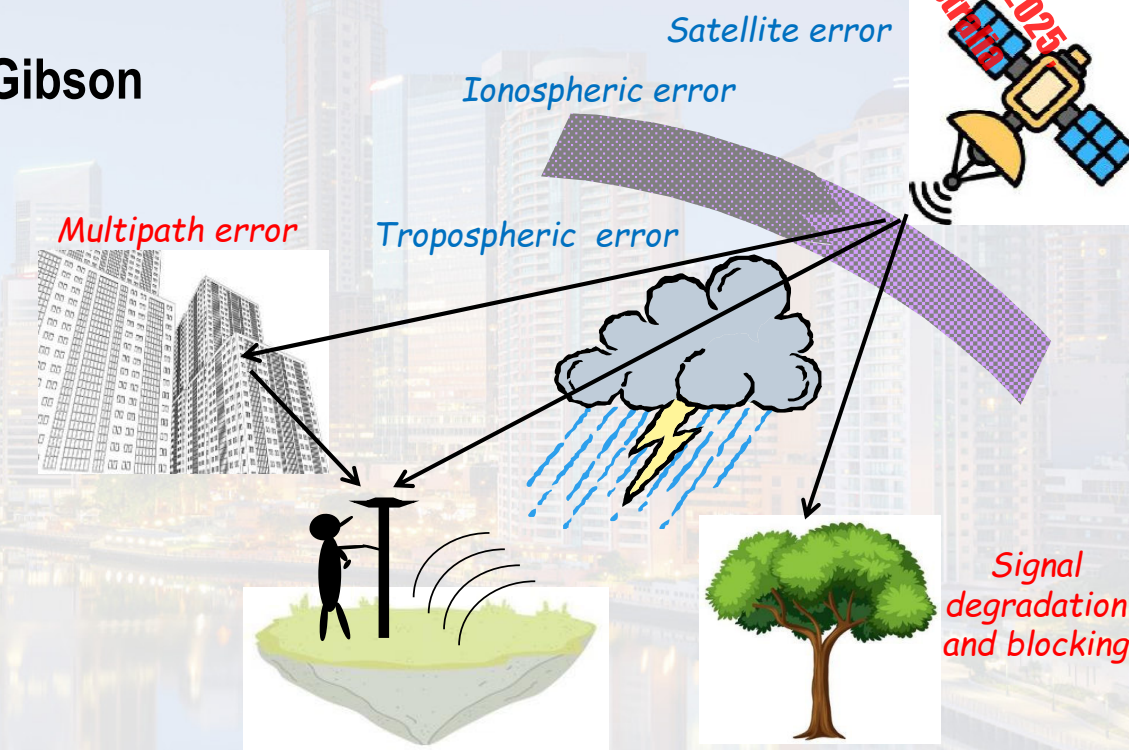


Determination of GNSS RTK accuracy in challenging environments

Paul Denys, Yuxi Jin, Jett Gannaway, Hamish Gibson

Presenter: Emily Tidey

School of Surveying, Otago University
Dunedin, New Zealand

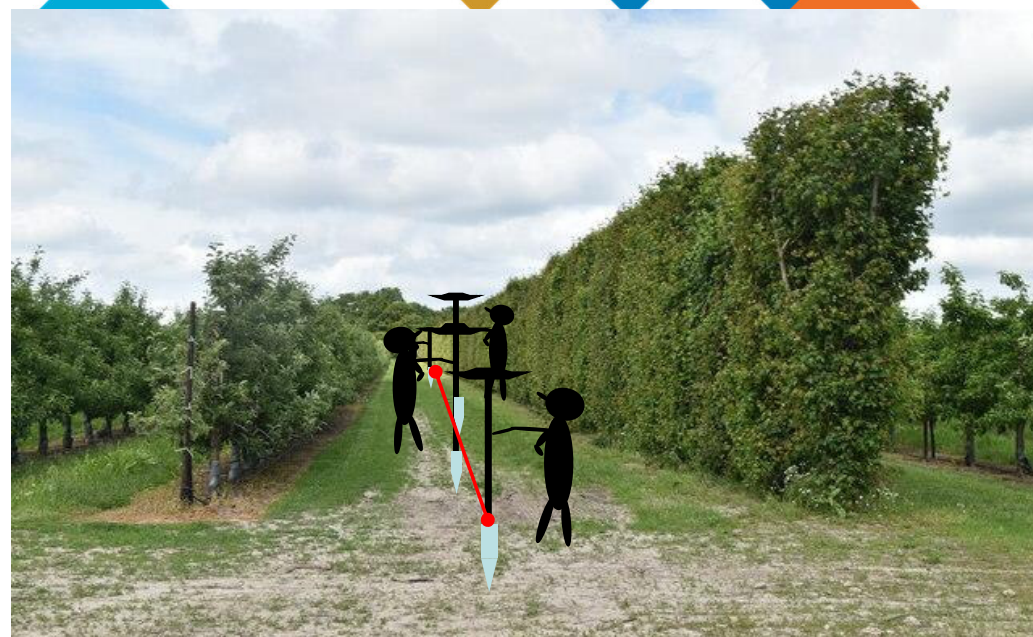


Motivation:

“Practitioners say Graduates are too accepting of the accuracy of GNSS RTK positioning ...”



“I’ve got a position” - “What’s the problem?”



Set out pegs on-line?

Credit: Orchard and shelterbelt © N Chadwick

GPS/GNSS can measure everything, anywhere ...

GPS
Positioning –
Accurate,
Precise and
Reliable

[NZ Beer Ad]







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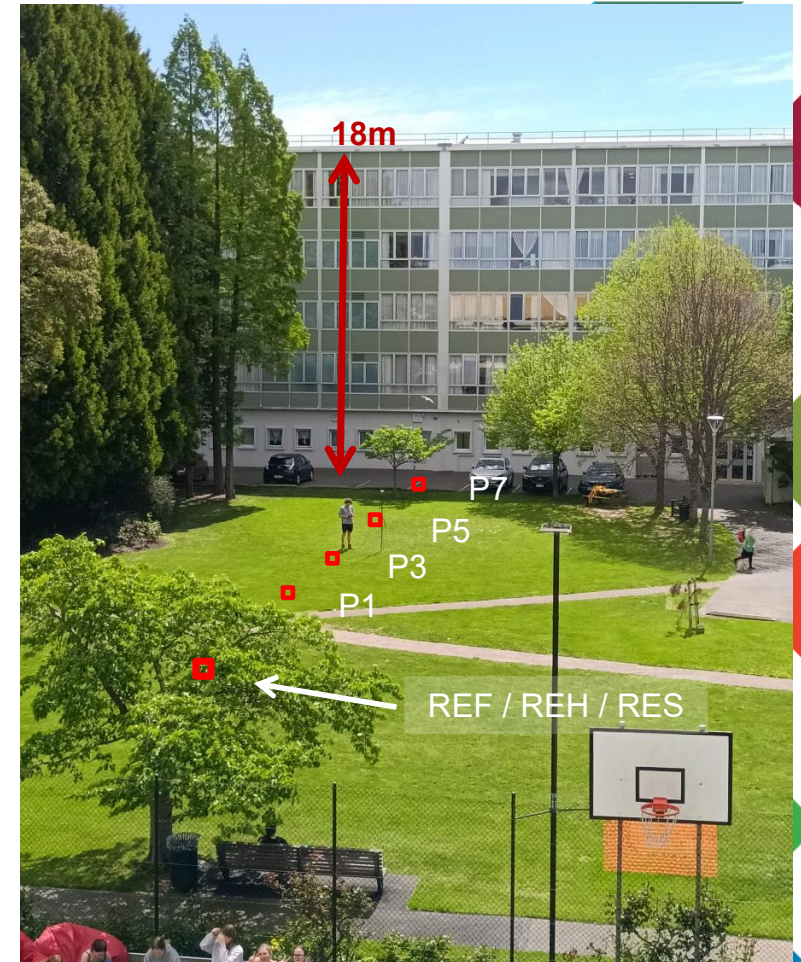
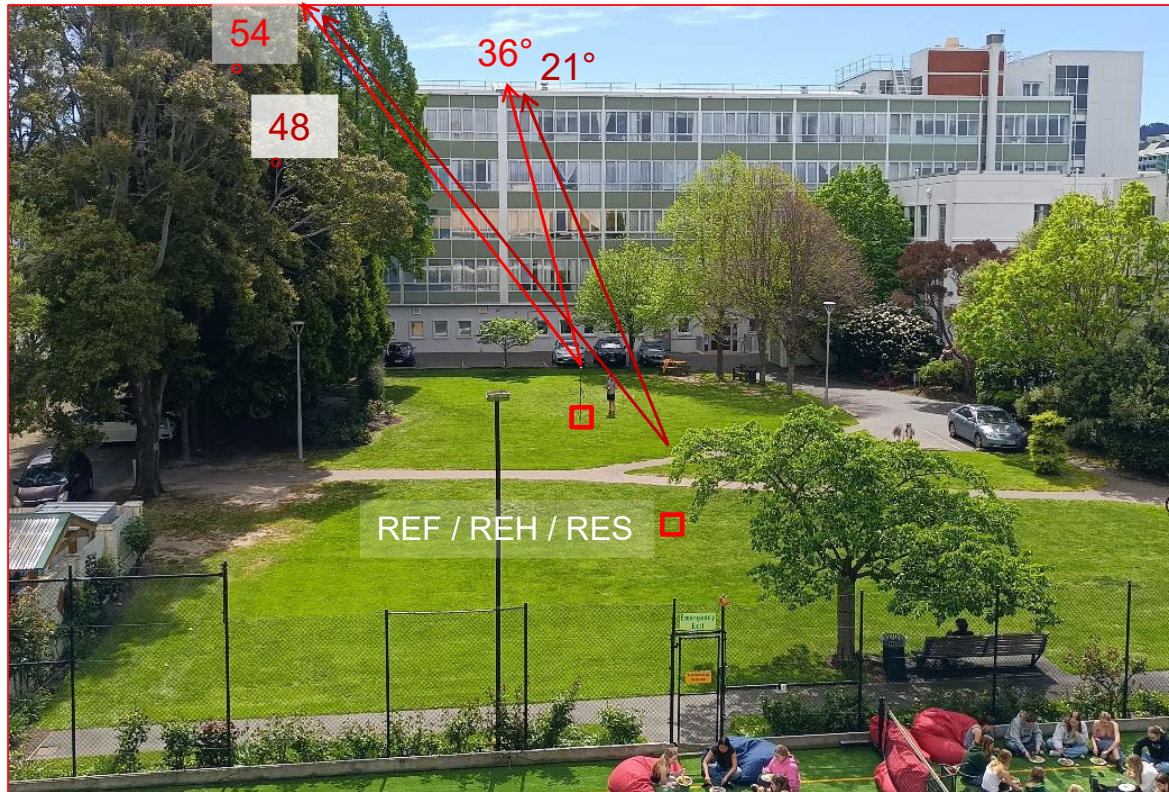


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GPS/GNSS can measure everything, anywhere ...

- Question:
 - How do you know your RTK position is correct?
 - Who pushes the boundaries when the environment is challenging?
- Be Sceptical!
 - How do you mitigate measurement errors?
 - What checks do you do?
 - Check, Check and Check again.

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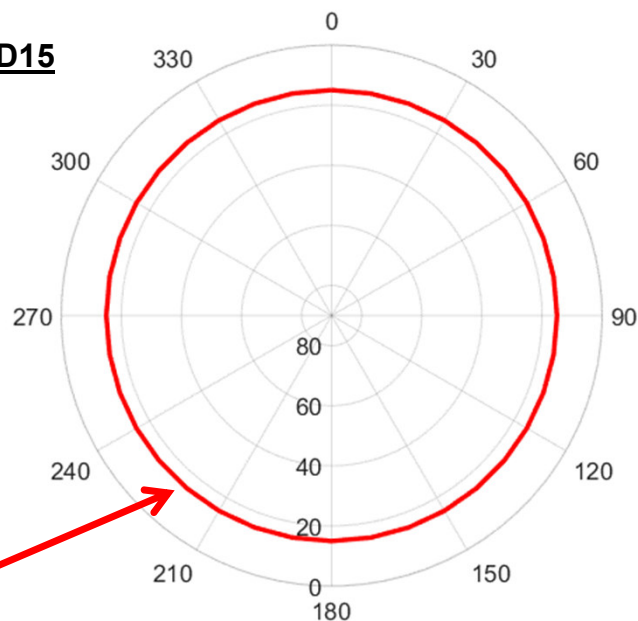
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Skyplots

Roof Sites – 0% obstructions

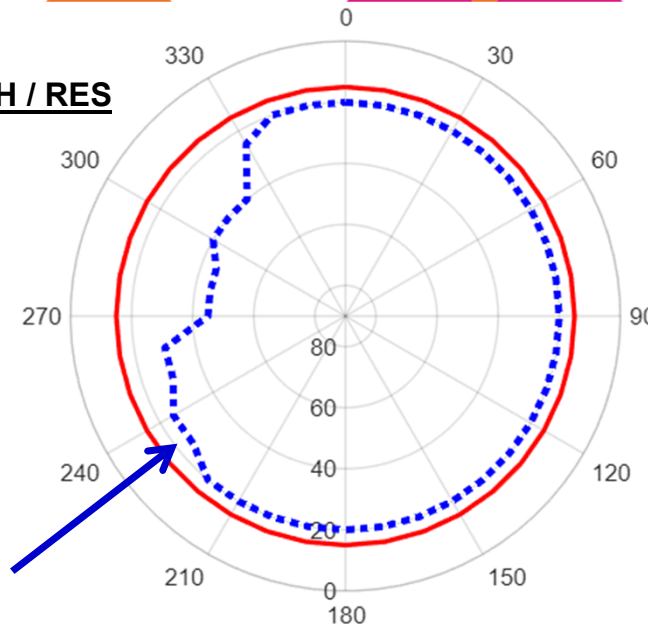
OUSD / SD14 / SD15



15° elevation mask

Reference Site – 19% obstructions

REF / REH / RES



Obstructions

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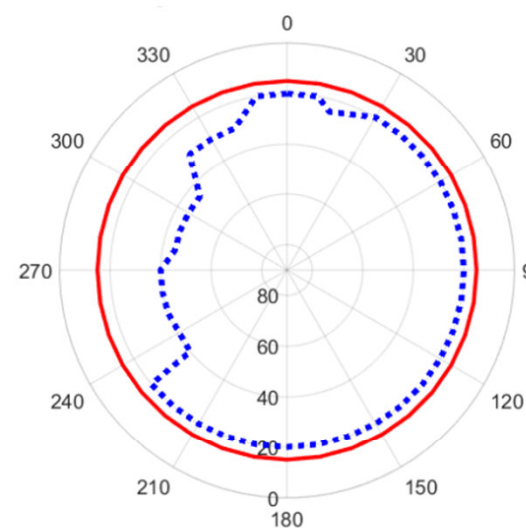


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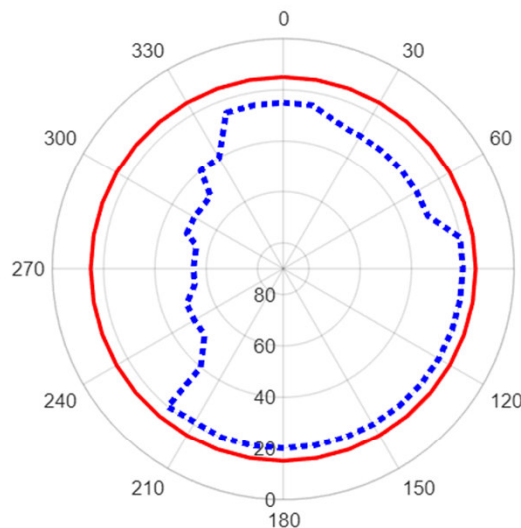
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Skyplots – Pegs 1, 3, 5, 7

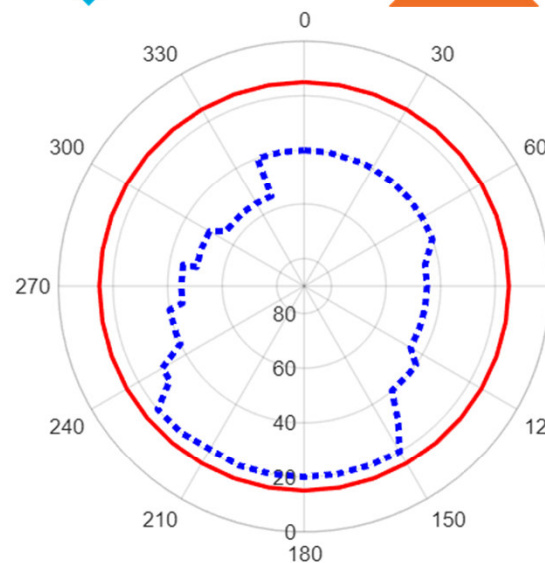
P01 – 24% obstructions



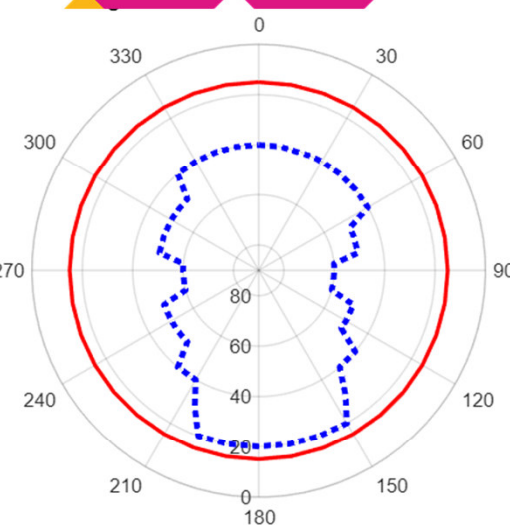
P03 – 33% obstructions



P05 – 43% obstructions



P07 – 52% obstructions



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Roof Sites – SD14 and SD15

- | | | | |
|--------|---------------------|-----|-------------|
| • SD14 | GPS Only | G | Trimble R6 |
| • SD15 | GPS Only | G | Trimble R10 |
| • SD15 | GPS + Galileo | GE | Trimble R10 |
| • SD15 | GPS + Galileo + BDS | GEC | Trimble R10 |

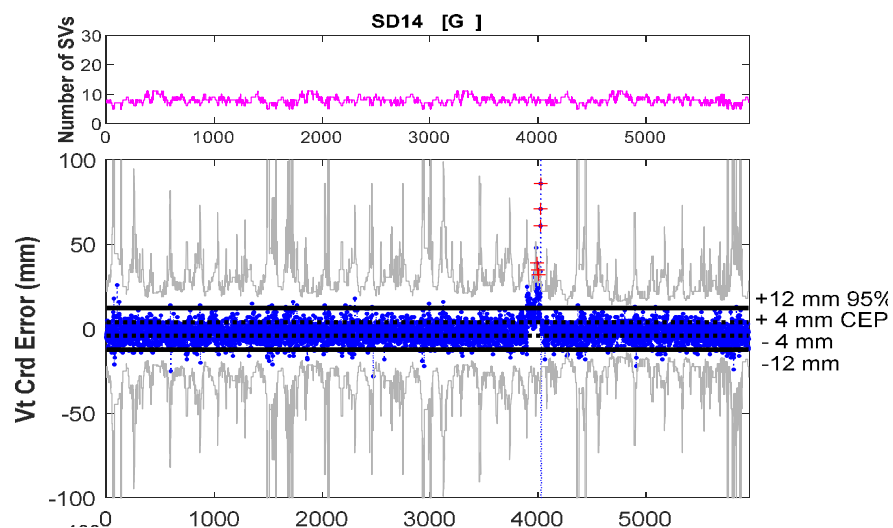
SD14 – GPS only [R6]

— Grey lines:
— Black lines:
+ Red plus:

95% CI computed by RTK (formal uncertainty)
95% CI computed from data
RTK position > 95% CI (RTK uncertainty)

Median 8 SVs

95% CI: ± 12 mm
CEP: ± 4 mm

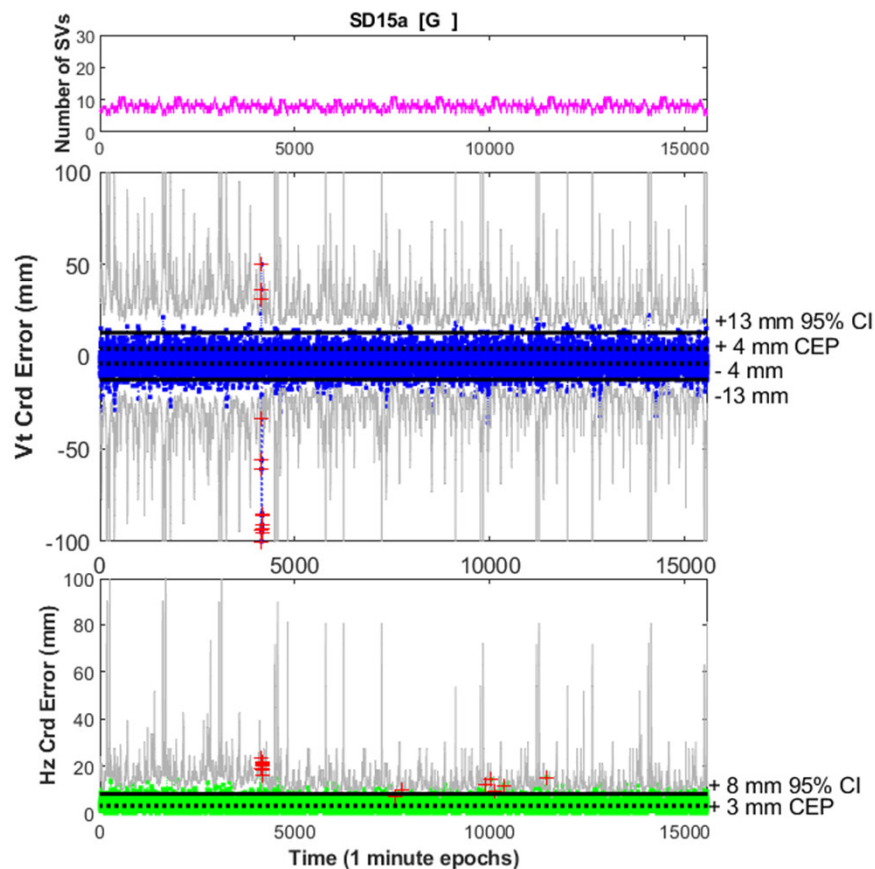


SD15 – GPS only [R10]

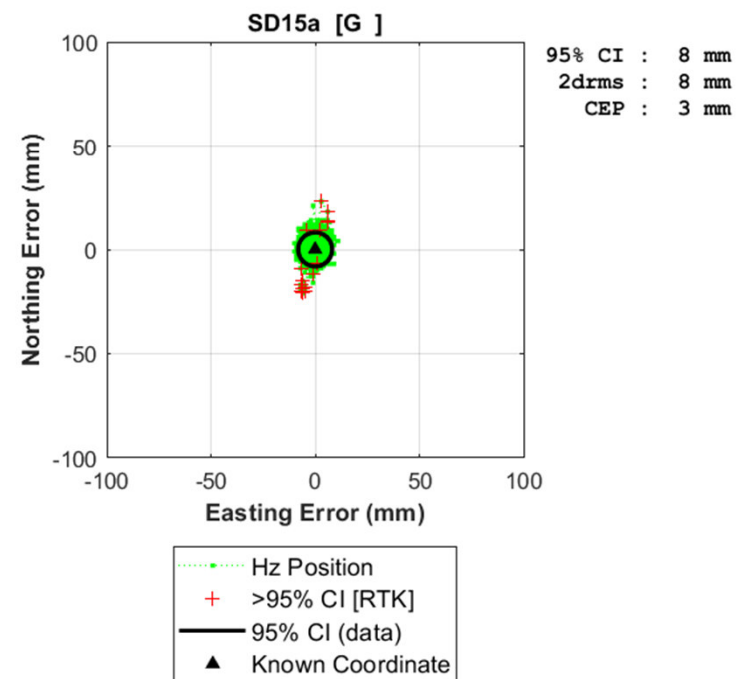
Median 8 SVs

95% CI: ± 13 mm
CEP: ± 4 mm

95% CI: +8 mm
CEP: ± 3 mm



Observations: >95% CI
Vertical: 0.1% [3 +ve / 13 -ve] Rejected: 1
Horizontal: 0.1% [16] Rejected: 0

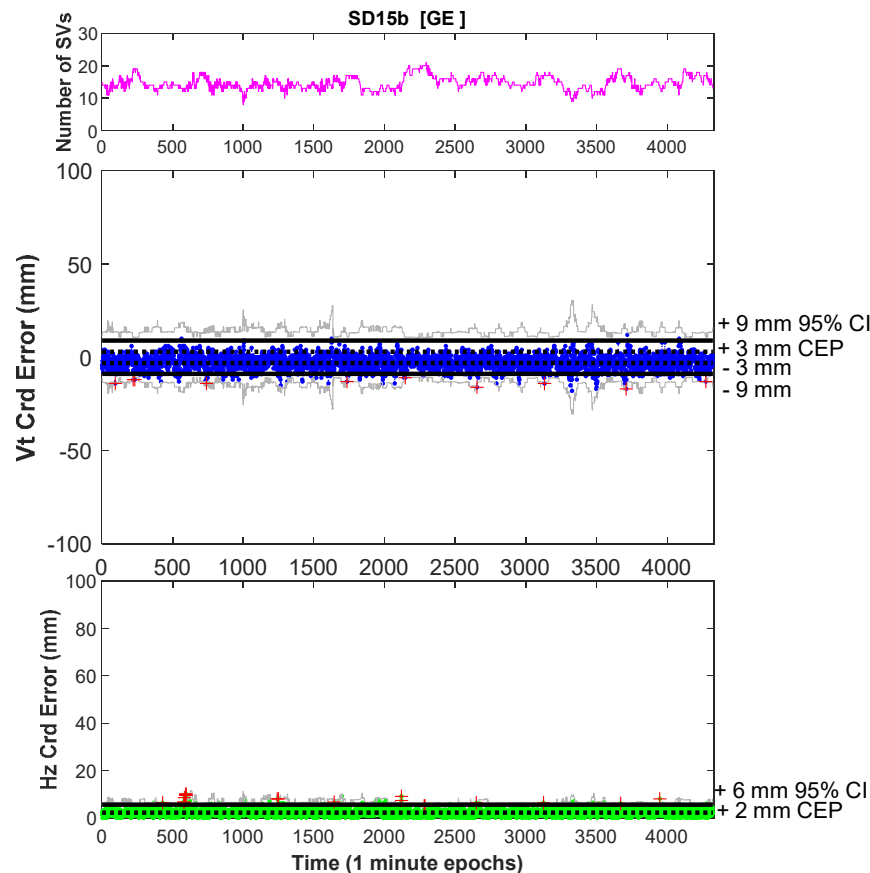


SD15 – GPS + Galileo [R10]

Median 14 SVs

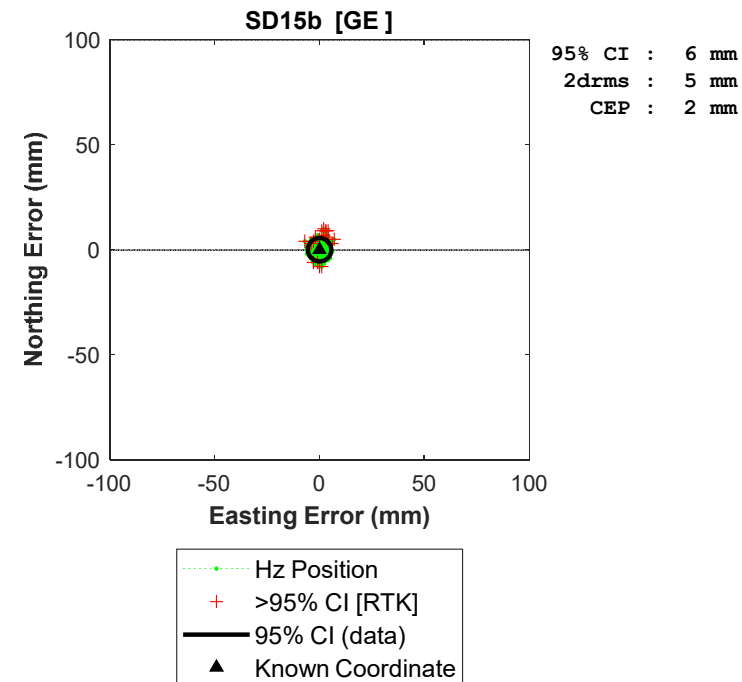
95% CI: ± 9 mm
CEP: ± 3 mm

95% CI: +6 mm
CEP: +2 mm



Observations: >95% CI

	Vertical	Horizontal	Rejected
Vertical	0.2% [0 +ve / 10 -ve]		0
Horizontal		0.5% [20]	0



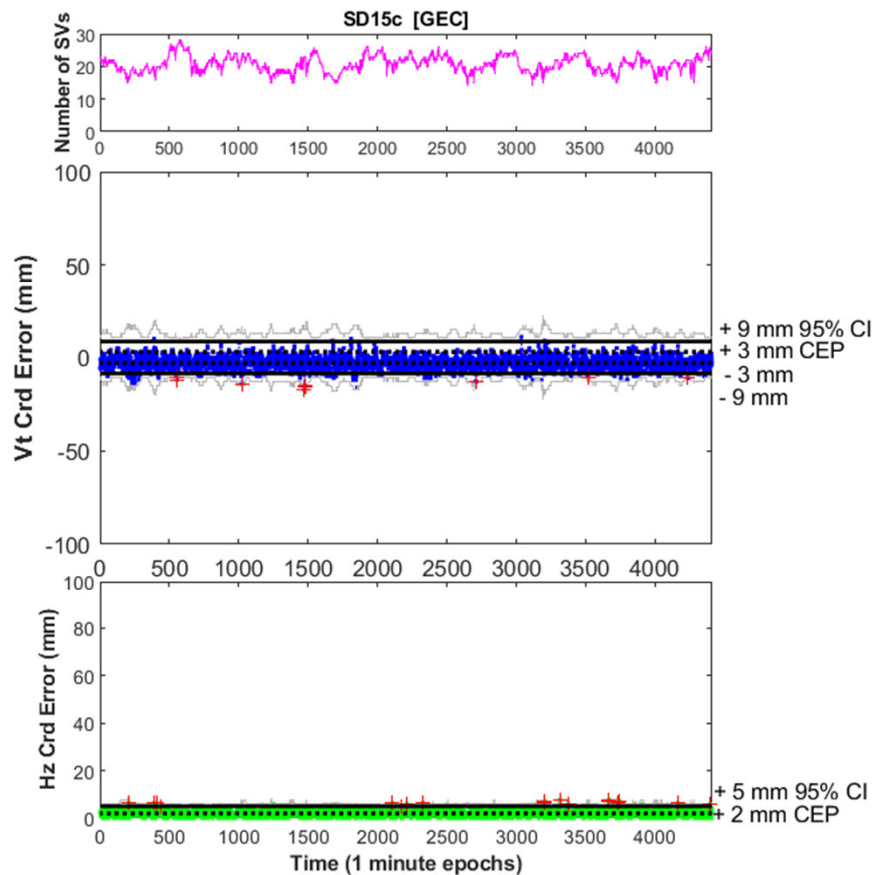
SD15 – GPS + Galileo + BDS

[R10]

Median 21 SVs

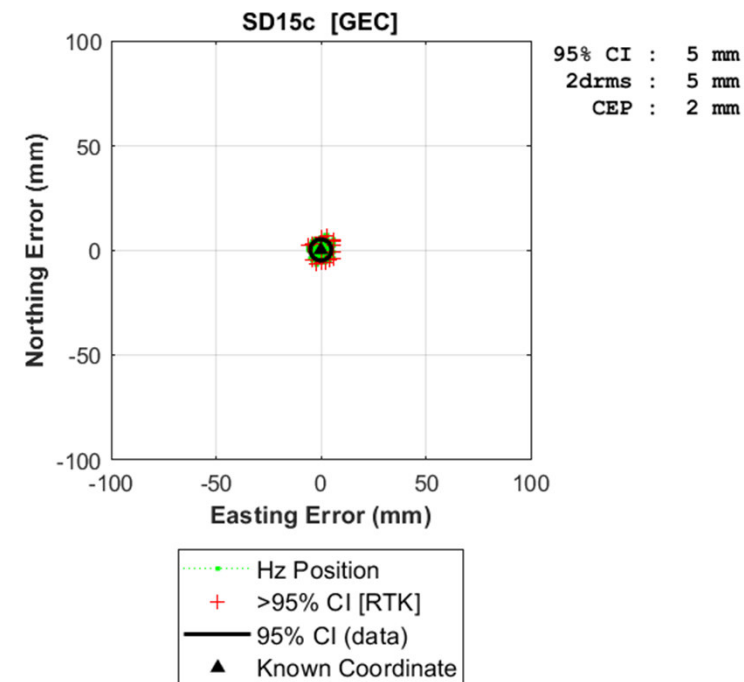
95% CI: ± 9 mm
CEP: ± 3 mm

95% CI: +5 mm
CEP: +2 mm



Observations: >95% CI

	Vertical:	Horizontal:	Rejected
	0.2% [0 +ve / 11 -ve]	0.4% [19]	0

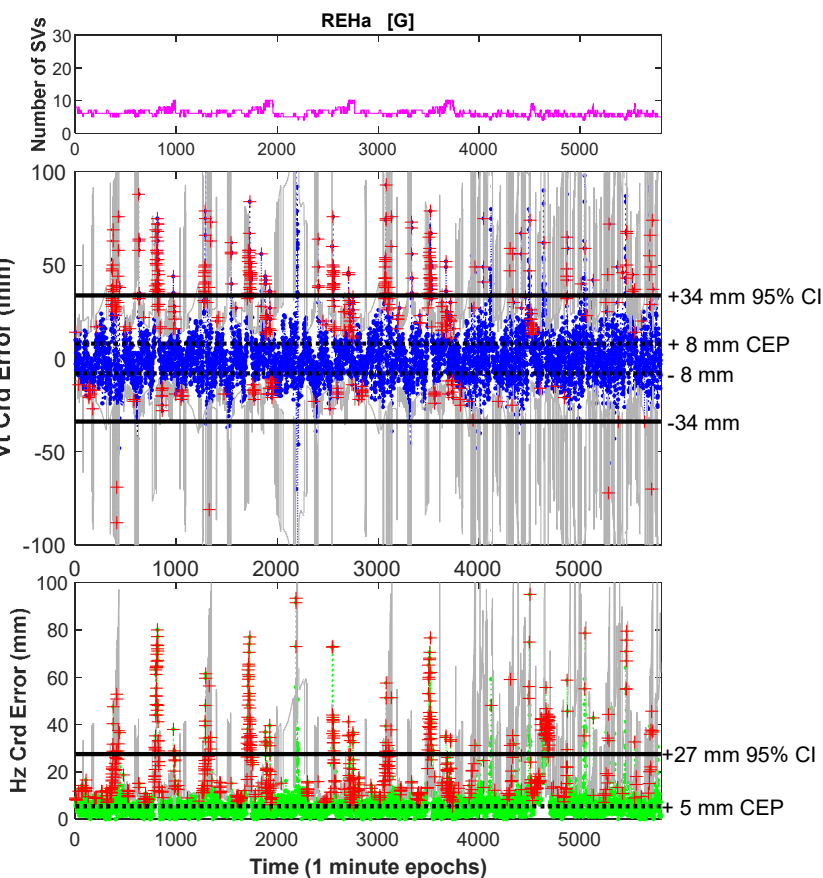


REH – GPS [G]

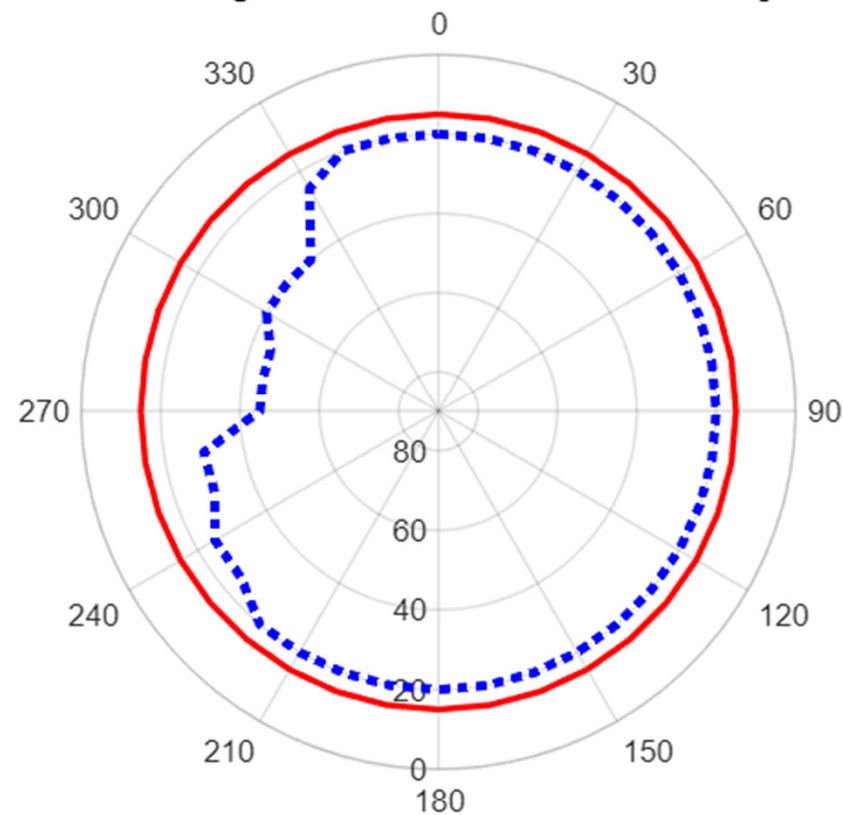
19% Obstructions

Median 8 SVs

95% CI: ± 34 mm
CEP: ± 8 mm



Reference Site
Masking Q1-Q4: 3 - 3 - 4 - 9% Total: 19%]



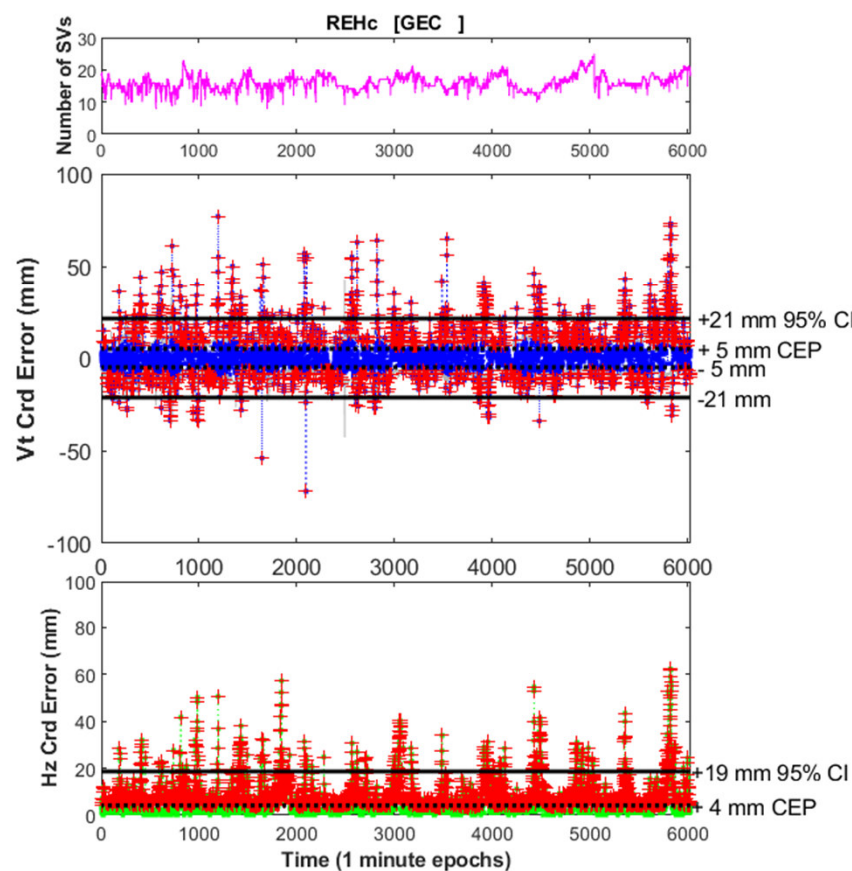
REH – GPS + Galileo + BDS [GEC]

19% Obstructions

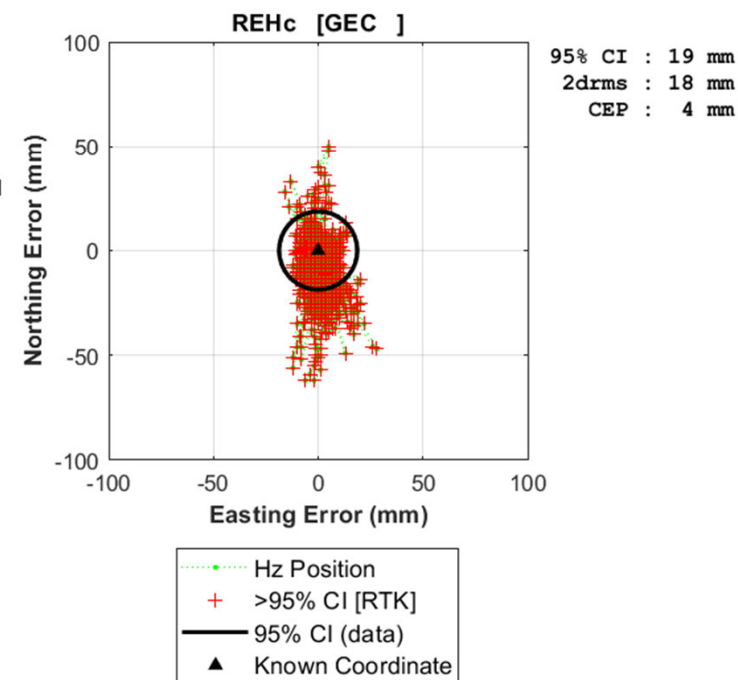
Median 16 SVs

95% CI: ± 21 mm
CEP: ± 5 mm

95% CI: $+19$ mm
CEP: $+4$ mm



Observations:	>95% CI	Rejected
Vertical:	30.5% [1099 +ve / 737 -ve]	0
Horizontal:	45.6% [2748]	0

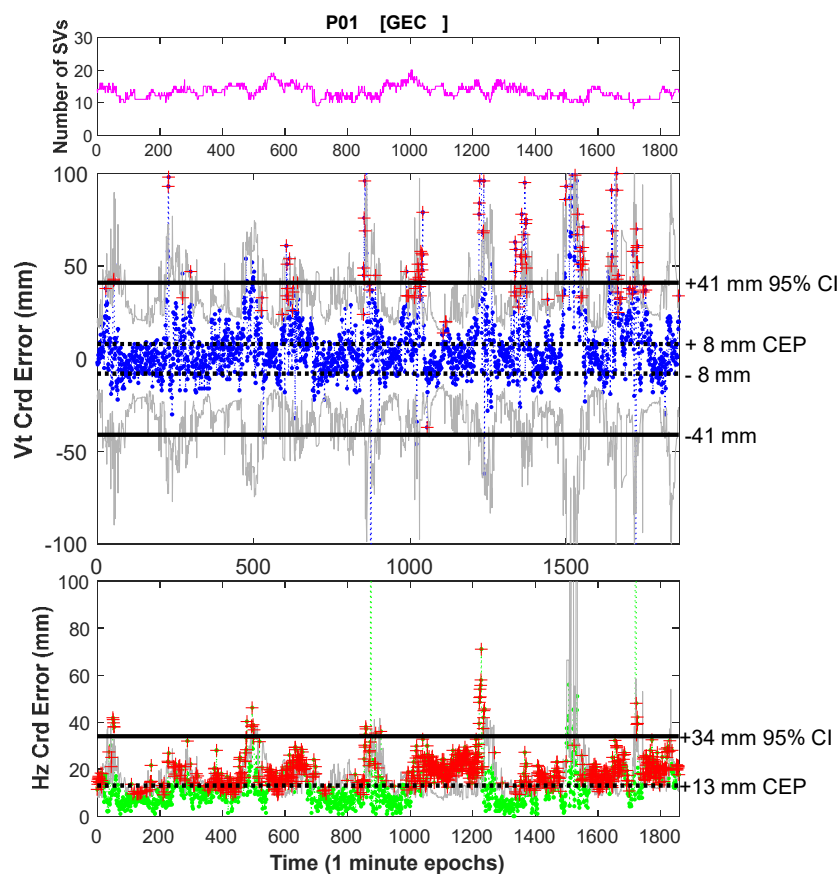


P01 – GPS + Galileo + BDS [GEC] 24% Obstructions

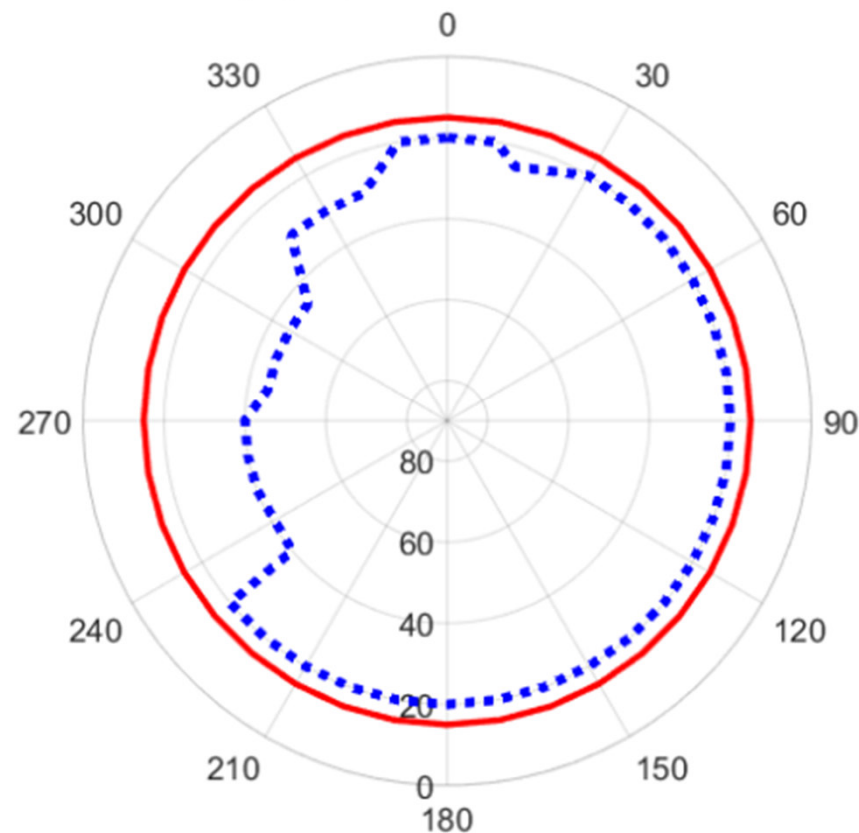
Median 13 SVs

95% CI: ± 41 mm
CEP: ± 8 mm

95% CI: +34 mm
CEP: +13 mm



Peg 1
Masking Q1-Q4: 3 - 3 - 7 - 11% Total: 24%

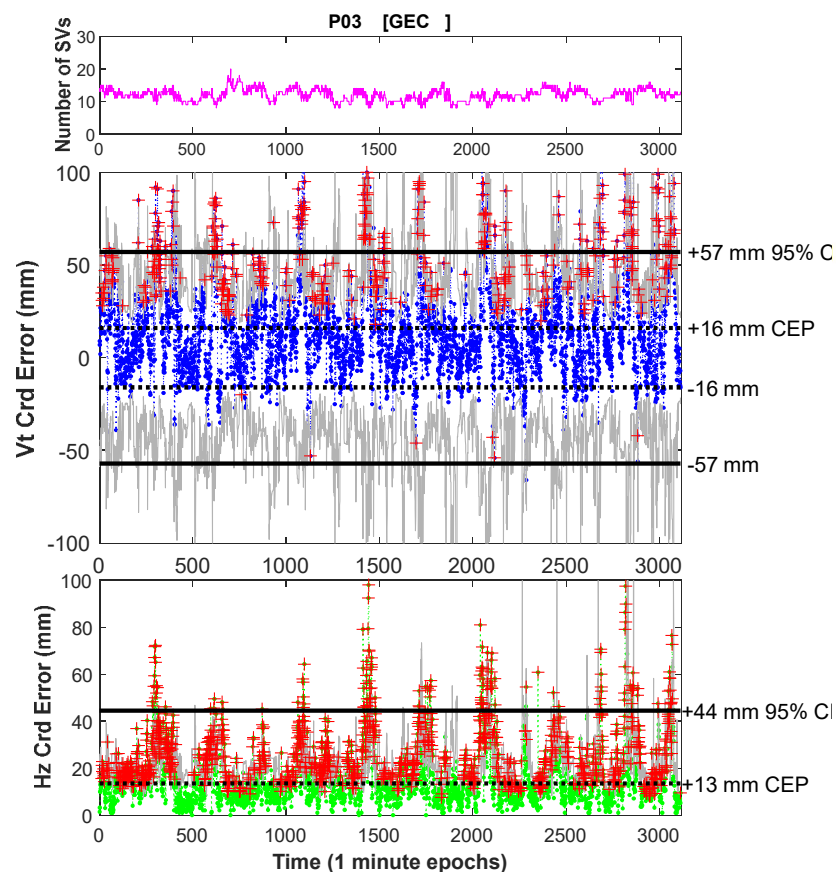


P03 – GPS + Galileo + BDS [GEC] 33% Obstructions

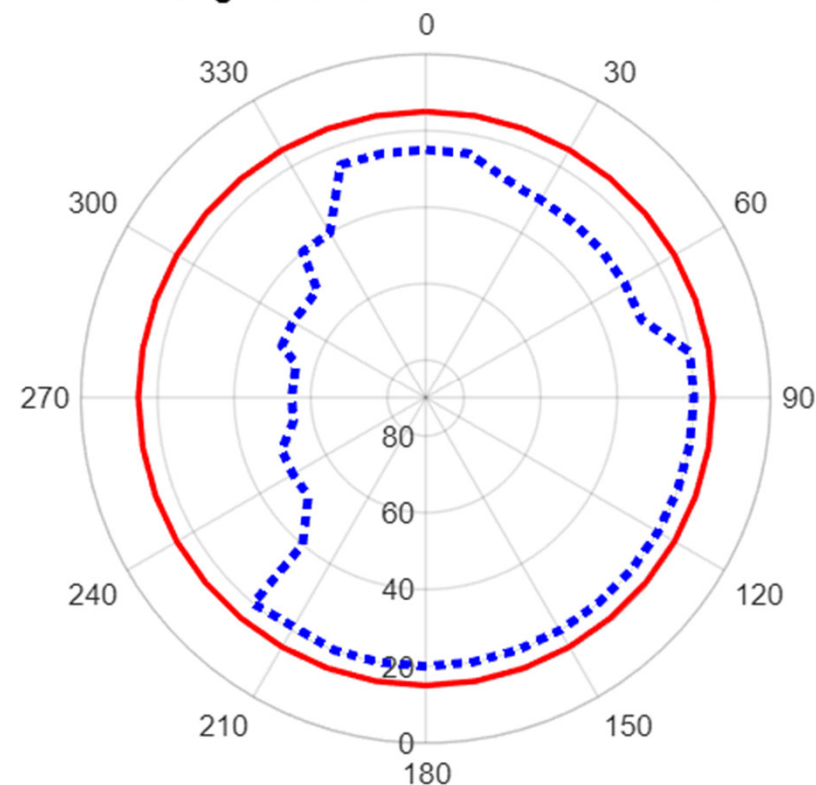
Median 12 SVs

95% CI: ± 57 mm
CEP: ± 16 mm

95% CI: +44 mm
CEP: ± 13 mm



Peg 3
Masking Q1-Q4: 6 - 3 - 11 - 13% Total: 33%

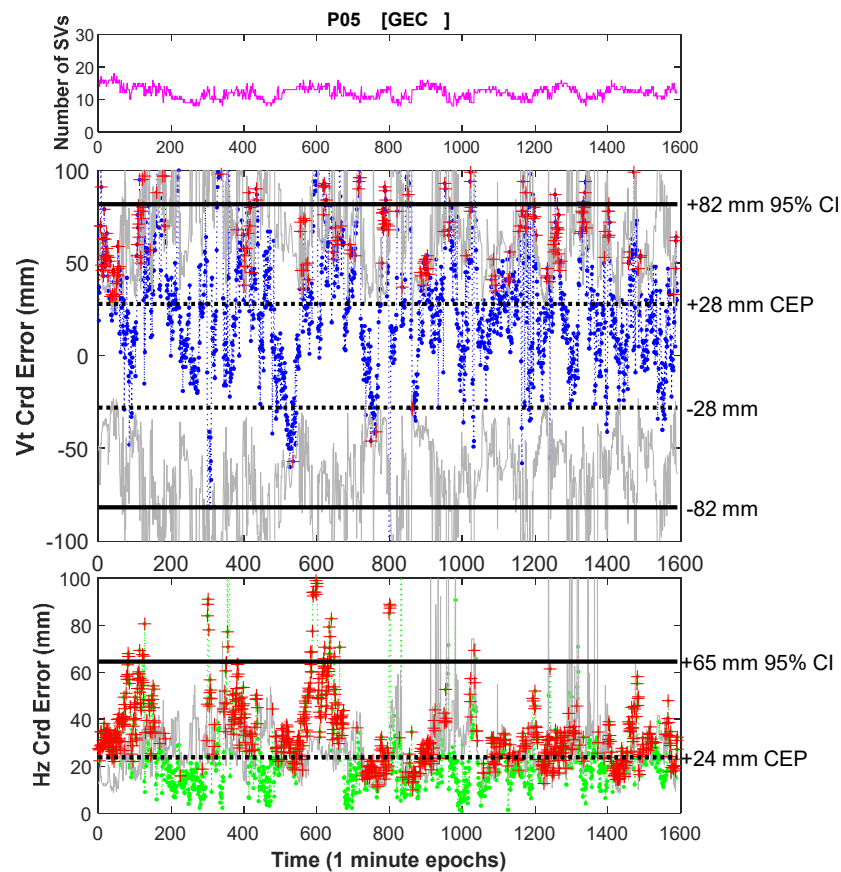


P05 – GPS + Galileo + BDS [GEC] 43% Obstructions

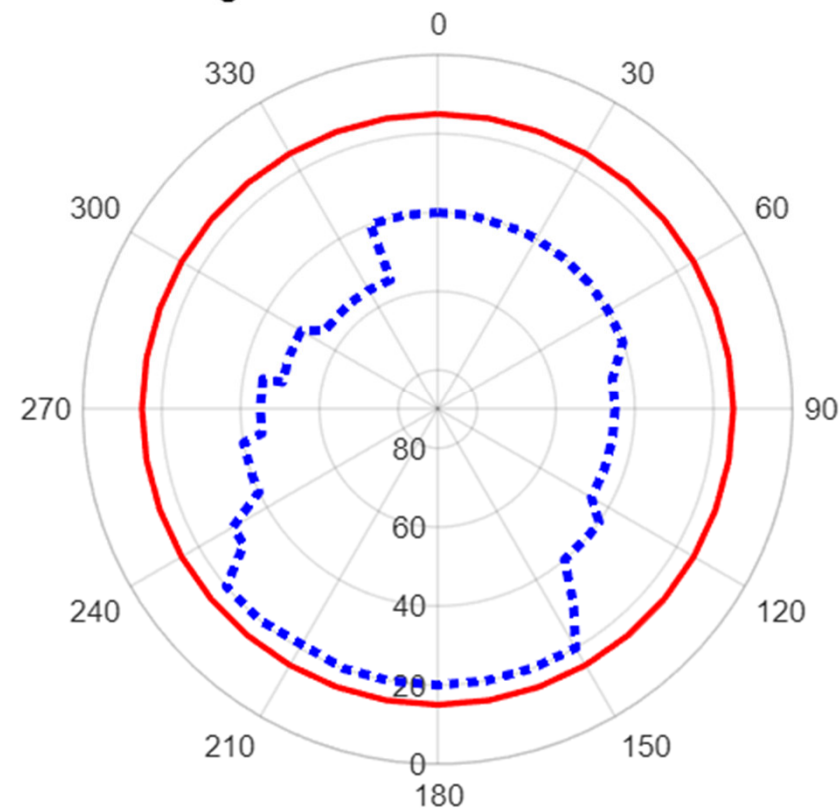
Median 12 SVs

95% CI: ± 82 mm
CEP: ± 28 mm

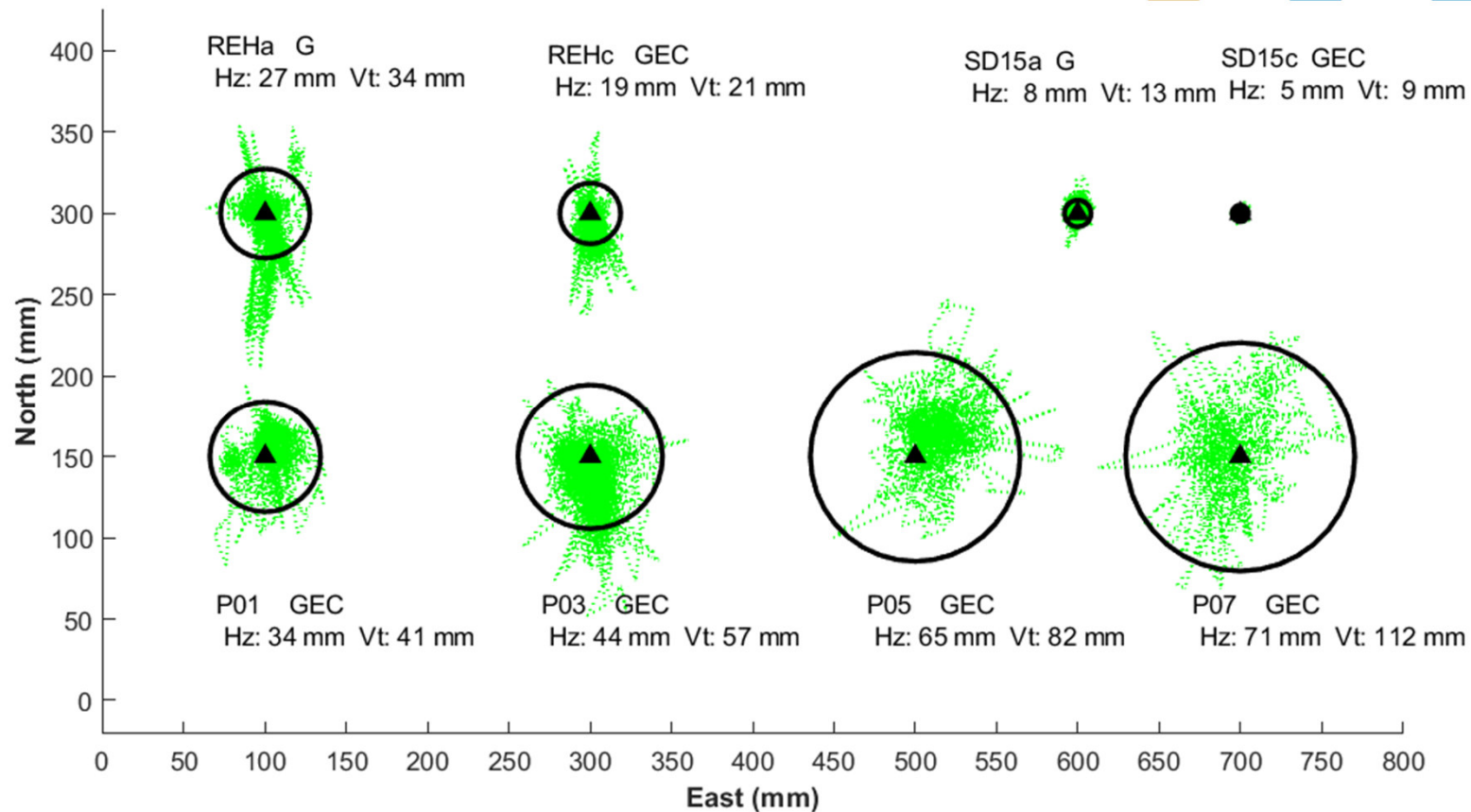
95% CI: +65 mm
CEP: +24 mm



Peg 5
Masking Q1-Q4: 13 - 8 - 7 - 15% Total: 43%



Horizontal Error Plot And 95% CI Hz & Vt Uncertainties



Summary

- Clear sky visibility, No obstructions
 - RTK accuracy consistent with manufacturers specifications
 - Slight improvement with multi-constellation GNSS
- Obstructed sky visibility, > 20% obstructions
 - Significant reduction in accuracy
 - Errors significant with multi-constellation GNSS
- GPS only constellation
 - Formal error (RTK estimate) conservative
- GNSS constellation
 - Formal error (RTK estimate) optimistic
- Accuracy
 - 20% obstruction: 20-30 mm accuracy
 - 50% obstruction: ~100 mm accuracy
- Horizontal
 - centimetre level bias
 - obstructions north and west
- Vertical
 - positive bias
 - error ~40% worse than Hz

The most relevant SDGs related to the presentation and theme of this session

1st relevant
SDG

9 INDUSTRY, INNOVATION
AND INFRASTRUCTURE



2nd relevant
SDG

11 SUSTAINABLE CITIES
AND COMMUNITIES



3rd relevant
SDG

15 LIFE
ON LAND



**SUSTAINABLE
DEVELOPMENT GOALS**

International Federation of Surveyors supports the
Sustainable Development Goals



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STEP 1: SELECT HERE THE THREE MOST RELEVANT SDGs
STEP 2: COPY THE SDG INTO PREVIOUS SLIDE



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