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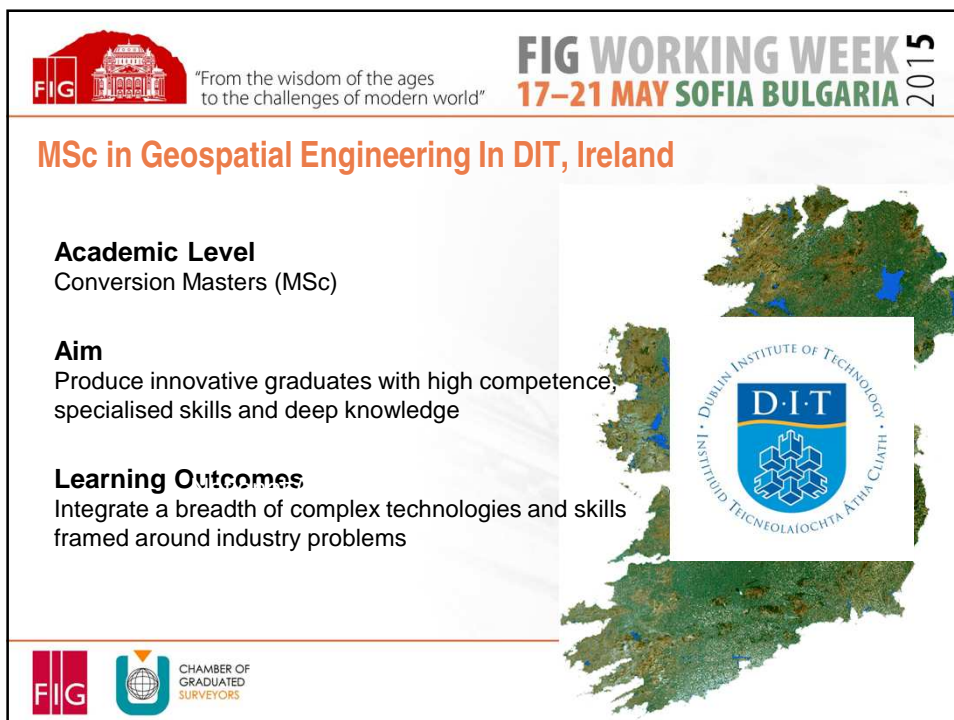
**An Assessment of the Accuracy of PPP in Remote Areas in Oman**

Rashid Al Alawi  
National Survey Authority (NSA) Oman

Dr. Audrey Martin FSCSI FRICS  
Dublin Institute of Technology (DIT) Ireland

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**MSc in Geospatial Engineering In DIT, Ireland**

**Academic Level**  
Conversion Masters (MSc)

**Aim**  
Produce innovative graduates with high competence, specialised skills and deep knowledge

**Learning Outcomes**  
Integrate a breadth of complex technologies and skills framed around industry problems

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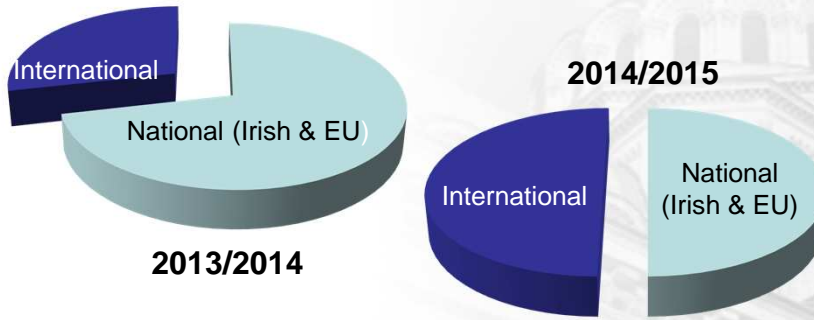




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**MSc Geospatial Engineering Student Cohort**



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**MSc in Geospatial Engineering DIT Structure**



Phase 1 (30 ECTS)	Phase 2 (30 ECTS)	Phase 3 (30 ECTS)
Project Management	Work Placement	
Coordinate Transformations	Research Skills	
Geodetic Surveying	Geospatial Reference Systems	Dissertation
Geospatial Data Provision	Point Cloud Science	
Systems and Practise 1	Systems and Practise 2	
Option 1	Option 2	

**2014 Optional Modules (5 ECTS each)**

- Digital Elevation Models from Airborne sources
- Visualisation and Delivery of Geospatial Information
- Geographic Information Science I
- Spatial data for 3D Urban Models
- National Landscape and Land Cover models
- Geospatial Engineering for Building Information Modelling

**1 ECTS = 20 learning hours**





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## Rashid Al Alawi MSc Dissertation (May – September)

### Aim

To establish a best practice guidelines document for GNSS positioning in Oman.

### Objectives

1. Review the best practice guidelines of the (CORS) networks.
2. Critically review the current CORS network design for Oman
3. Determine the accuracy of extending a CORS network using the TRS method.
4. Assess PPP alternative GNSS solution for remote areas in Oman.



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## Oman: Surveying and Mapping Infrastructure

### National Survey Authority (NSA)

**1954** - Fahud Geodetic Datum established

**1979** - Doppler satellite campaign 42 control stations in the Fahud Datum network occupied.

**2014** - New geocentric datum based on the ITRF2008 frame solution adopted (ONGD14)

ONGD14 realised through occupation of 20 geodetic control points and connected to almost 50 IGS sites.

Transformation parameters between ITRF2008@2013 and ITRF89



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The Cooperative International GPS Tracking Network (CIGNET) WGS84 was established in 1994.

Comprised of 7 GPS primary stations established by NSA observed for 60 hours

Known as The Sultanate of Oman WGS84 stations.



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In 1993, the First Order GPS Network was established by NSA.

Comprised of 79 GPS control stations.

GPS observation conducted for every control point for 24 hours.

Connection was made to the 7 primary stations.



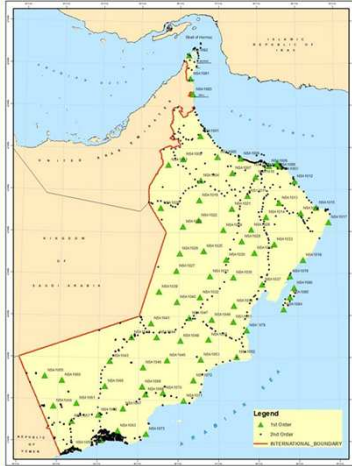


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NSA First Order & Second Order Control Network



## Second Order GPS Network

Comprised of 494 stations, established progressively by NSA until 2010 .

Stations were observed for 2-4 hours depending on the baseline length.

More than 90% of these stations are benchmarks.



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NSA Observed 20 Primary GPS Stations



## First Order GPS Field Campaign

In 2013, 20 control point stations were selected,

The campaign covers 7 primary stations and 13 First Order GPS stations.

Each station was observed for one week while connected to almost 50 IGS sites.



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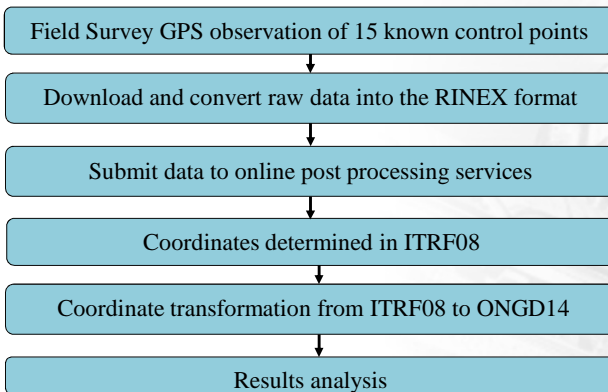
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**Objective 4:**  
**Assess PPP alternative GNSS solution for remote areas in Oman.**



Online PPP services selected:

1. Trimble RTX
2. CSRS
3. AUSPOS



## Field Survey

27<sup>th</sup> April and 13<sup>th</sup> May, 2014 by a NSA field survey team.

15 control points were selected from the Oman National Geodetic Network.

1 and 2-hour GPS data recorded with a Trimble 5700 receiver

Control point accuracy  
 $< 1 \text{ ppm/km}$  in the horizontal and  
 $< 3 \text{ ppm/km}$  in the vertical

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### Trimble RTX 1 hour

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$\Delta E$	0,013	-0,267	-0,126	-0,232	-0,19	-0,038	-0,106	-0,176	-0,052	-0,029	-0,081	-0,031	-0,005	-0,034	-0,059
$\Delta N$	0,117	0,13	0,266	-0,061	0,178	-0,242	0,115	0,147	0,017	-0,115	-0,08	-0,128	-0,053	-0,052	0,023
$\Delta \text{Height}$	-0,130	0,000	-0,082	-0,069	-0,020	0,023	0,302	0,067	0,088	0,180	0,155	0,056	-0,099	-0,020	0,116

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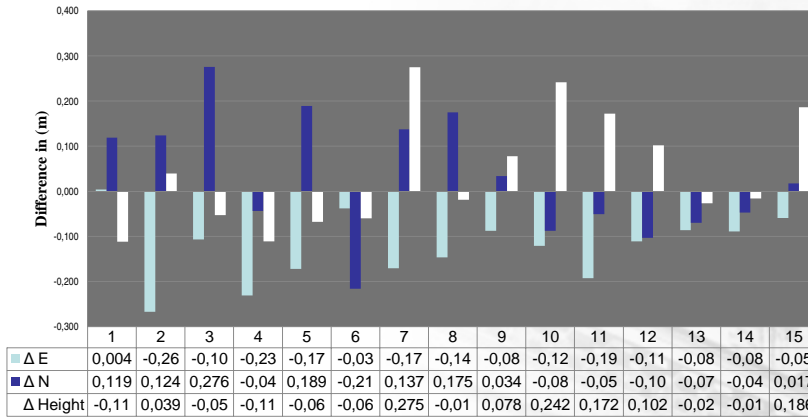


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### Trimble RTX 2 hour



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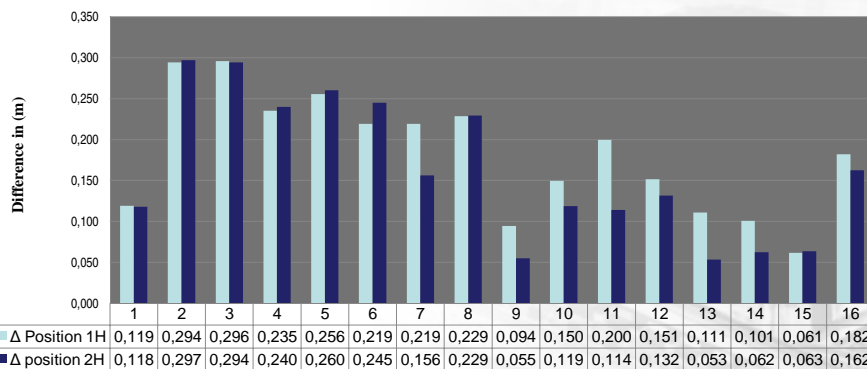


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### Trimble RTX – Δ 2D position 1 vs 2-hour Obs



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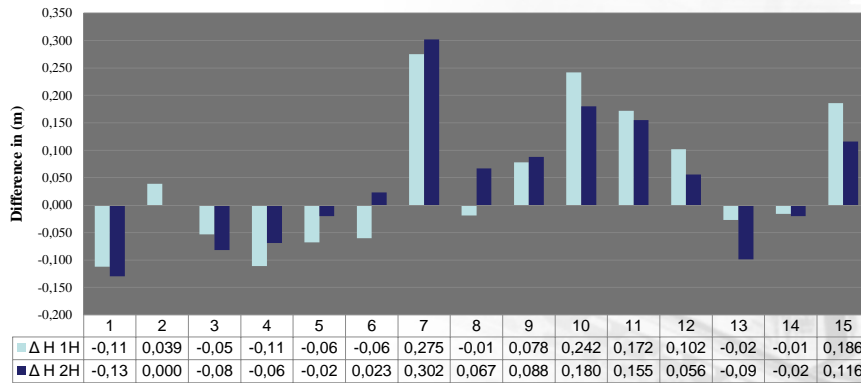


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### Trimble RTX - $\Delta$ Height in 1 vs 2-hour Obs



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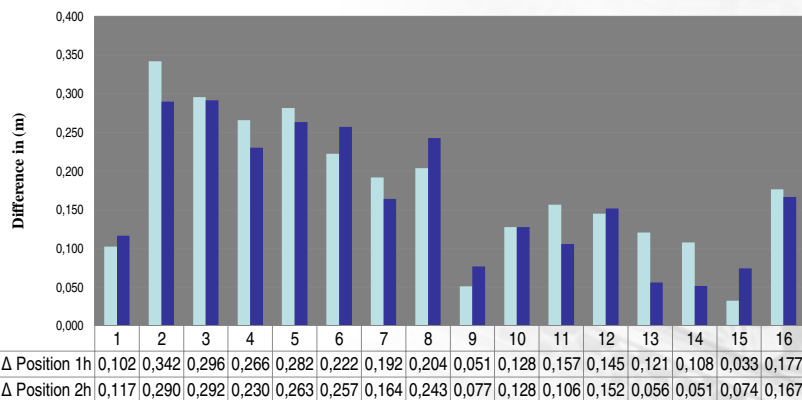


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### CSRS - $\Delta$ 2D position in 1 hour vs 2-hour Obs



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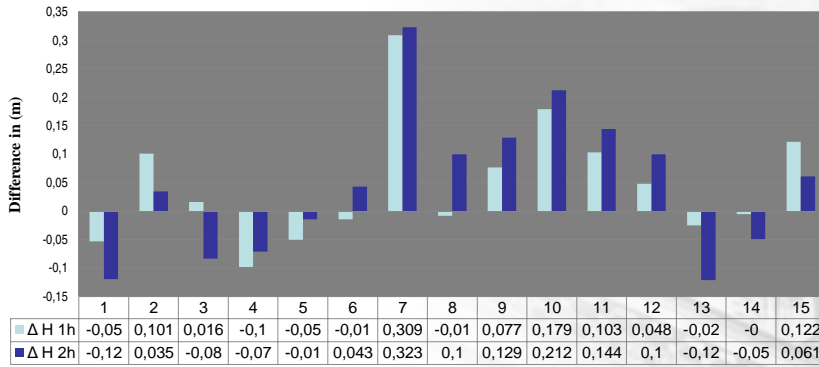




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### CSRS $\Delta$ Height in 1 vs 2-hour Obs



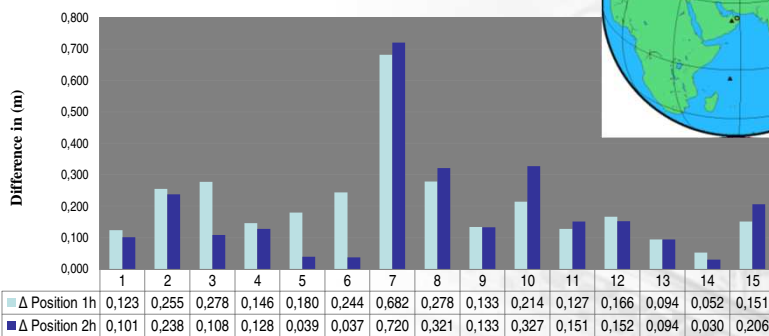
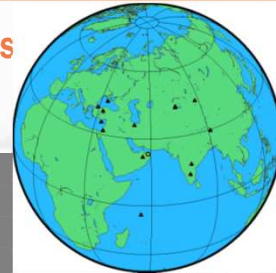
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### AUSPOS – $\Delta$ 2D Position 1 hour vs 2-hour Obs



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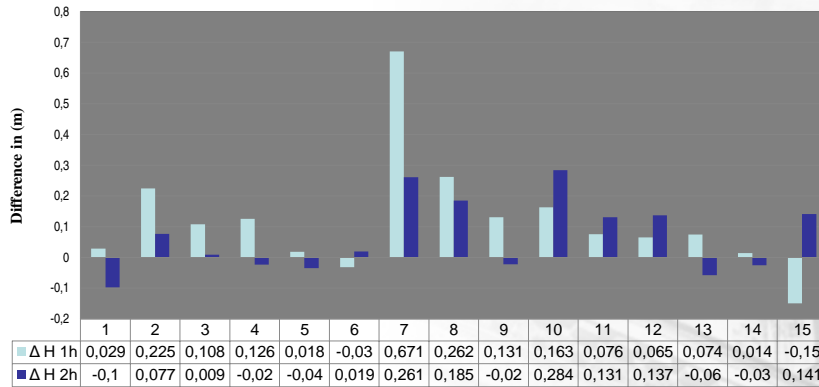




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### AUSPOS – Δ Height 1 vs 2-hour Obs



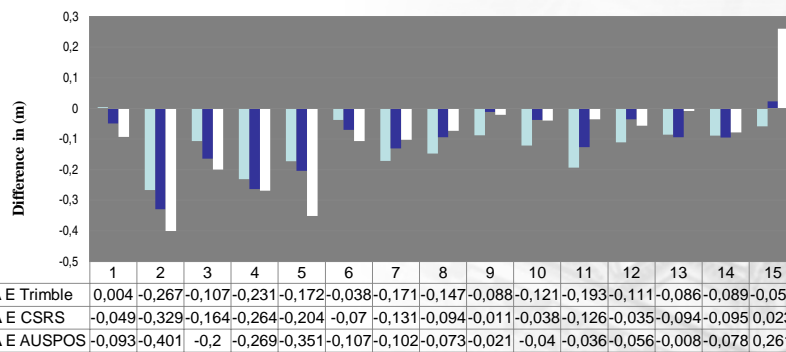
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### All Services – 1 Hour Δ Eastings



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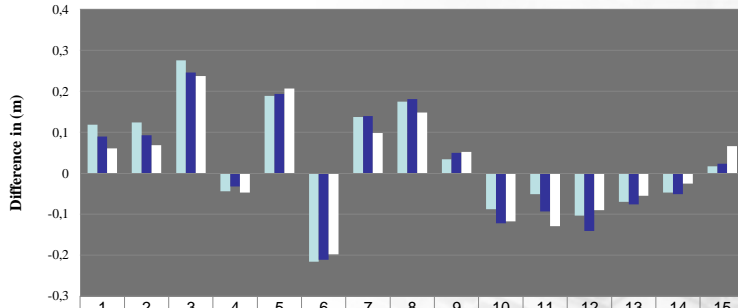


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**All Services – 1 Hour  $\Delta$  Northings**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$\Delta$ N Trimble	0,119	0,124	0,276	-0,04	0,189	-0,22	0,137	0,175	0,034	-0,09	-0,05	-0,1	-0,07	-0,05	0,017
$\Delta$ N CSRS	0,09	0,093	0,246	-0,03	0,194	-0,21	0,14	0,181	0,05	-0,12	-0,09	-0,14	-0,08	-0,05	0,023
$\Delta$ N AUSPOS	0,061	0,069	0,237	-0,05	0,207	-0,2	0,098	0,148	0,052	-0,12	-0,13	-0,09	-0,05	-0,02	0,066



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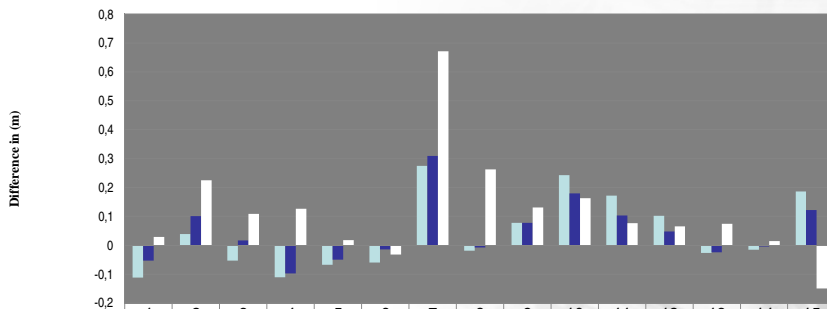


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**All Services – 1 Hour  $\Delta$  Height**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$\Delta$ H Trimble	-0,11	0,039	-0,05	-0,11	-0,07	-0,06	0,275	-0,02	0,078	0,242	0,172	0,102	-0,03	-0,02	0,186
$\Delta$ H CSRS	-0,05	0,101	0,016	-0,1	-0,05	-0,01	0,309	-0,01	0,077	0,179	0,103	0,048	-0,02	-0	0,122
$\Delta$ HAUSPOS	0,029	0,225	0,108	0,126	0,018	-0,03	0,671	0,262	0,131	0,163	0,076	0,065	0,074	0,014	-0,15



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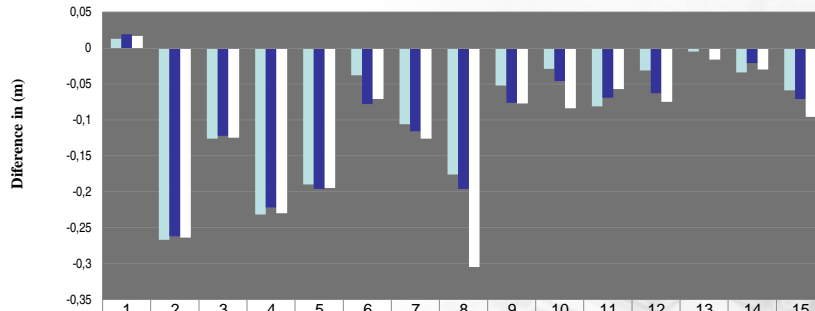


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**All Services – 2 hour  $\Delta$  Easting**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$\Delta E$ Trimble	0,013	-0,27	-0,13	-0,23	-0,19	-0,04	-0,11	-0,18	-0,05	-0,03	-0,08	-0,03	-0,01	-0,03	-0,06
$\Delta E$ CSRS	0,019	-0,26	-0,12	-0,22	-0,2	-0,08	-0,12	-0,2	-0,08	-0,05	-0,07	-0,06	0	-0,02	-0,07
$\Delta E$ Auspos	0,017	-0,26	-0,13	-0,23	-0,19	-0,07	-0,13	-0,3	-0,08	-0,08	-0,06	-0,08	-0,02	-0,03	-0,1



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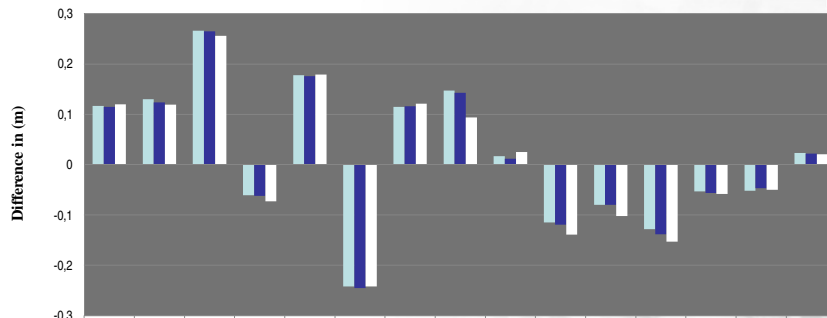


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**All Services – 2 hour  $\Delta$  Northings**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$\Delta N$ Trimble	0,117	0,13	0,266	-0,061	0,178	-0,242	0,115	0,147	0,017	-0,115	-0,08	-0,128	-0,053	-0,052	0,023
$\Delta N$ CSRS	0,115	0,124	0,265	-0,062	0,176	-0,245	0,116	0,143	0,012	-0,119	-0,08	-0,138	-0,056	-0,047	0,022
$\Delta N$ AUSPOS	0,12	0,119	0,256	-0,073	0,179	-0,242	0,121	0,094	0,025	-0,139	-0,102	-0,153	-0,058	-0,05	0,021



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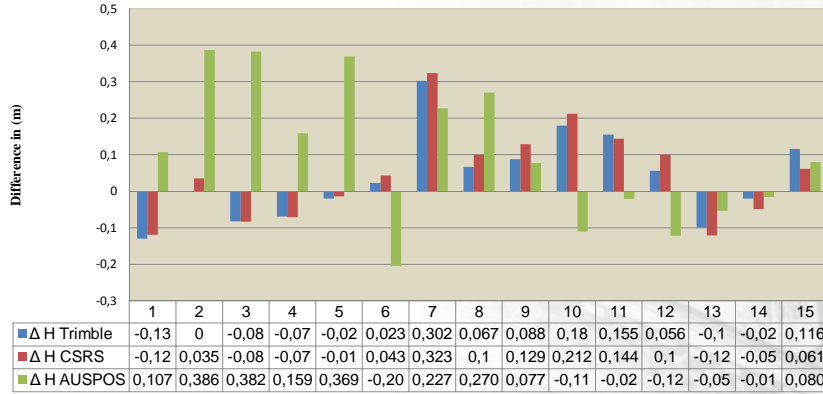


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**All Services – 2 hour  $\Delta$  Height**



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**Average  $\Delta$  1 and 2-hour PPP online services**

PPP online service	Obs time	Easting	Northing	Height
Trimble RTX	1-hour	131	112	104
	2-hours	96	115	94
CSRS	1-hour	115	116	81
	2-hours	104	115	107
AUSPOS	1-hour	140	107	143
	2-hours	117	116	66



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## Conclusion



- Overall, variability in the results across the 15 sites between all three PPP services was recognized.
- Differences in the 3D position of 33% of the samples were approximately 50 mm in 1-hour and 2-hour results across all three services.
- Evident systematic bias in Easting values.
- Thus the PPP method can be used for medium-accuracy positioning purposes, such as map production to small and medium scales.



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## Thank You

### An Assessment of the Accuracy of PPP in Remote Areas in Oman

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