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Does BeiDou enhance positioning performance within CORSnet-NSW?

UNSW
THE UNIVERSITY OF NEW SOUTH WALES

Never Stand Still

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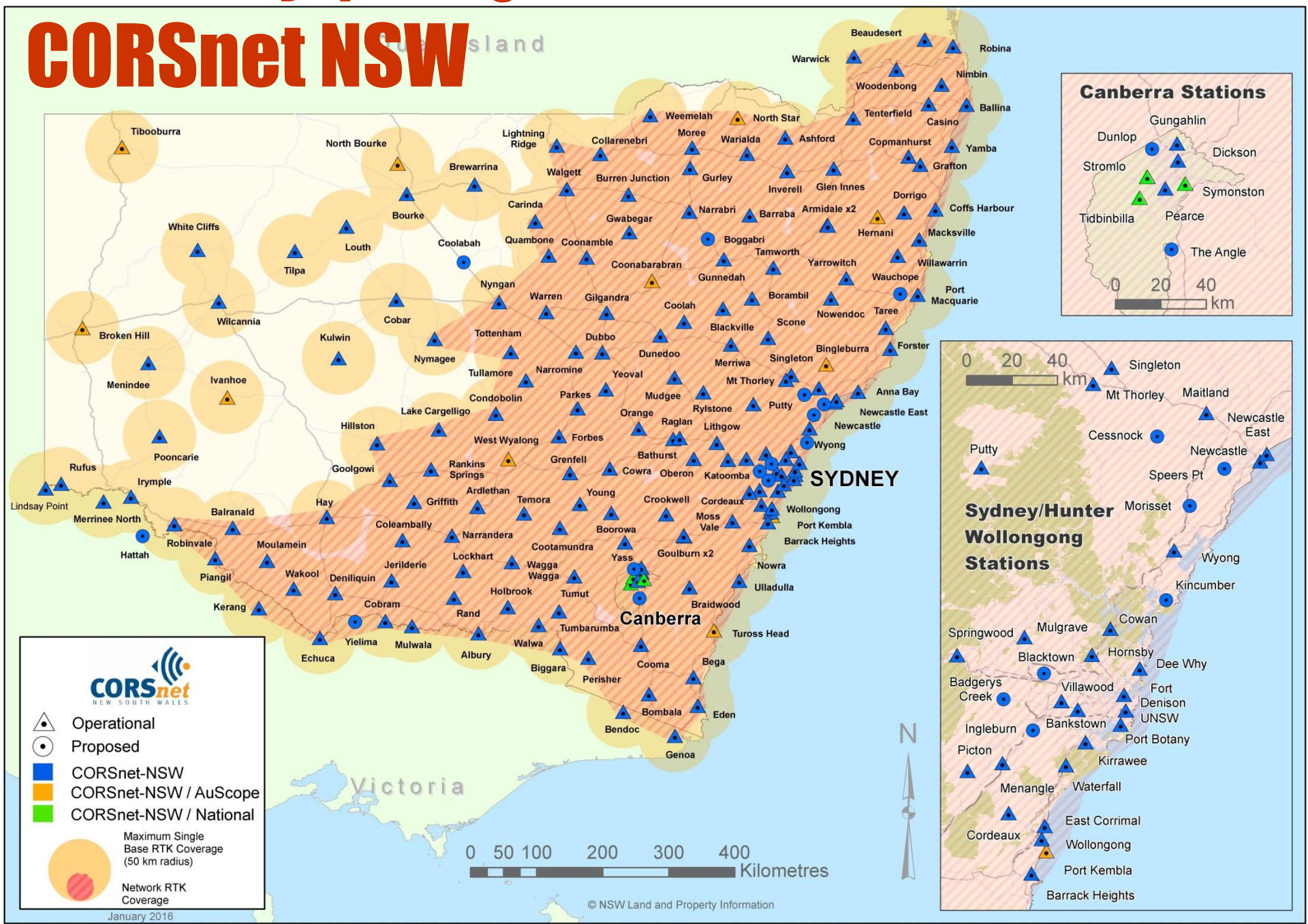
Jerom Vanderstappen, Thomas Grinter

Continuously Operating Reference Station – CORS

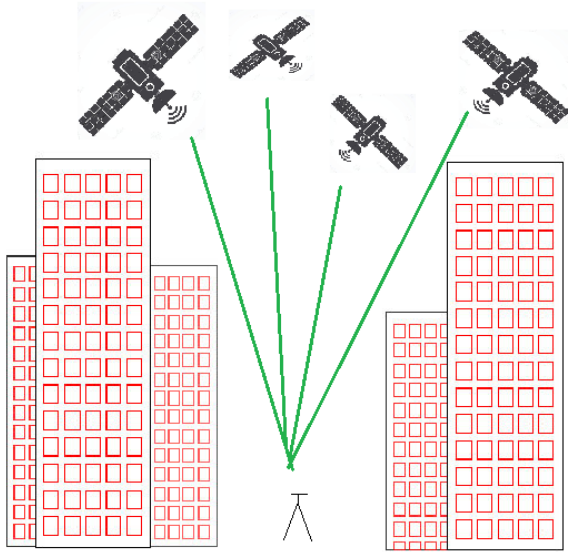


Justification & Aims

- CORSnet-NSW (managed by LPI) currently has a limited number of BeiDou capable stations

- LPI is interested in integrating BeiDou (and other GNSSs) into CORSnet-NSW. Issues are costs for firmware upgrades, quality assurance, hardware replacement.

- Preliminary research suggests BeiDou *improves robustness and accuracy within urban canyons*



Will BeiDou enhance positioning performance within CORSnet-NSW?

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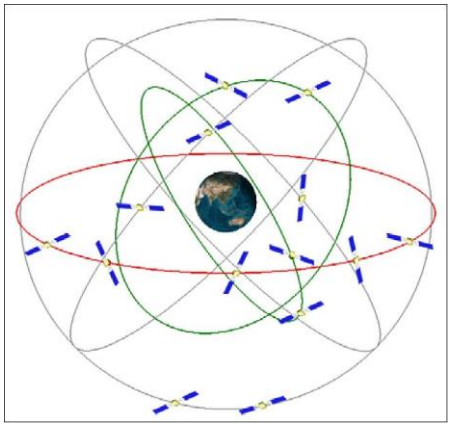
BeiDou Satellite Navigation System

- China's independent Navigation Satellite System providing positioning, navigation and timing (PNT) services regionally and ultimately globally.

- Consists of 17 satellites in three different orbital planes – MEO, GEO and IGSO. Planned for 35 sats by 2020.

- BeiDou achieved initial operational capability (IOC) in 2012 providing regional coverage and providing continuous PNT services to the Asia-Pacific area.

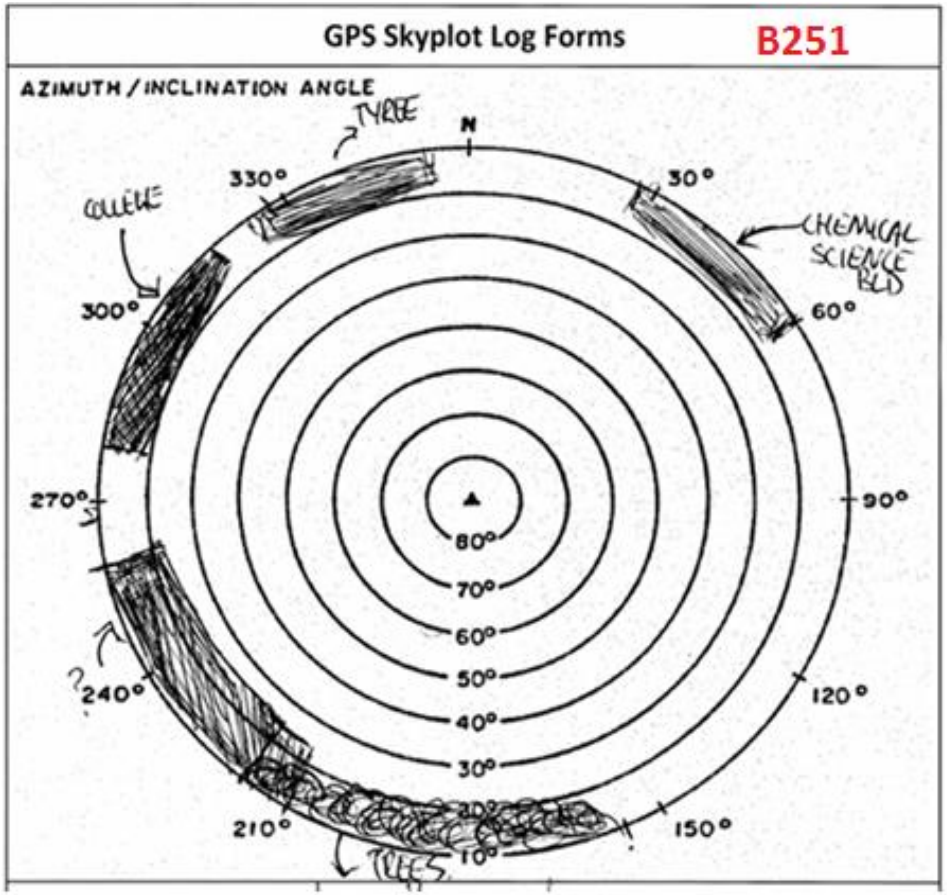


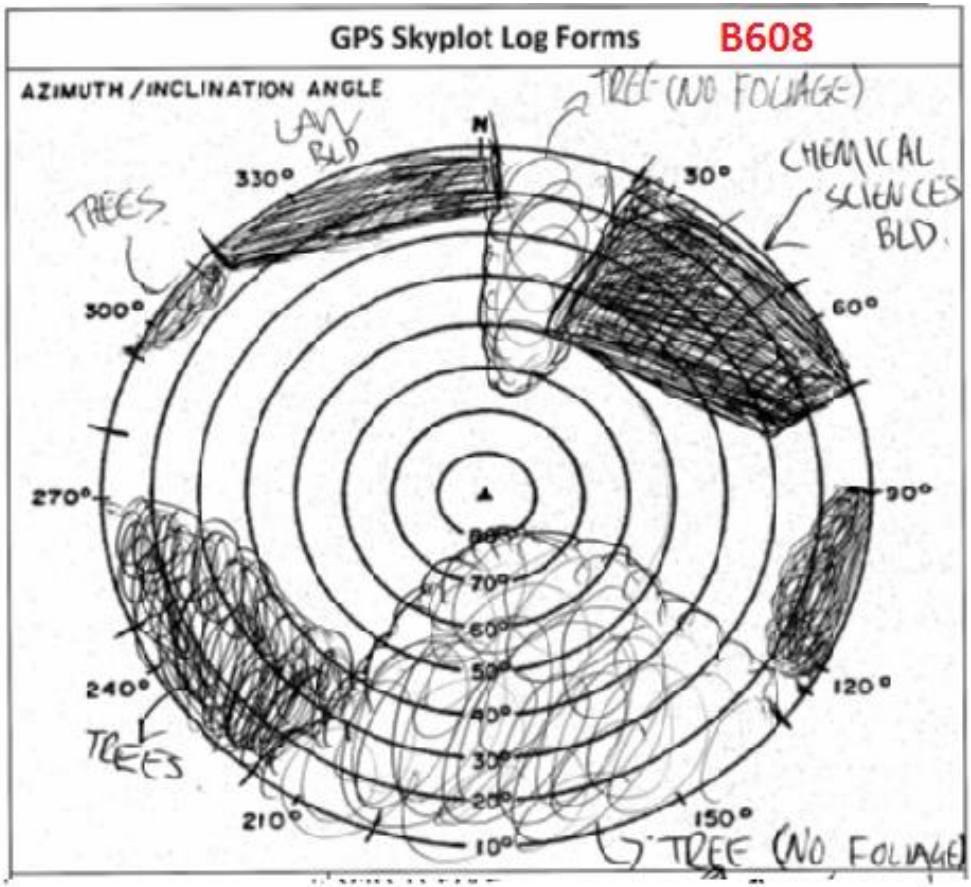
Australia will benefit given its geographical position and versatile GNSS infrastructure

Single base-RTK fieldwork

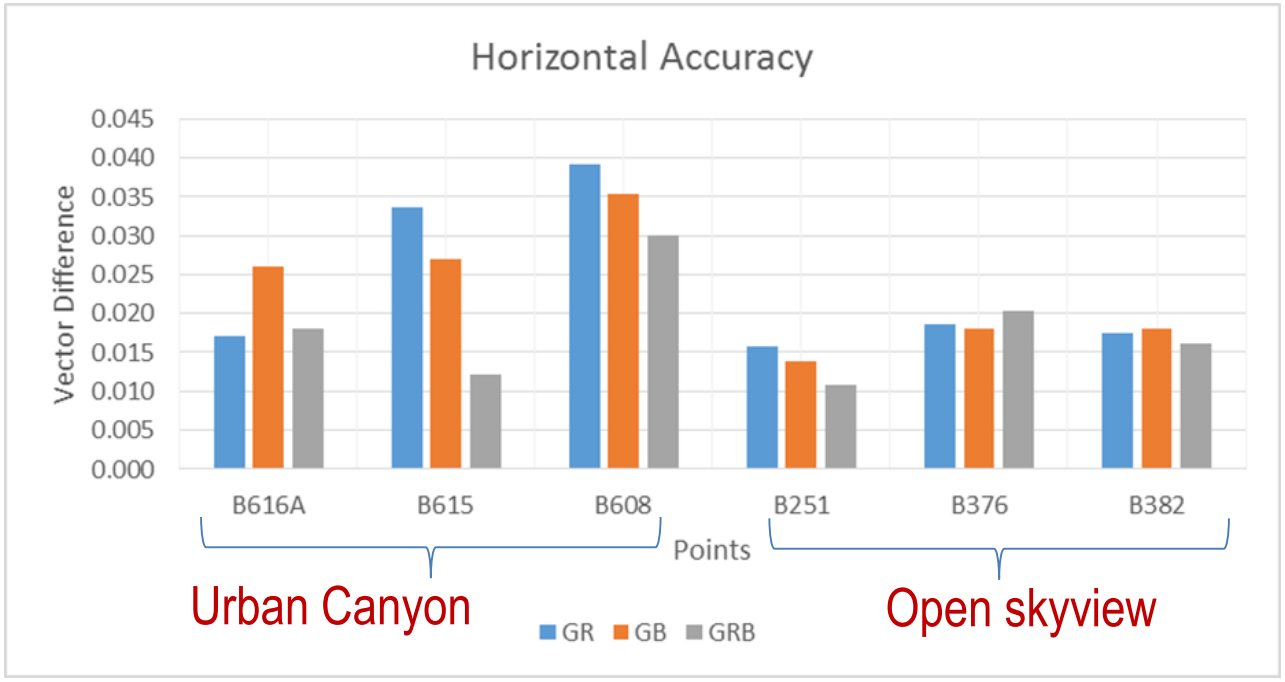
- Three different GNSS combinations were tested using single-base RTK – GB, GR, GRB
- 6 different marks on UNSW campus observed in open environments and urban canyons
- Field methodology adopted recommendations/standards set out by LPI and ICSM
- Marks were observed a total of 15x for each observation leading to 7 full days of fieldwork
- All GNSS observations are in given in GDA94(2010)
- In order to test for accuracy against the local campus control network (which ties into the SCIMS ground control network), a *block shift* is applied to move GNSS observations onto GDA94(1997)

RTK Position Combinations
GPS + BeiDou **(GB)**
GPS + GLONASS **(GR)**
GPS + GLONASS + BeiDou **(GRB)**


GPS Skyplot Log Forms
B251
AZIMUTH / INCLINATION ANGLE
TYREE
N
330°
30°
COLLEGE
CHEMICAL SCIENCE BLD
300°
60°
270°
90°
80°
70°
60°
50°
40°
30°
240°
120°
210°
150°
TREES

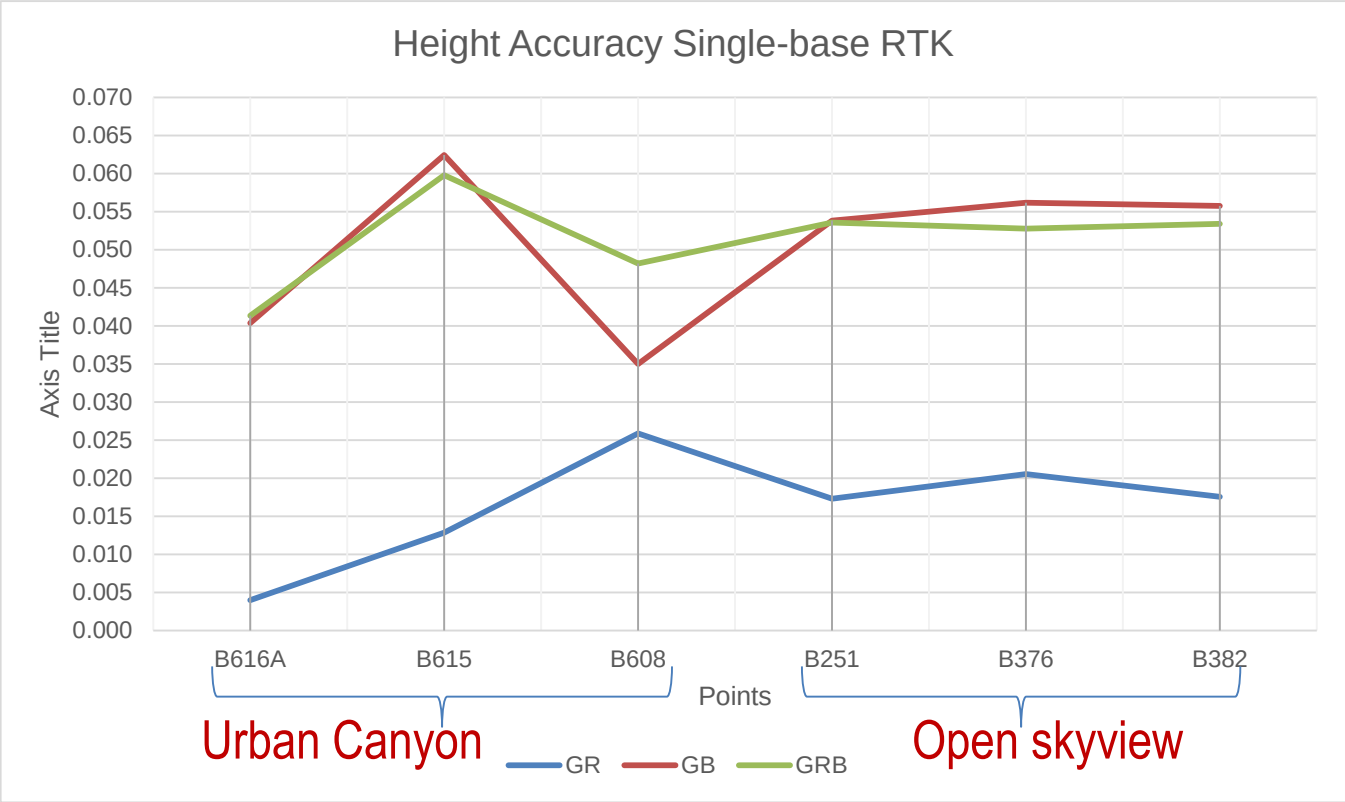

GPS Skyplot Log Forms
B608
AZIMUTH / INCLINATION ANGLE
TREE (NO FOLIAGE)
LAW BLD
N
330°
30°
TREES
CHEMICAL SCIENCES BLD.
300°
60°
270°
90°
70°
60°
50°
240°
120°
TREES
210°
150°
TREE (NO FOLIAGE)

Single-base RTK - Horizontal Results



- No appreciable horizontal accuracy improvement with BeiDou
- GRB marginally better in urban environments
- Lack of BeiDou MEO satellites to strengthen geometry
- GEO and IGSO satellites cut off due to UNSW location and elevation angles (cf Perth)

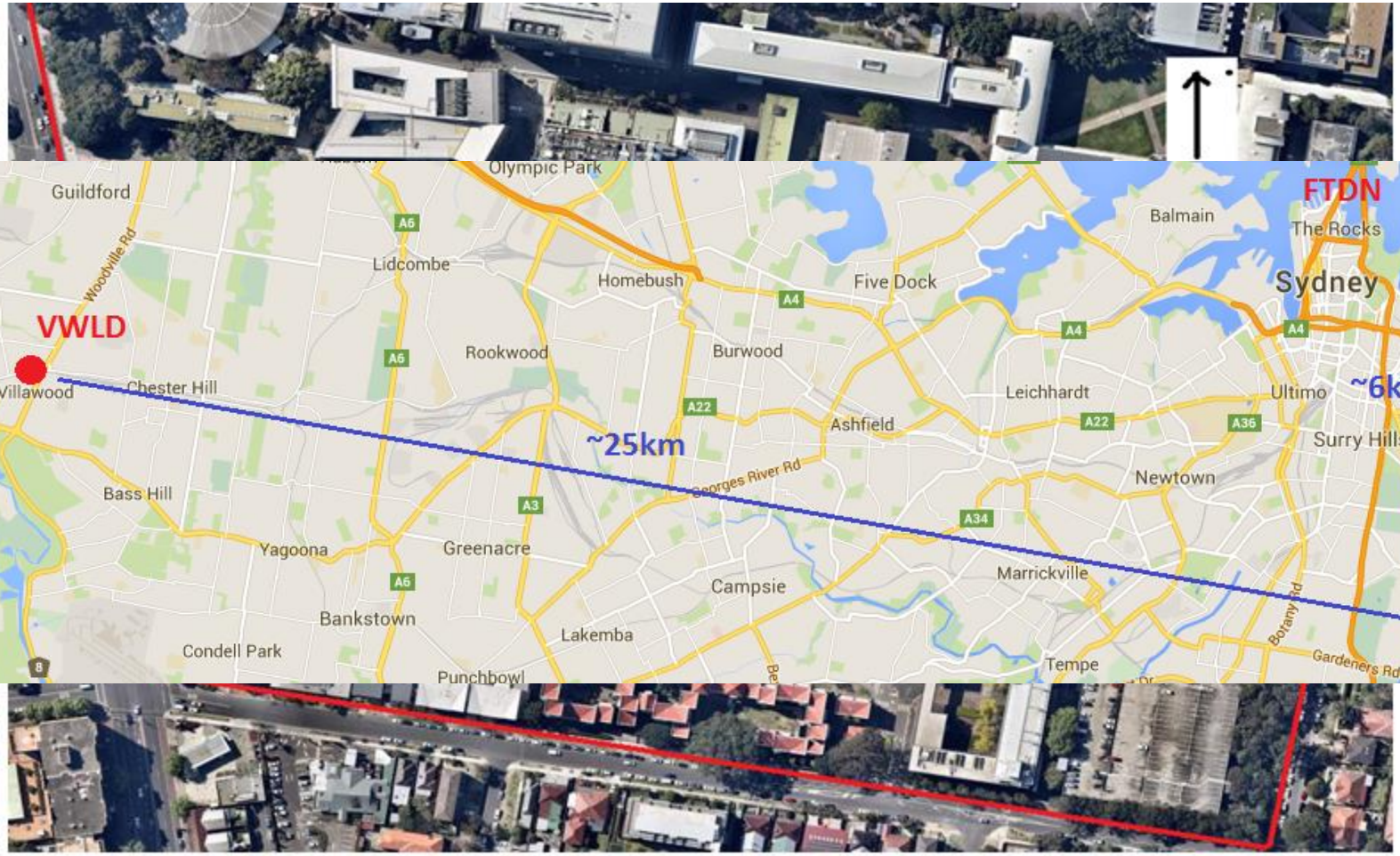
Single-base RTK – Vertical Results



BeiDou system seems to bias the height across all marks regardless environment.

RTK Position Combinations
GPS + BeiDou **(GB)**
GPS + GLONASS **(GR)**
GPS + GLONASS + BeiDou **(GRB)**

Single-base RTK Two Peg Test



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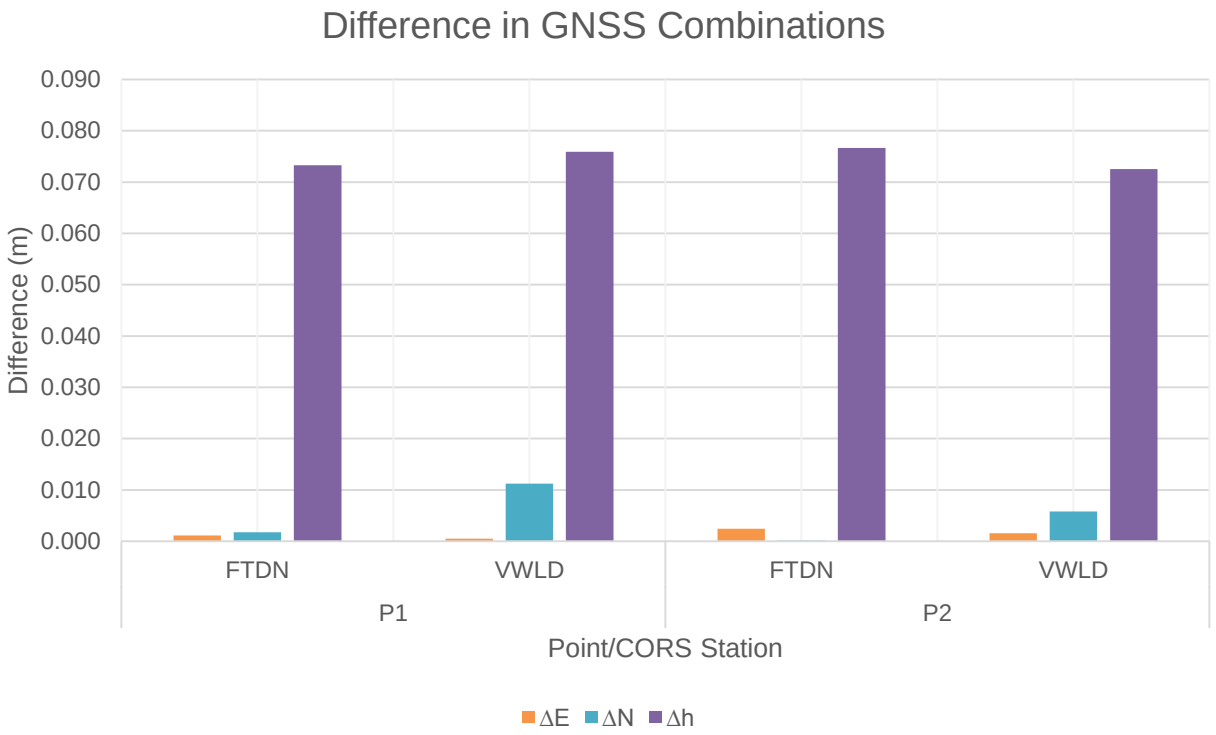
Single-base RTK Two Peg Test Results



Ionosphere/troposphere errors negligible between 6km & 25km baselines

Geometry and observation conditions kept constant

Heights between GR and GB combinations should be at the mm level

Investigating the Height discrepancy

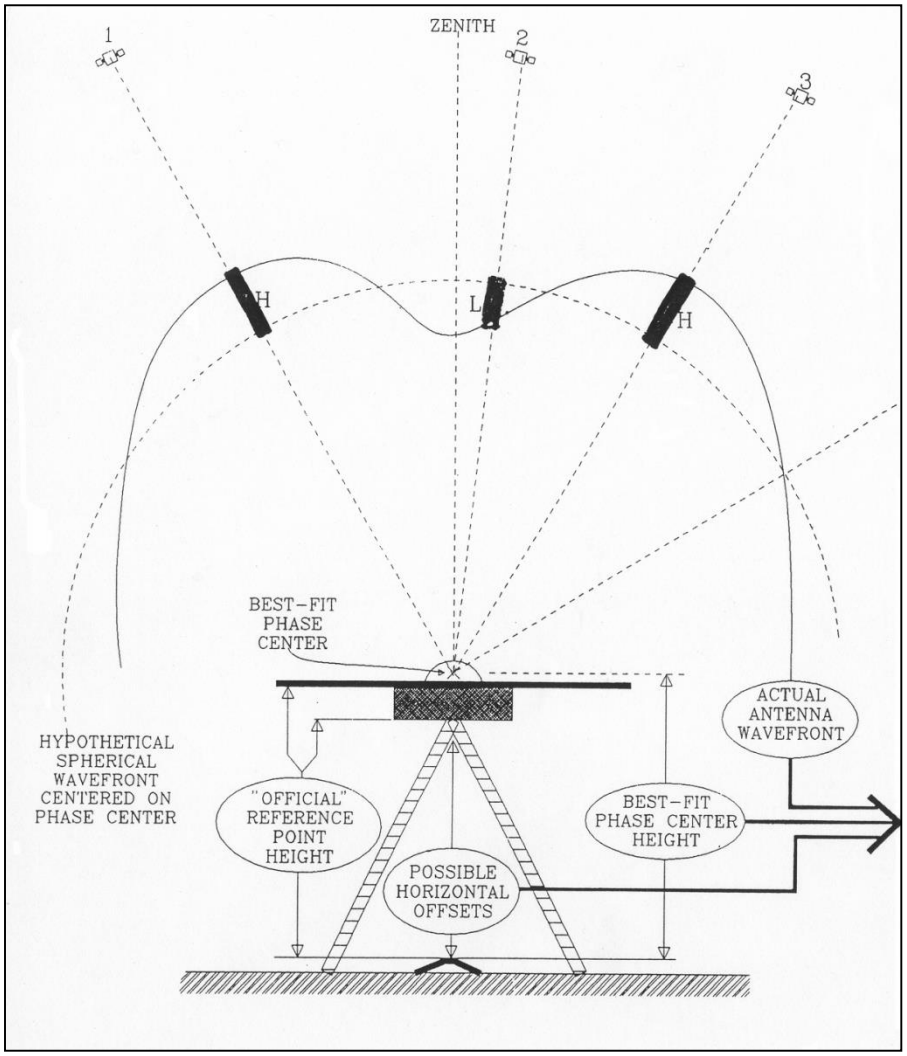
- Single-base RTK results showed bias in height when BeiDou used
- GNSS Two Peg Test reinforced this trend when the GR and GB heights were compared.
- Atmospheric errors were considered negligible between VLWD vs FTDN CORS.
- The IGS08.atx and NGS equivalent revealed no APCV model *for BeiDou signals (*or GLONASS)
- Riddell (2015) notes that it is common convention to use GPS values for GLONASS signals were there are none

Is a wrong Antenna Phase Centre Variation model the culprit?

	Default Manufacturer Settings	LEIGS15 NONE (IGS)	LEIGS15 NONE (NGS)
Hz Offset	0.0000	-	-
Vertical Offset	0.0000	-	-
L1 Phase Offset	0.1999	0.2021	0.2021
L2 Phase Offset	0.1983	0.2007	0.2007

Antenna Phase Centre Variation

- like 3D prism constant for GPS -



(Courtesy Clark & Schupler, 1996)

- Unique to each antenna type
- Two components
  - Offset up to 100mm
  - Zenith dependent up to 15mm
- Different for L1 & L2
- Old models relative, new models are absolute
- Models differentiated by IGS naming convention
  - Make sure your Rx recognises the name!!

Other possibilities for Height discrepancy

- CORS single base RTK sites:
  - FTDN Trimble NetR9/ TRM antenna
  - VLWD Trimble NetR9/ Ashtech choke ring antenna
  - Rover was a Leica Viva GS15 receiver/ antenna.
- Mixed receivers and Multi-GNSS could be the issue.

- Was the rover correctly configured by users?

- Were the data streams from CORSnet-NSW correctly configured?

- Chinese researchers have reported consistent results in height when measuring BeiDou-Beidou

- Testing at CRKennedy have confirmed consistent results Leica-Leica

Conclusion

This was an undergraduate student thesis. Whilst carefully performed, should be regarded as a limited study.

Horizontal Accuracy:

- The introduction of BeiDou in dual and triple combination solutions did improve initialisation success rates but not necessarily TTFF
- The horizontal accuracy was marginally improved in difficult environments with the addition of BeiDou signals
- The eastern proximity of Sydney and the current lack of MEO satellites in the BeiDou constellation translated to little improvement in positioning acquisition or accuracy in urban environments.

Vertical Accuracy:

- Combinations including BeiDou signals consistently degraded the height accuracy across all marks in this study.

Conclusion

Possible causes of Vertical Accuracy degradation:

- Two peg test from single base RTK solutions from 6km and 25km baselines were consistent which implies ionosphere/troposphere effects were not the cause of the height bias.

- Both CORSnet-NSW single base RTK base stations employed Trimble NetR9 receivers. In combination with Leica Viva receivers, the configuration on either receiver or data stream could cause the height bias

- Incomplete APCV modelling may have an effect, especially in the context of multi-GNSS signals and combinations of mixed brand receivers.

CORS system providers, receiver manufacturers and users should be wary of mixed combinations of receivers and constellations for high accuracy positioning


Questions?