submit GPS RINEX data for processing by the LINZ PositioNZ online GPS processing service. For more information about this service see the <u>help</u>.

Note: Land Information New Zealand (LINZ) does not provide a warranty of any kind with respect to the PositioNZ-PP service. In no event shall LINZ be liable for loss of any kind whatsoever with respect to the availability or use of this service, or the accuracy of any results obtained from it. Data submitted to PositioNZ-PP may be retained indefinitely by LINZ for testing the PositioNZ-PP service.

Please enter your email address. This will be used to send results to you. The title of the processing job will be used to refer to the job in correspondence.

Email Address:	
my_name@myaddress.com	
Processing Job Title:	1
Test	
Next >>	,
If you are experiencing difficulties or would like to submit feedback on	the PositioNZ-PP service you may contact LINZ by:
<ul> <li>emailing us at <u>crm_geodetic@linz.govt.nz</u> with "PositioNZ-PP Iss</li> </ul>	ue" or "PositioNZ-PP Feedback" in the subject line, or
calling customer support: 0800 665 463	

PositioNZ-PP is an online GNSS post-processing service operated by Land Information New Zealand. It's purpose is to provide global International Terrestrial Reference Frame (ITRF) and local NZGD2000 coordinates by processing a RINEX file submitted by the user with data from three nearby CORS. In the wake of an earthquake, the service can be used to calculate post-earthquake coordinates where and when the user requires them, rather than waiting for LINZ to provide updated control. In this series of slides, we show how PositioNZ-PP could be used to calculate coordinates after the 14 February 2016 earthquake in Christchurch. This earthquake did not significantly impact any of the CORS. If they had been impacted, the CORS coordinates would need to be updated by LINZ prior to the user generating their own control using PositioNZ-PP. Currently the PositioNZ-PP service only works using data collected in New Zealand.

The service is located at http://www.linz.govt.nz/positionzpp

In Step 1, the user enters an email address and job name.

PositioNZ-PP - GNSS	Post-processing
service	

#### Step 2/4: Select RINEX files

RINEX files should have extension .yyO where yy is the last two digits of the year. They may be compressed using the Hatanaka compression scheme, with extension .yyD, using unix compress (extension .Z), or using gzip (extension .gz). They may be uploaded in a zip file (extension .zip) which can contain several files.

Currently only dual frequency data observed in New Zealand after 1-Jan-2000 are accepted by this service. Each job can process a maximum of 10 RINEX files.

Select RINEX files

Filename	Size	Status
ERCW0490.160	1 MB	0% 🥥 î
Add files     Select your DINEX Files have then click Next to yoursed them	1 MB	0%
Select your KINEX files here then click Next to upload them.		

In Step 2, the user uploads their RINEX data. The minimum length of data is 1 hour, although 4 hours is recommended for more accurate results, given that some of the reference stations could be up to 100km away.

PositioNZ-PP - GNSS Post-proce	ssing
service	

Step 3/4: Edit RINEX file metadata

Check that the information extracted from the RINEX header (station name, antenna type, and antenna height) is correct. Note that PositioNZ-PP will only accept "official" antenna types. You can remove files that were unintentionally added.

Uploaded R	INEX file: E	RCW0490	.160 details.
Remove	e file from j	job	
Station Nan	ne:		
ERCW			
The value in	n the RINE)	K file is: ER	CW
Antenna/ra	dome type:		
TRMR8_0	SNSS		•
The value in	n the RINE)	( file is: TR	MR8_GNSS
Antenna he	ight (metre	s, max 4dp	):
1.6280			
The value in	n the RINE	( file is: 1.6	5280
	Marth	Cancol	

In Step 3, the service reports on the key metadata it has read from the RINEX file header. Any of this information can be changed at this stage. It is important that the antenna height and type are both correct, or there will be errors in the vertical coordinate. The antenna height is the height from the ground mark to the Antenna Reference Point (ARP).

# PositioNZ-PP - GNSS Post-processing service

Step 4/4: Confirm job details and submit for processing

Please confirm the following details and then click Submit Job for Processing otherwise click Back to amend the job.

Email Address :my\_name@myaddress.com Job Title :Test Filename : ERCW0490.160 Station name :ERCW Antenna height :1.6280 Antenna Type :TRMR8\_GNSS

<< Back Submit Job for Processing Cancel

In Step 4, there is an opportunity to check that the supplied information is correct, before the job is submitted. Once submitted, it will typically take 2-5 minutes for results to be returned, although the time can be longer if there are a large number of jobs already in the queue.

	Input data		
PositioNZ-PP Results and Geodetic Database	File : ERCW0490.160 Mark : ERCW Antenna : TRMR8_GNSS (changed to TRMR8_GNSS NONE) Receiver : TRIMBLE NETRS Antenna height: 1.628 m Orbit type: Final Final Coordinates		
ERCW: Mark details MARK IDENTIFICATION Code: ERCW Name: IT VII SO 11487 POSN 20111223 Alternatives: IT VII SO 11487 NZTM: S180045.000 1575882.010	Epoch coordinates - defined at the observation epoch (decimal year 2016.13) ITRF2008 XYZ (m) : -4593921.1492 588371.9411 -4370563.8455 ITRF96 XYZ (m) : -4593921.1427 588371.9155 -4370563.8734 ITRF2008 lon/lat/hgt : 172.701508453 -43.532144476 17.7288 ITRF96 lon/lat/hgt : 172.701508757 -43.532144719 17.7410 NZCD2000 security defined at a province acces 2000 0		
NZGD 2000 COORDINATES Latitude: 43° 31° 55.73415° 5 Order: 4 Longitude: 172° 42° 05.45543° E <sup>Authorised:</sup> 9-Jul-2014 Historical Ellipsoidal height (m): 17.786 Reference: 2014 Mise Control - BDVV Disturbed values Circuit Circuit Northing (m) Easting (m) Scale Factor Convergence Mount Pleasant Circuit 2000 806488.939 397944.475 1.0000001 -0° 01° 03° Historical values	NEGD2000 cool data(25 definited at nonlinial epoch 2000)         Deformation model version:         NZGD2000 lon/lat/hgt (DMS): 172 42 05.45481 E 43 31 55.73645 S 17.7412         NZGD2000 lon/lat/hgt : 172.701515225 -43.532149013 17.7412         NZTM2000 east/north : 1575882.0006 5180044.9327         PLEATM2000 east/north : 397944.4608 806488.8676         NZVD2009 height :		

The results are sent via email, as shown on the right-hand side of the slide. Several different coordinates are provided, but the one we are interested in is the Mt Pleasant Meridional Circuit (PLEATM2000) coordinate. We can compare these with the existing coordinates in the Geodetic Database http://apps.linz.govt.nz/gdb/ (left-hand side of slide).

The coordinates differ by 2cm in the easting and 7cm in the northing, indicating that the mark has moved during the 14 February 2016 earthquake.

## **Key Points**



- Data collected at different times in a deforming region can be combined using a deformation model to generate consistent coordinates
- Users can collect their own GNSS data and submit it using the PositioNZ-PP online processing service after an earthquake, to generate control where and when they need it

In summary, the presence of significant deformation (earthquake-related or otherwise) is a reality for many parts of New Zealand. Managing this deformation requires a deformation model to be incorporated into coordinate-generation tools. Examples of such tools are the Landonline system, used by LINZ to generate coordinates, and PositioNZ-PP, which may be used by external users to generate accurate coordinates.

## **Useful websites**



- Geodetic database: <u>http://apps.linz.govt.nz/gdb/</u>
- SNAP least squares adjustment software: <u>http://www.linz.govt.nz/data/geodetic-</u> <u>services/download-geodetic-software/snap-</u> <u>concord-downloads</u>
- PositioNZ-PP: <u>http://www.linz.govt.nz/positionzpp</u>





