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+1-703-256-8900 or 800-628-0885
info@NavtechGPS.com
www.NavtechGPS.com

VeroStar: A Novel Full GNSS Band Rover Antenna

Julien Hautcoeur, Ph.D.

Director of GNSS Product R&D

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Who we are

- Part of Calian Group
- Incorporated 2009 (11 years ago)
- Head office located in Ottawa, Canada

What we do

- Tallysman Manufacturers precision GNSS Antennas
- From affordable dual feed to reference grade Antennas
- ISO9001:2015 Certified
- Our Mission: Antenna Cost reduction by design
  - Declining Precision Receiver costs
  - Cost of Precision Antennas must Track
  - **Without compromising Precision**

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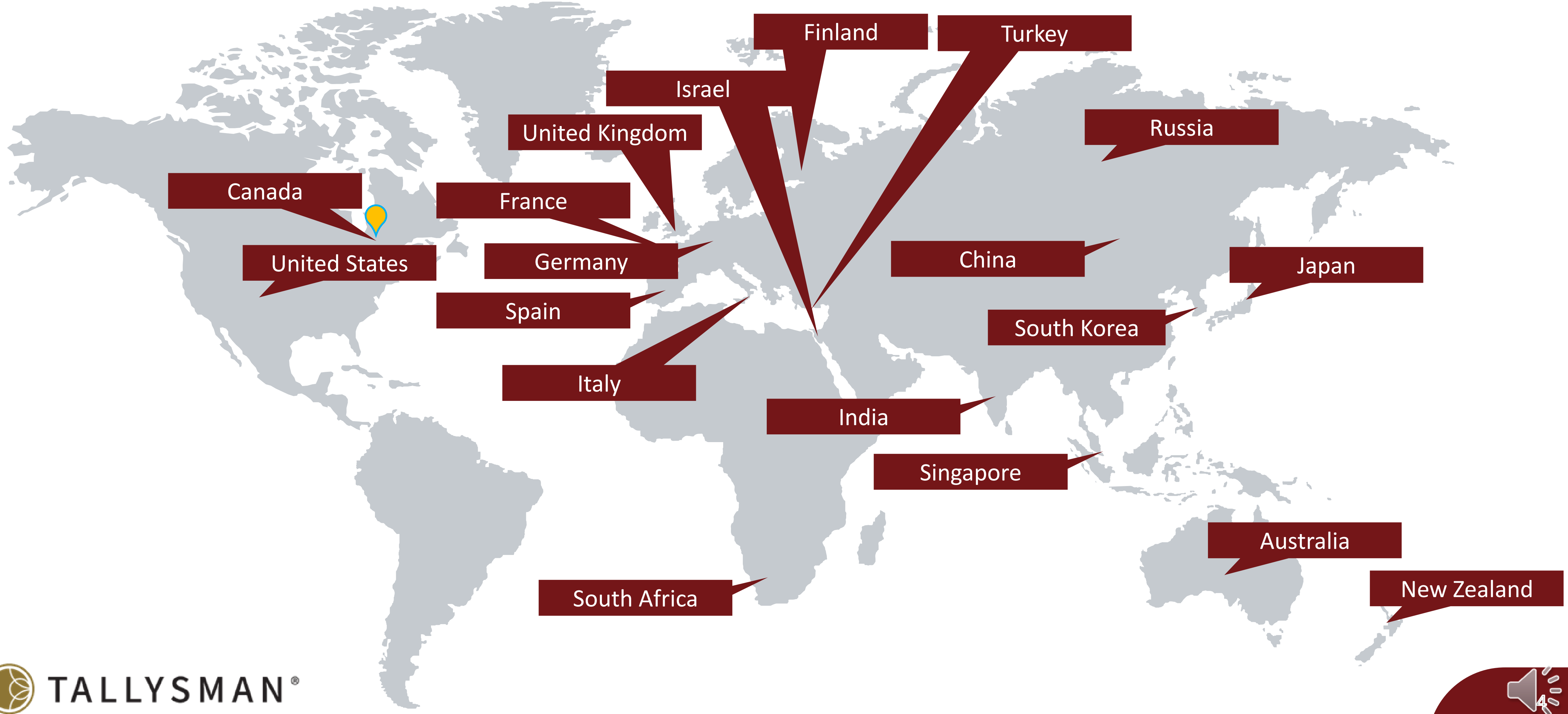
Global Distribution



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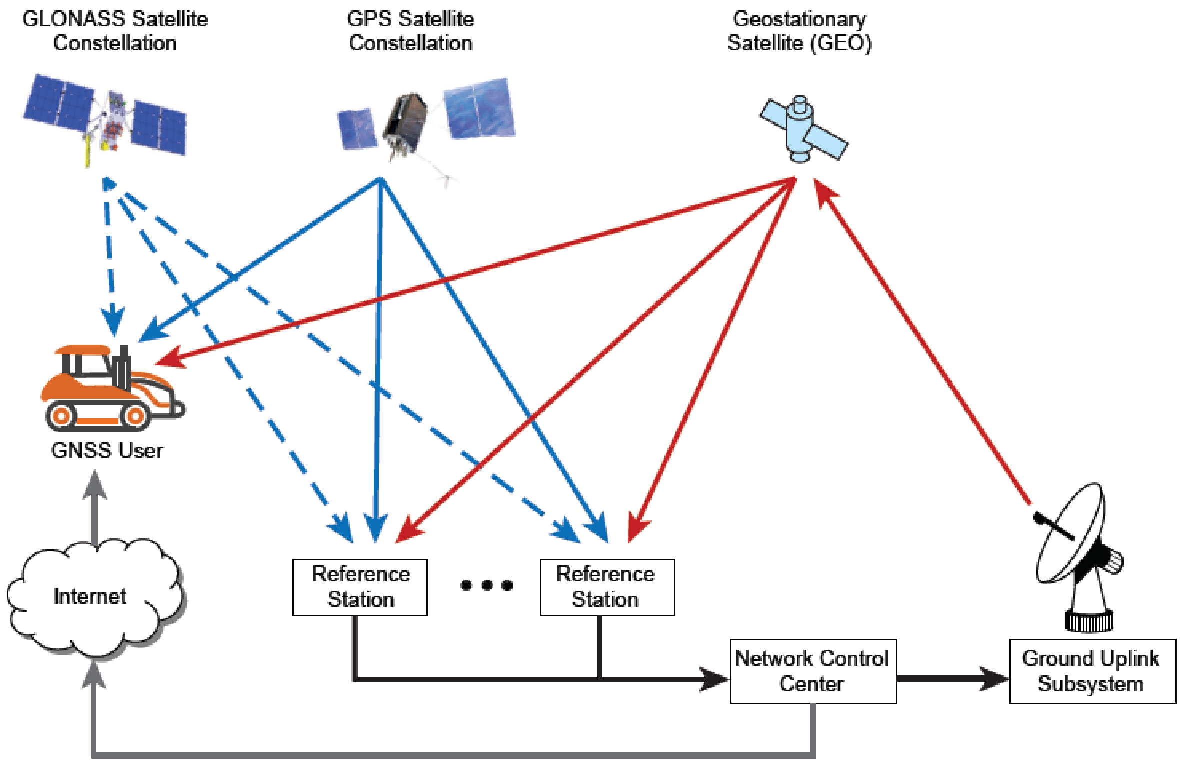
- GNSS Rover antenna requirements

Antenna requirements

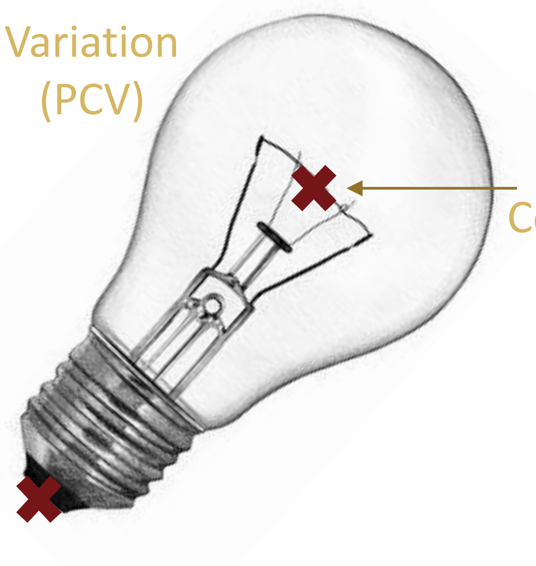
- Low elevation tracking and high G/T
  - Global adoption of the PPP corrections
  - Geostationary satellites and minimal L-band link margin
  - Issue at satellite beam edges and northern latitudes
  - Key design parameter is G/T:
    - objective of -25.5 dB/K at 10 deg



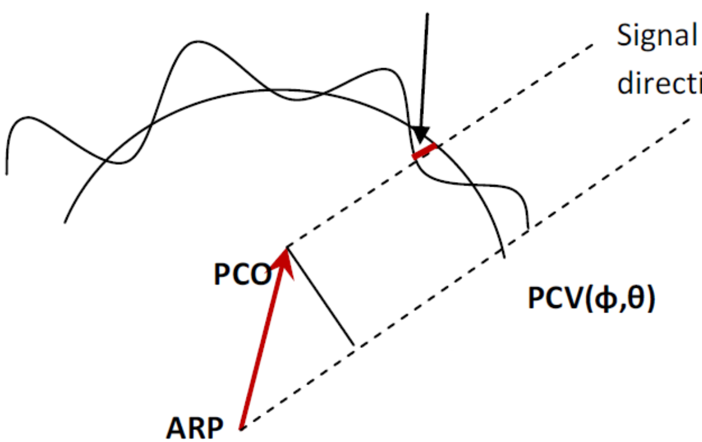
Need for high receiving gain at low elevation angles and low LNA noise figure

Antenna requirements

- Tight phase center variation
  - Modern GNSS systems use the phase information
  - Phase center is the beginning of your tape measure
  - Antenna phase center varies versus the angle of arrival
  - Rover antenna PCV is difficult to correct with calibration files



PCV → phase shift → tape measure variation



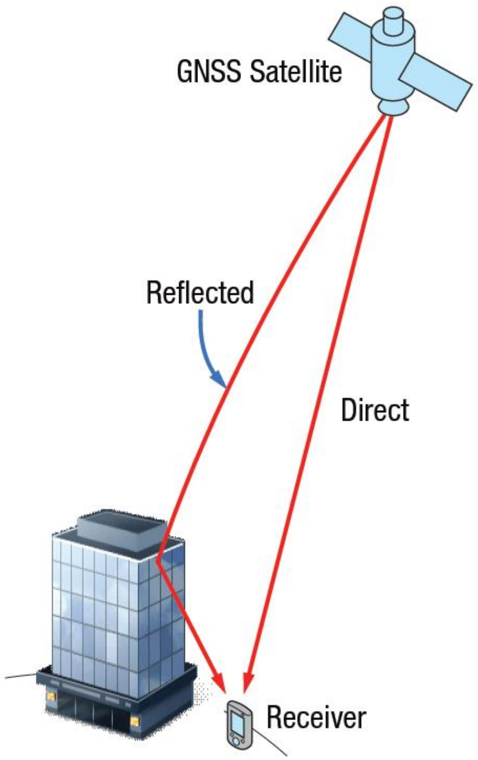
To achieve precise electrical position,
the antenna should have a small PCV

Graph source: An Introduction to GNSS – NovAtel Inc

Antenna requirements

- Multipath issue
  - The multipath generates the addition of delayed signals to the direct signals:
  - measured phase = direct phase + delayed phase
  - This looks like an increase of the PCV

  - Reflections coming from positive angles (building bounce)
  - Reflections coming from negative angles (ground bounce)



- Low axial ratio / up-down ratio ➡ high purity of circular polarization ➡ multipath mitigation
- Axial ratio objectives:
  - 0.5 dB typical at zenith
  - 3 dB or better at horizon

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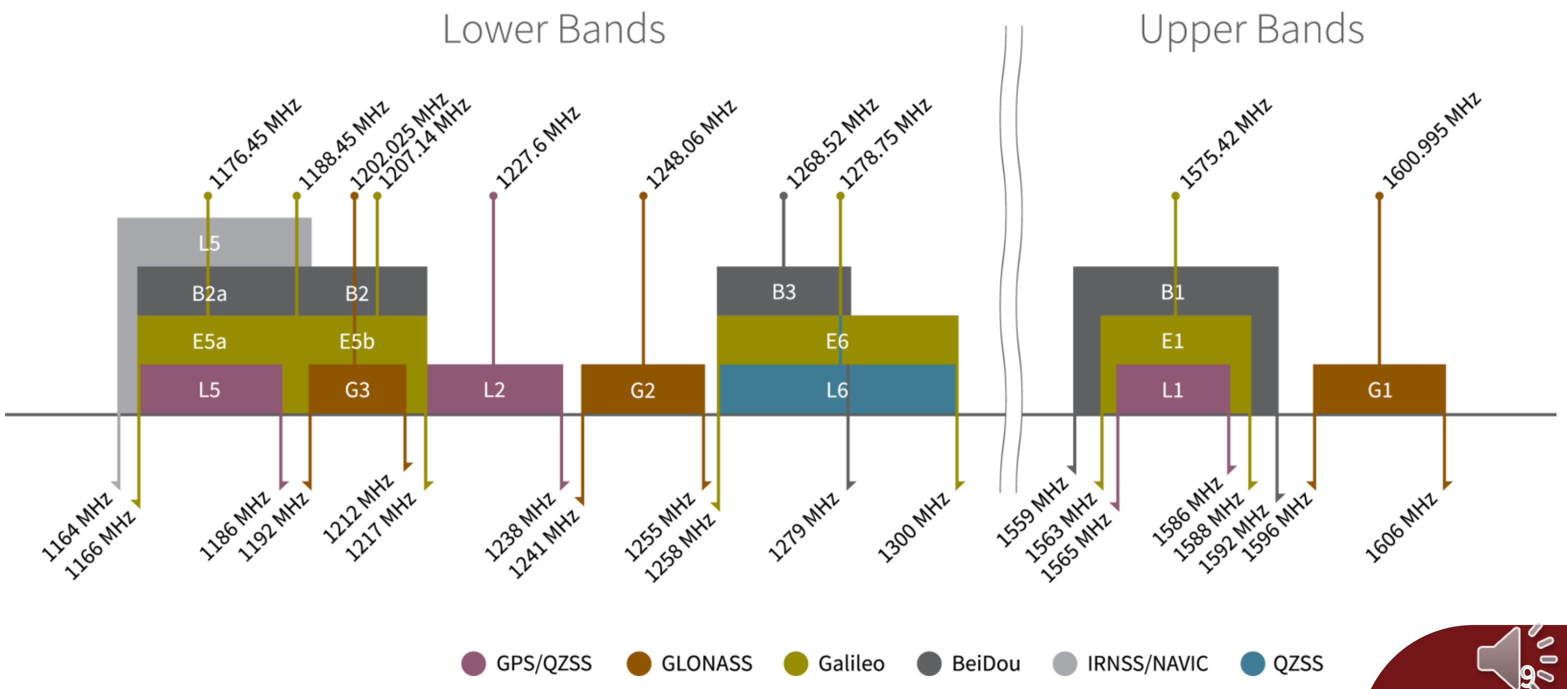
Graph source: An Introduction to GNSS – NovAtel Inc

Antenna requirements

- Antenna efficiency and bandwidth
  - Today is multi constellations
  - Today is multi frequencies
- Need excellent performance (gain, PCV, axial ratio…) on a wide frequency bandwidth
- Need for low loss high efficiency radiating element for better C/N0



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- Antenna Design

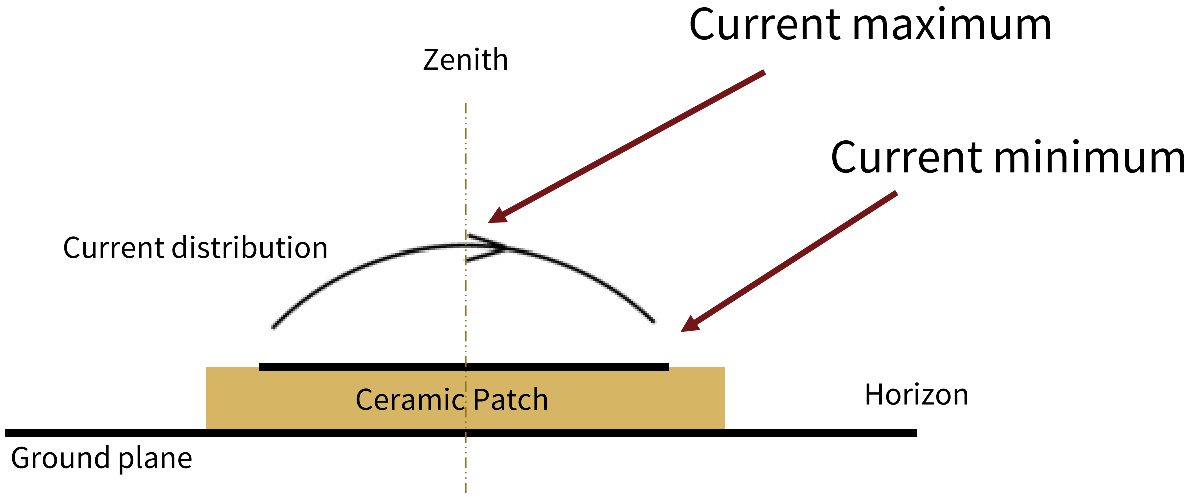
How to improve low elevation gain?

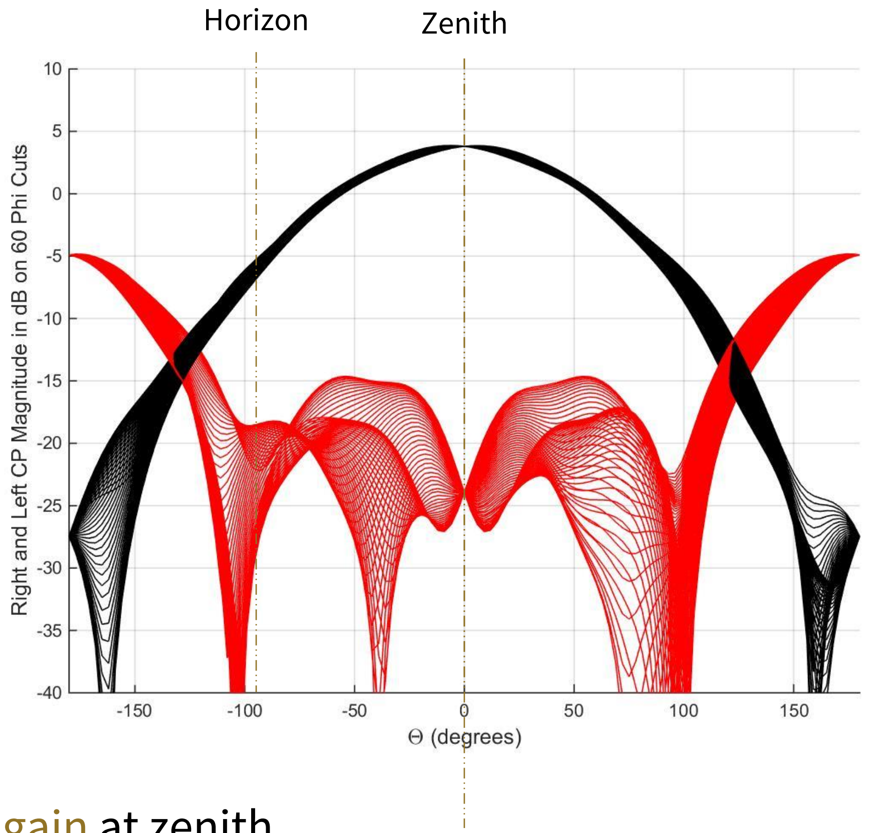
- Optimization of the radiation patterns:
  - Higher gain at zenith is not necessary
  - Lower gain roll-off allows
    - to track more satellites
    - Optimise the link budget of the L-band correction services
- Typical L1 gain values (dBic):

	Horizon	Zenith
Patch antenna:	-6.0	4.5
Helical antenna:	-5.0	2.5
Dipole antenna:	-7.0	7.0

Current distribution

- Std GNSS Patch antenna:

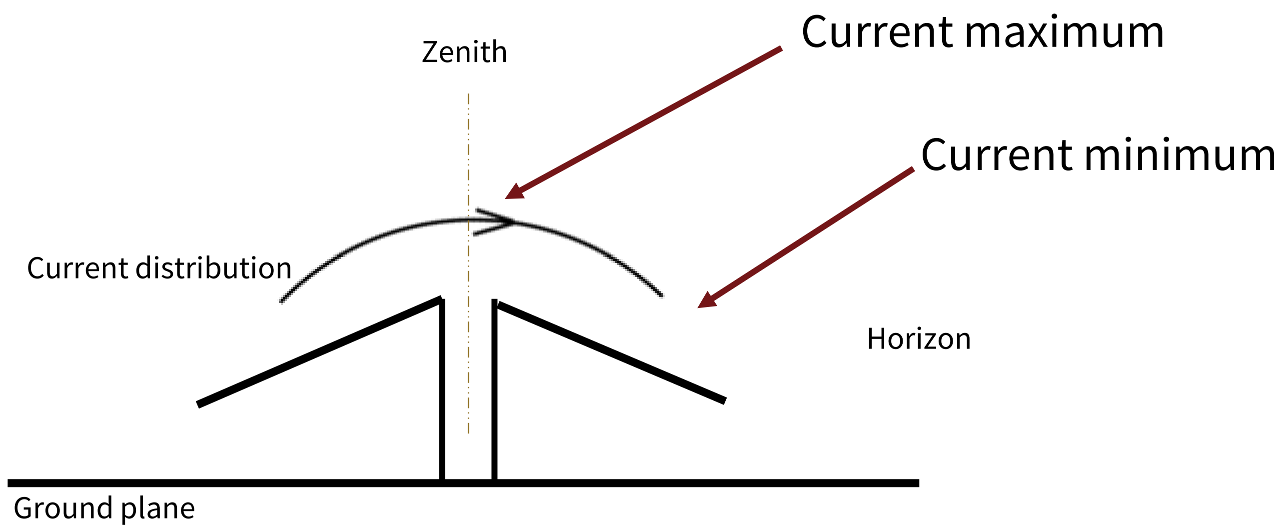


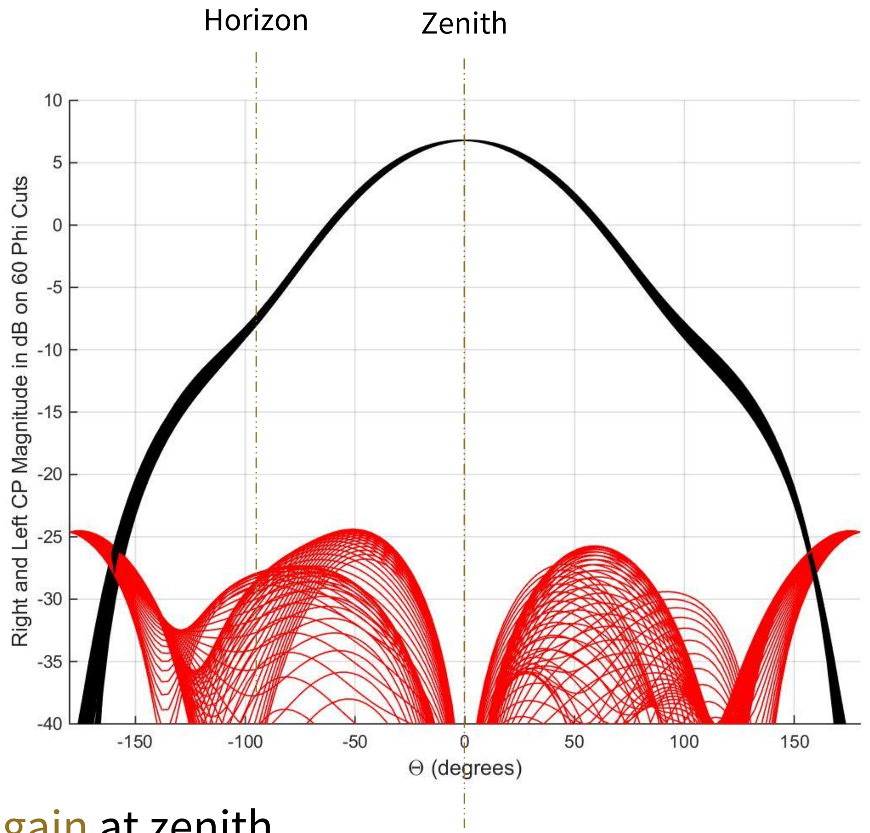


- Current maximum in the middle of the antenna → High gain at zenith
- Current minimum on the edges of the antenna → Low gain at horizon
- → 10 dB of gain roll-off

Current distribution

- λ/2 Dipole based antenna:





- Current maximum in the middle of the antenna → High gain at zenith
- Current minimum on the edges of the antenna → Low gain at horizon
- → Up to 14 dB of gain roll-off

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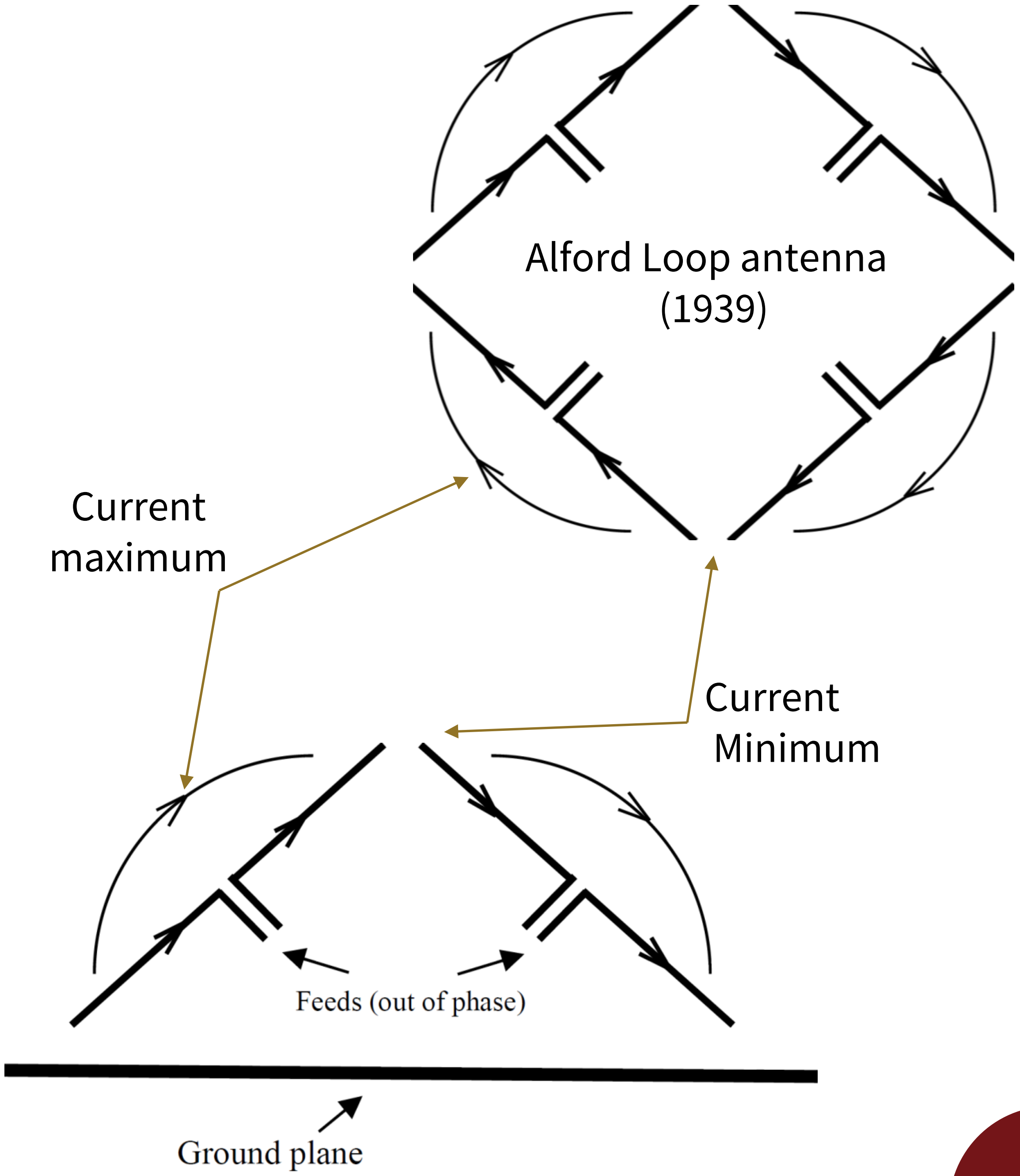
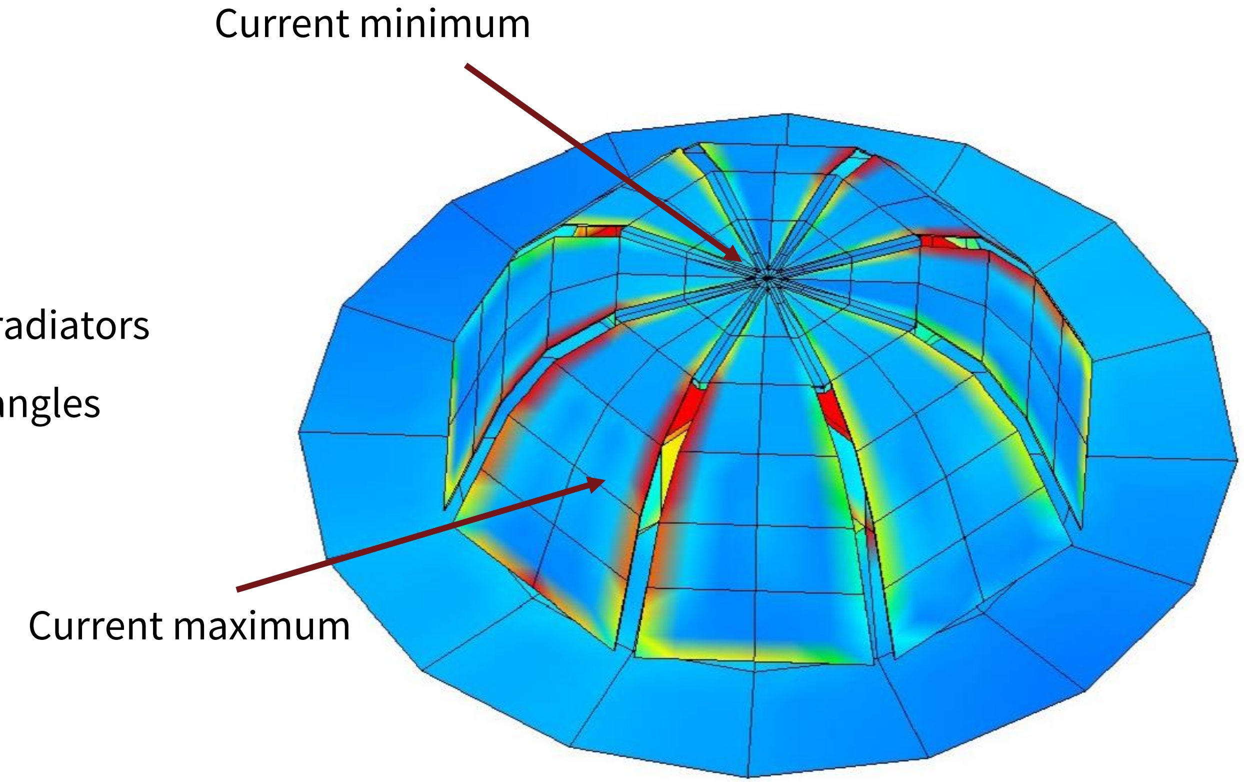
Antecedents

- Dorne & Margolin C146 reference antenna
  - Higher gain at low elevation angles
  - Current maximum offset from the center
  - Complex and costly to build
  - Poor axial ratio and PCV repeatability



VeroStar

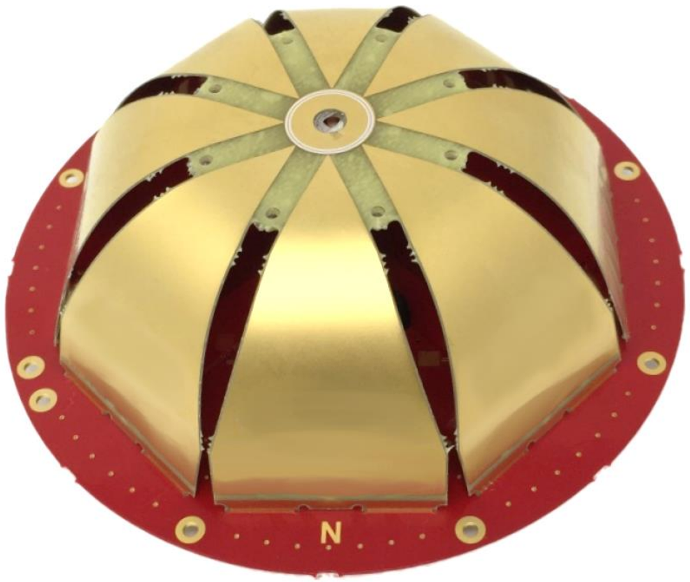
- VeroStar Design
  - Bowtie radiators coupled to low loss cross dipoles
  - Current maximum on the curvature of the bowtie radiators
  - Low gain roll-off and higher gain at low elevation angles
  - Low loss feed network to maximise the efficiency



Simulated current distribution

VeroStar

- VeroStar Design
  - Bowtie and dipoles radiators have a wide frequency response
  - Symmetrical and optimized design
    - Balance between electric field and magnetic field planes of the radiation pattern
    - Excellent axial ratio
    - Small PCV



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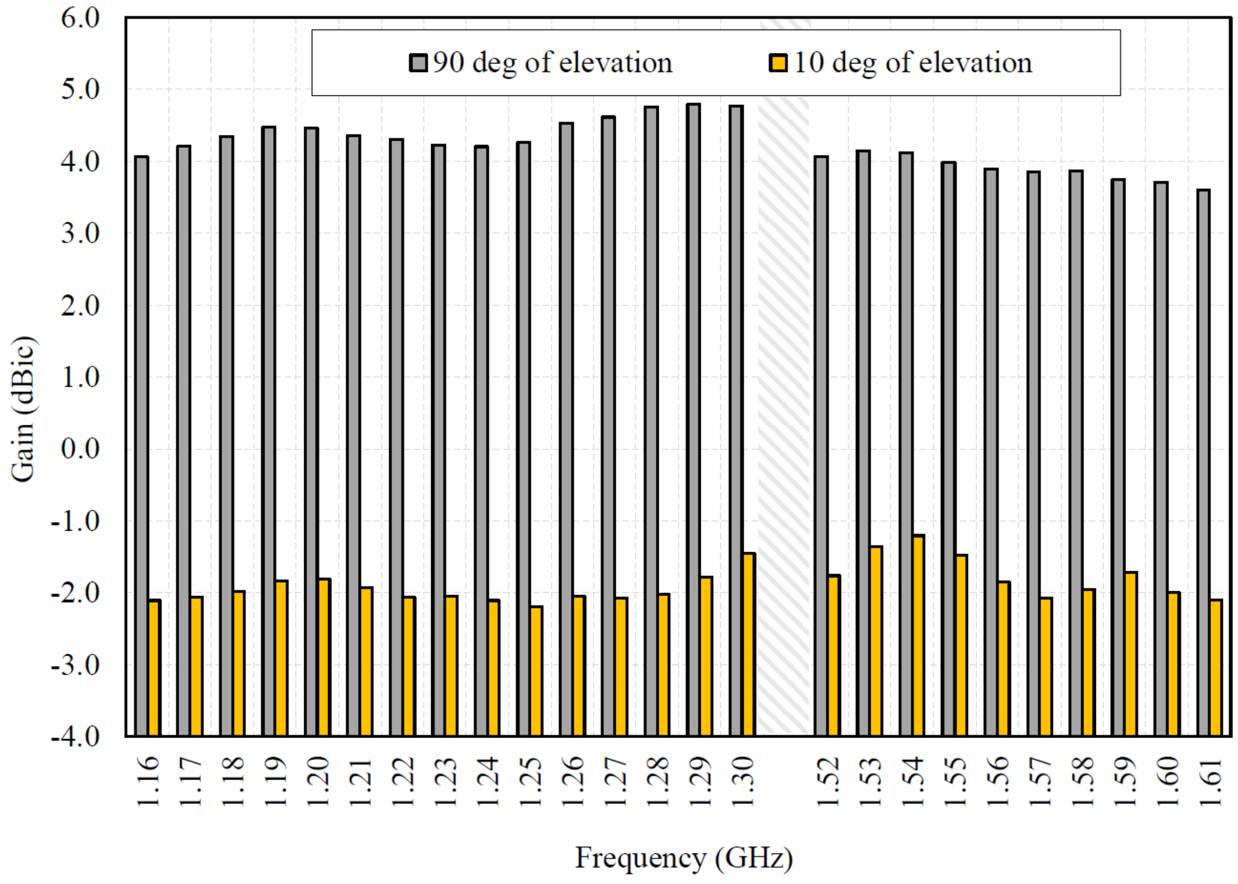
• Measurement results

Measured using Satimo Anechoic chamber at Syntronic R&D Canada in Ottawa
Data collected from 1160 MHz to 1610 MHz

Antenna Gain

- RHCP Gain at zenith and 10-degree elevation angle
- Flat gain over the full GNSS spectrum
  - Gain ripples < 0.5 dB
- High gain/sensitivity:
  - 4 dBic at zenith
  - -2 dBic at 10 deg



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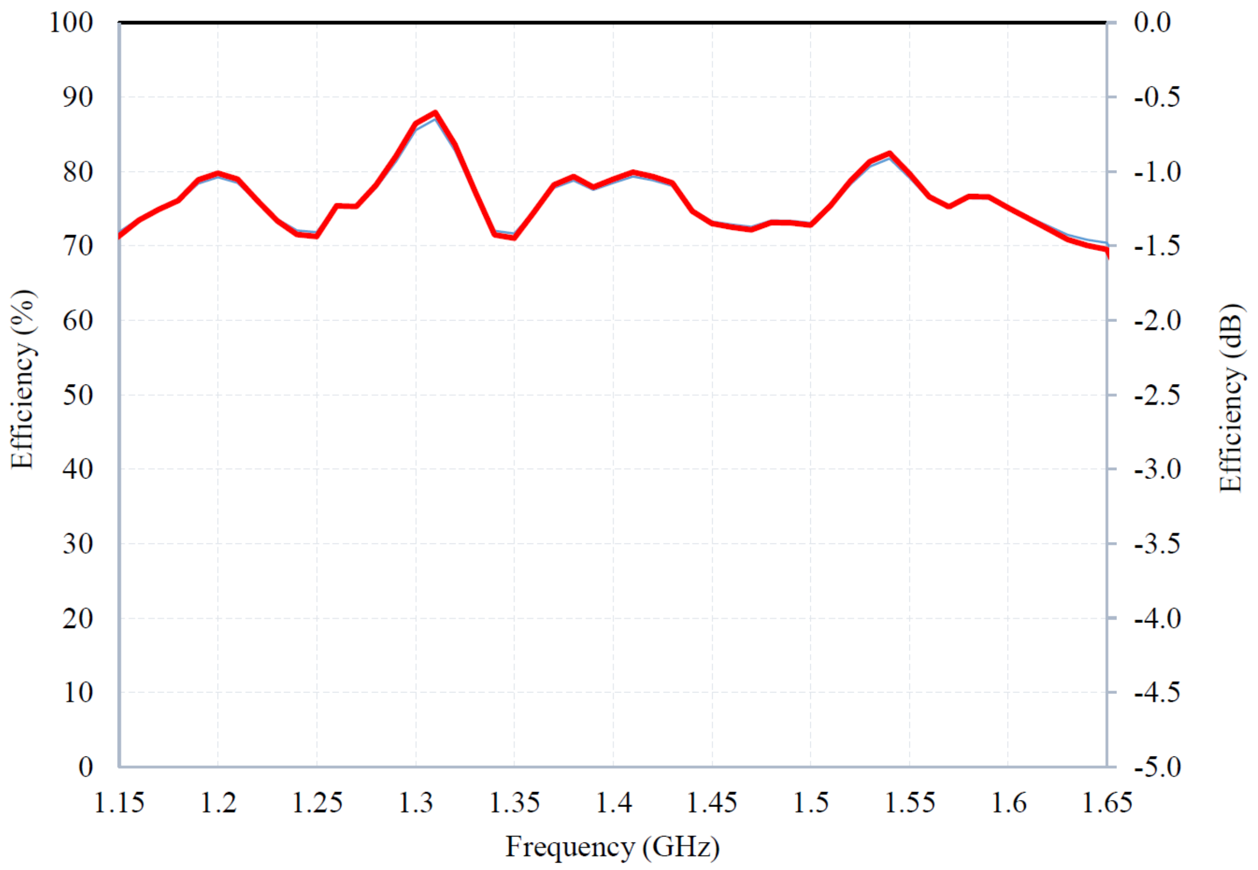
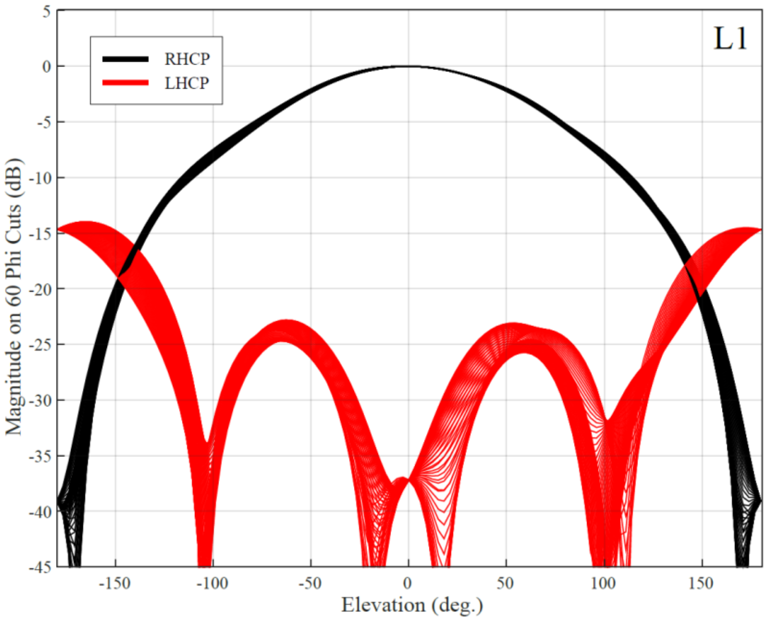
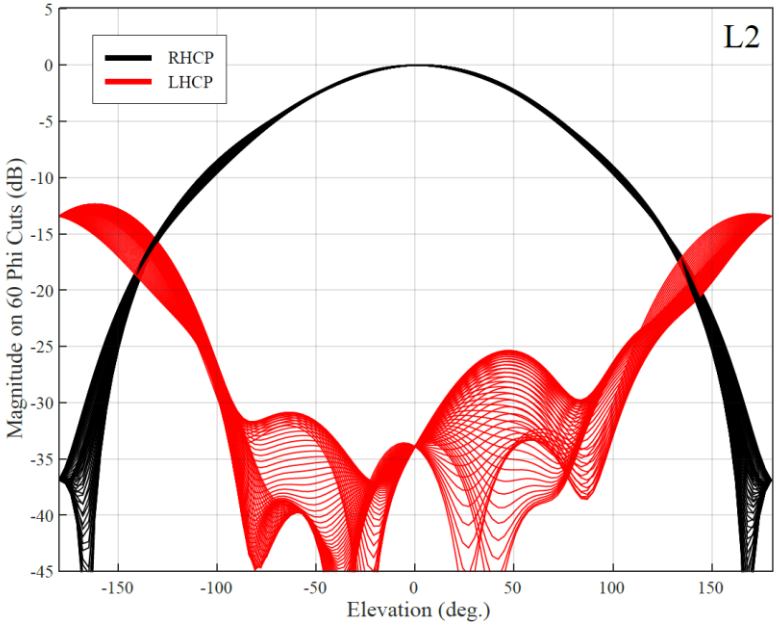
Antenna Efficiency

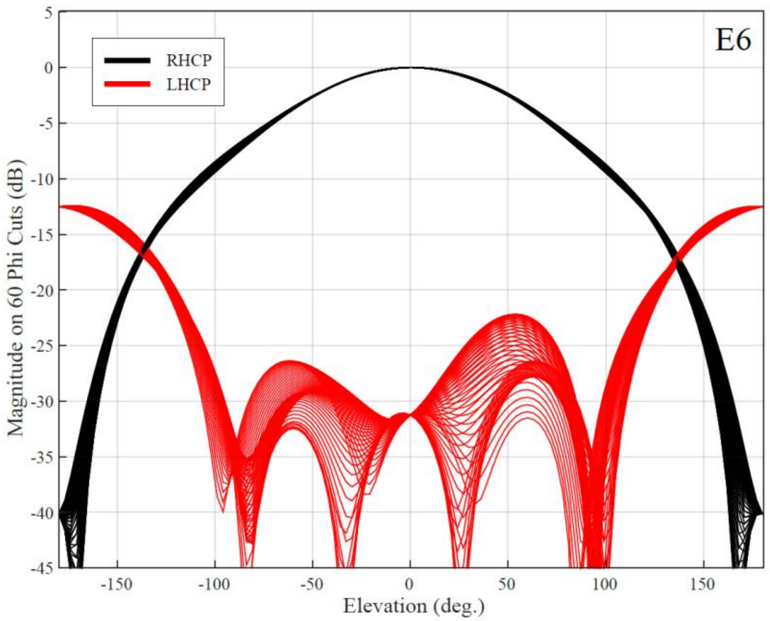
- High radiating efficiency
  - 70-80 %
  - 1-1.5 dB loss
- Optimised dipole feeding network
  - Better C/N0

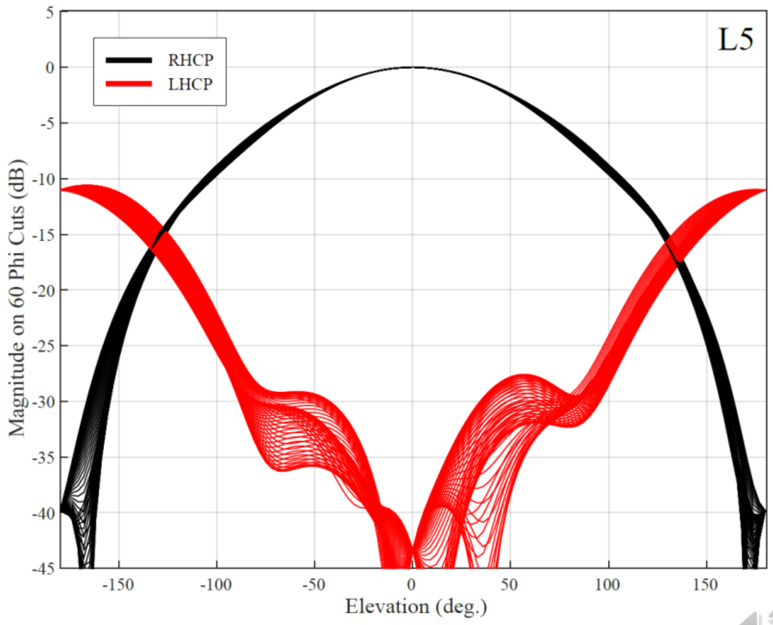


Radiation Patterns
(60 azimuth cuts)









- Homogenous results over the full GNSS spectrum
- Stable RHCP gain vs azimuth → Minimized PCV
- Low LHCP gain → Excellent axial ratio

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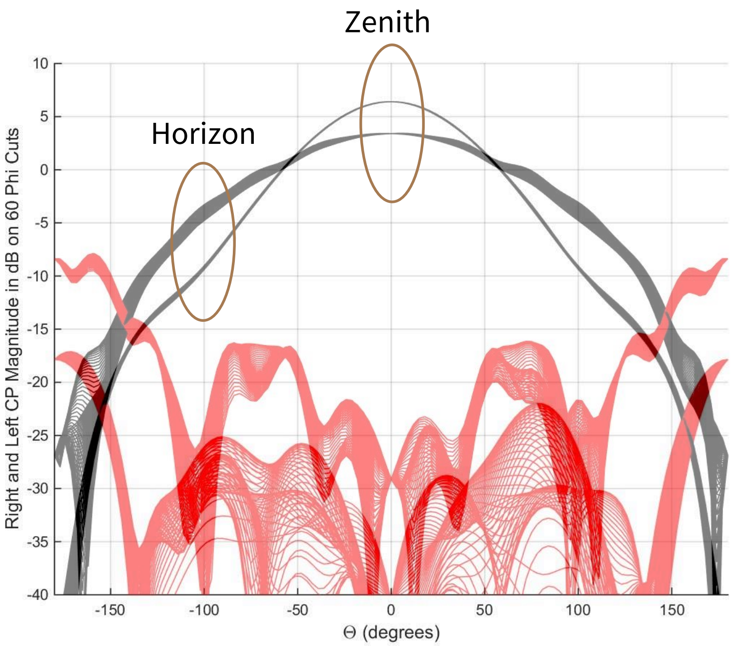
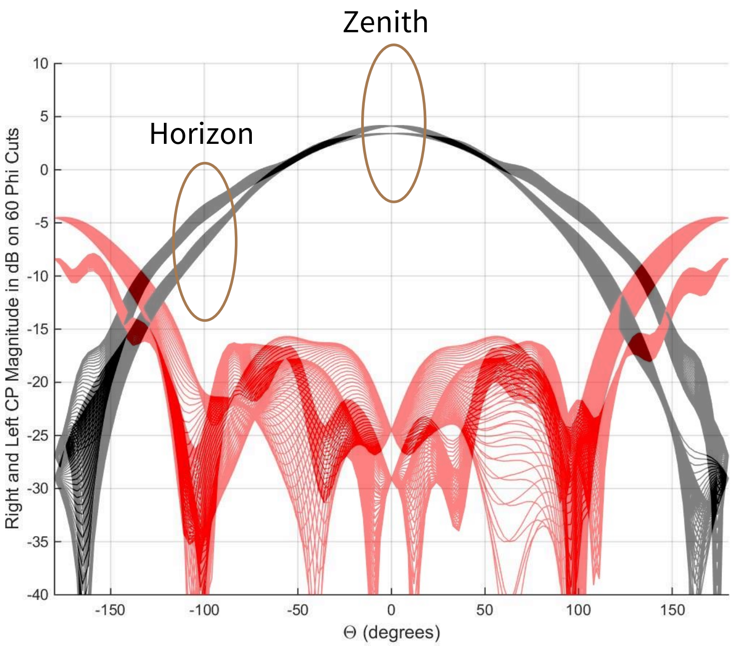
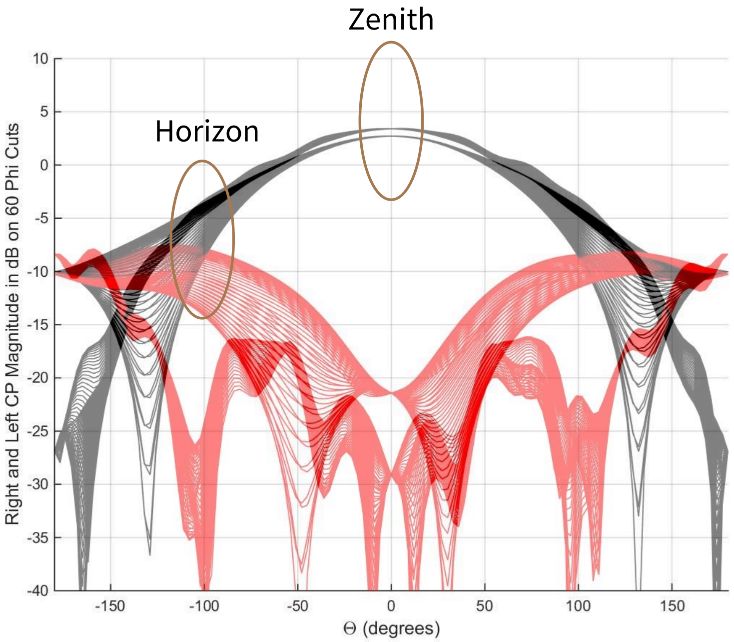
Gain Roll-off Comparison







VeroStar
vs
VeraPhase

VeroStar
vs
Patch antenna TW3972

VeroStar
vs
Helical antenna HC977

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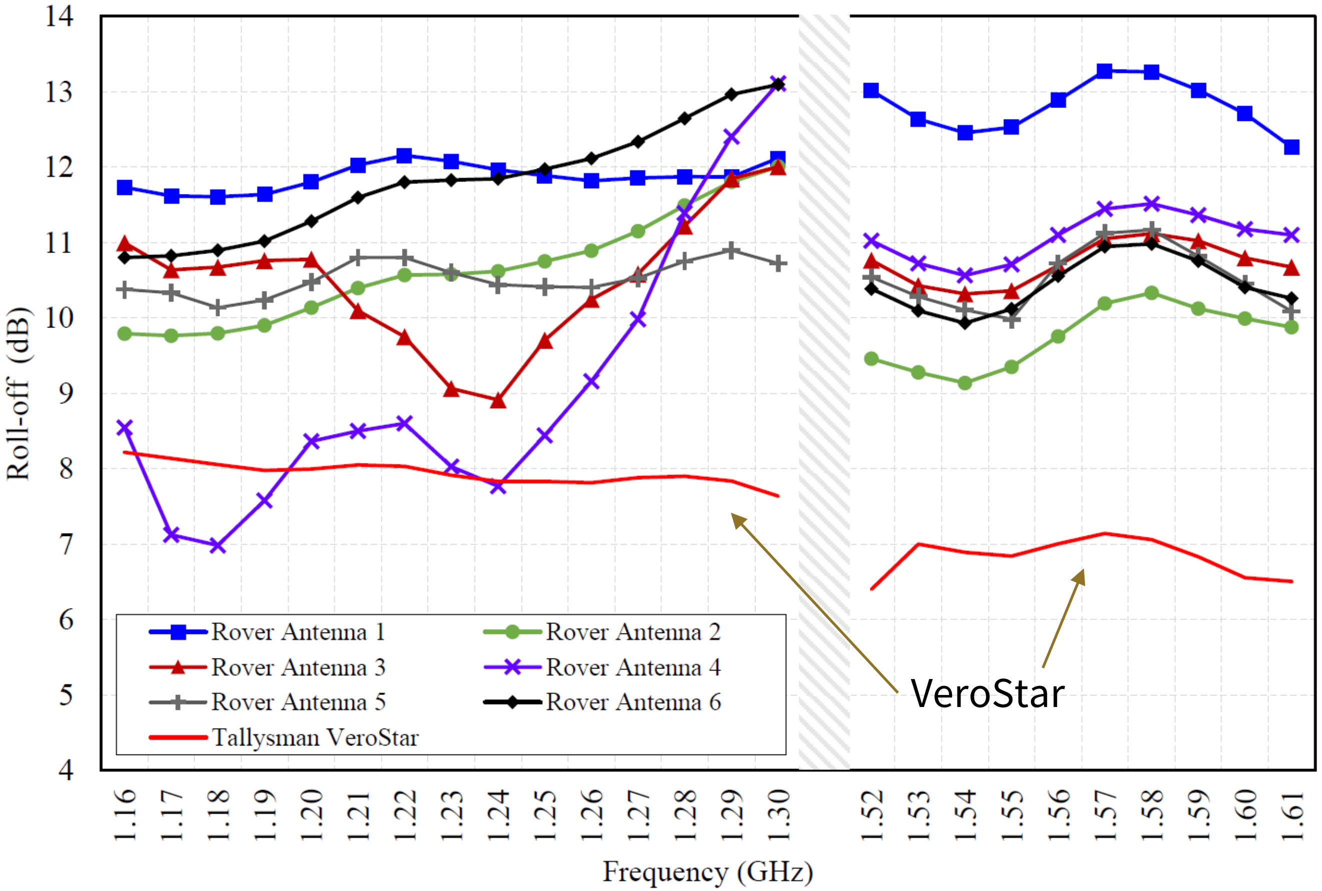
Antenna Gain Roll-off

- Comparison with 6 commercially available rover antennas
- All measured at the same time
- Similar gain at zenith
- But better gain roll-off
- 3-4 dB of gain improvement
- Measured G/T: ≥ -25 dB/K at 10 deg



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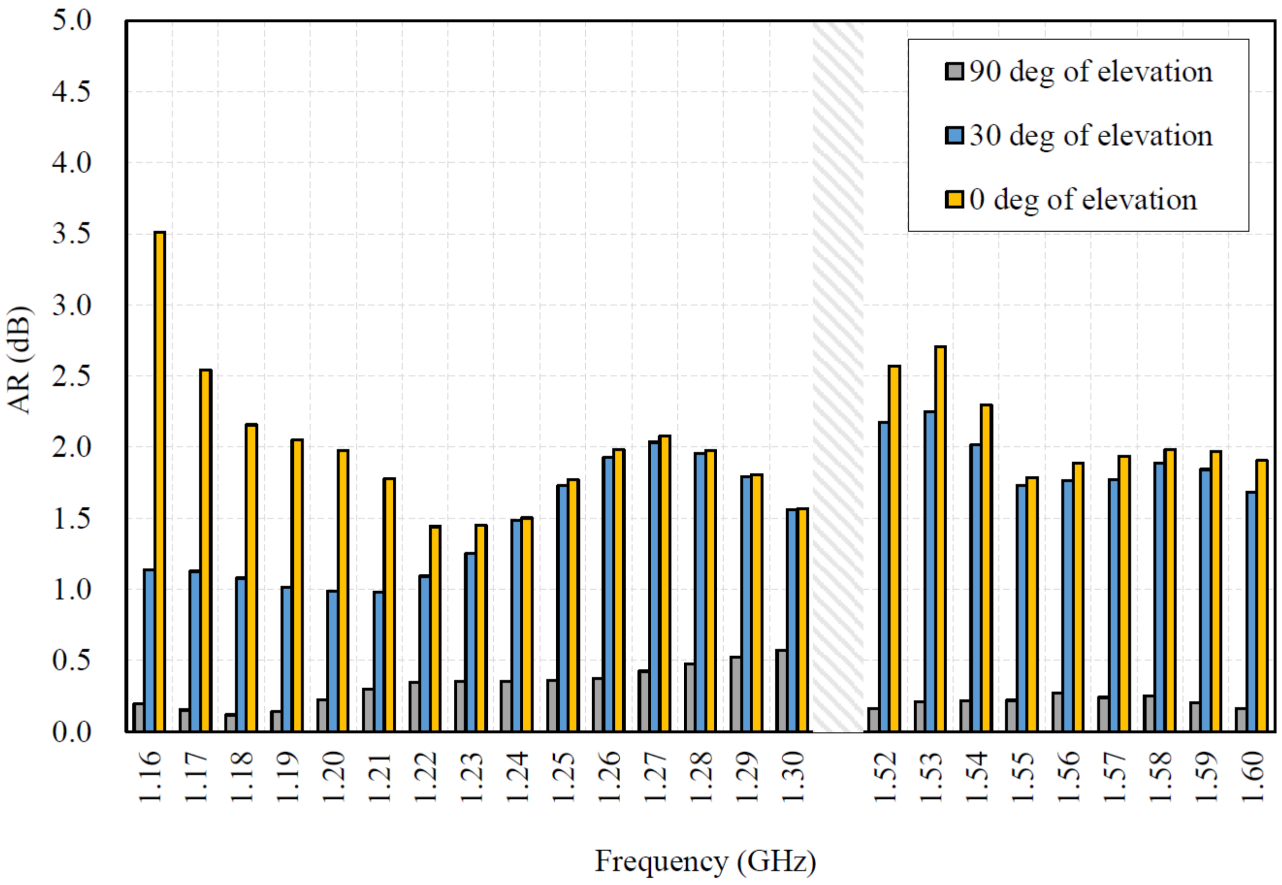
Antenna Axial Ratio

- Very low axial ratio
- 0.5 dB typical at zenith
- < 3 dB at horizon
- Better rejection of multipath



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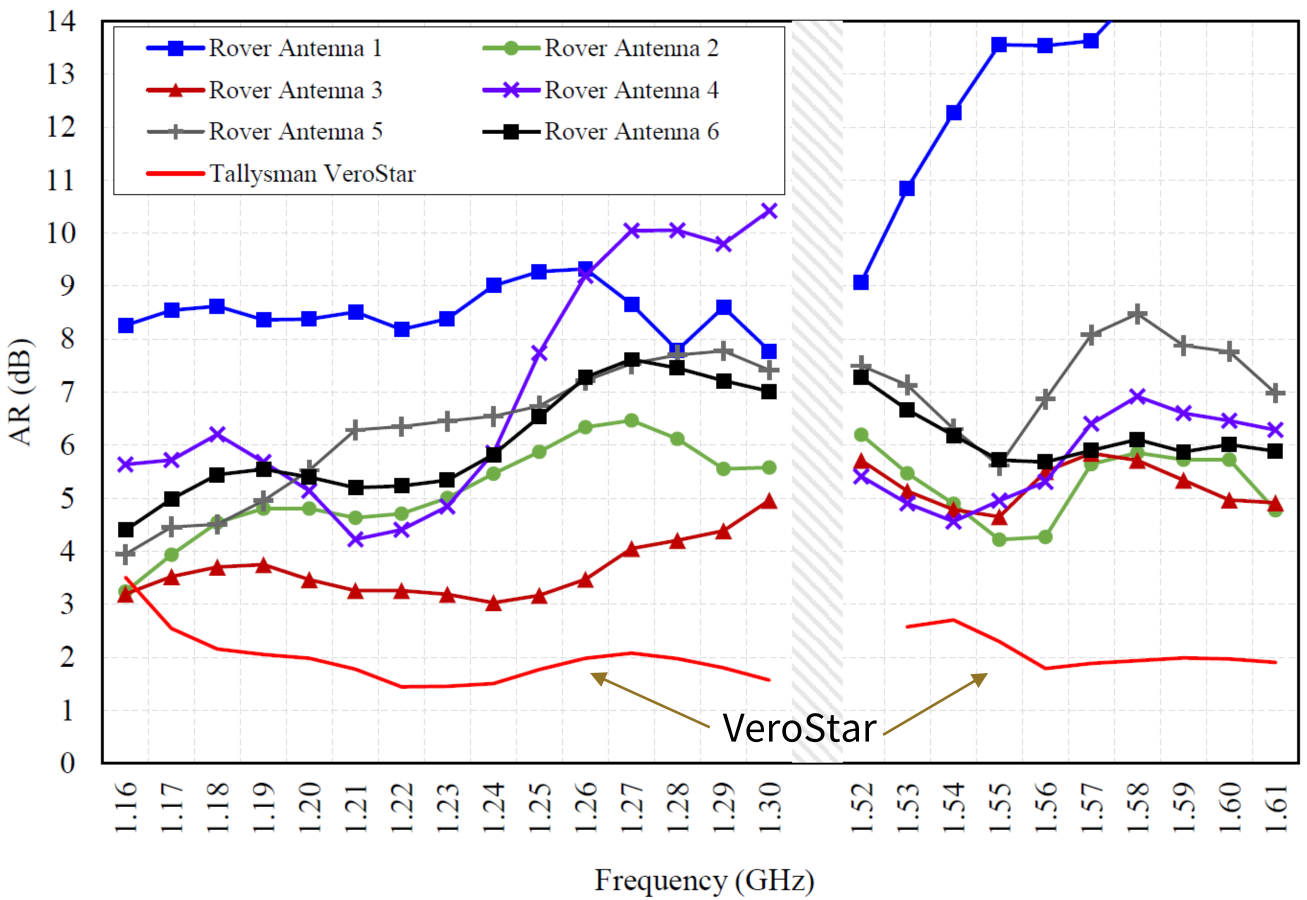
Antenna Axial Ratio

- Comparison with 6 commercially available rover antennas
- All measured at the same time
- Typical axial ratio at horizon:
  - 6 dB
  - Up to 8 dB and more



- Better by 3 to 4 dB
- In the real world:
  - More precise code, phase and position estimates

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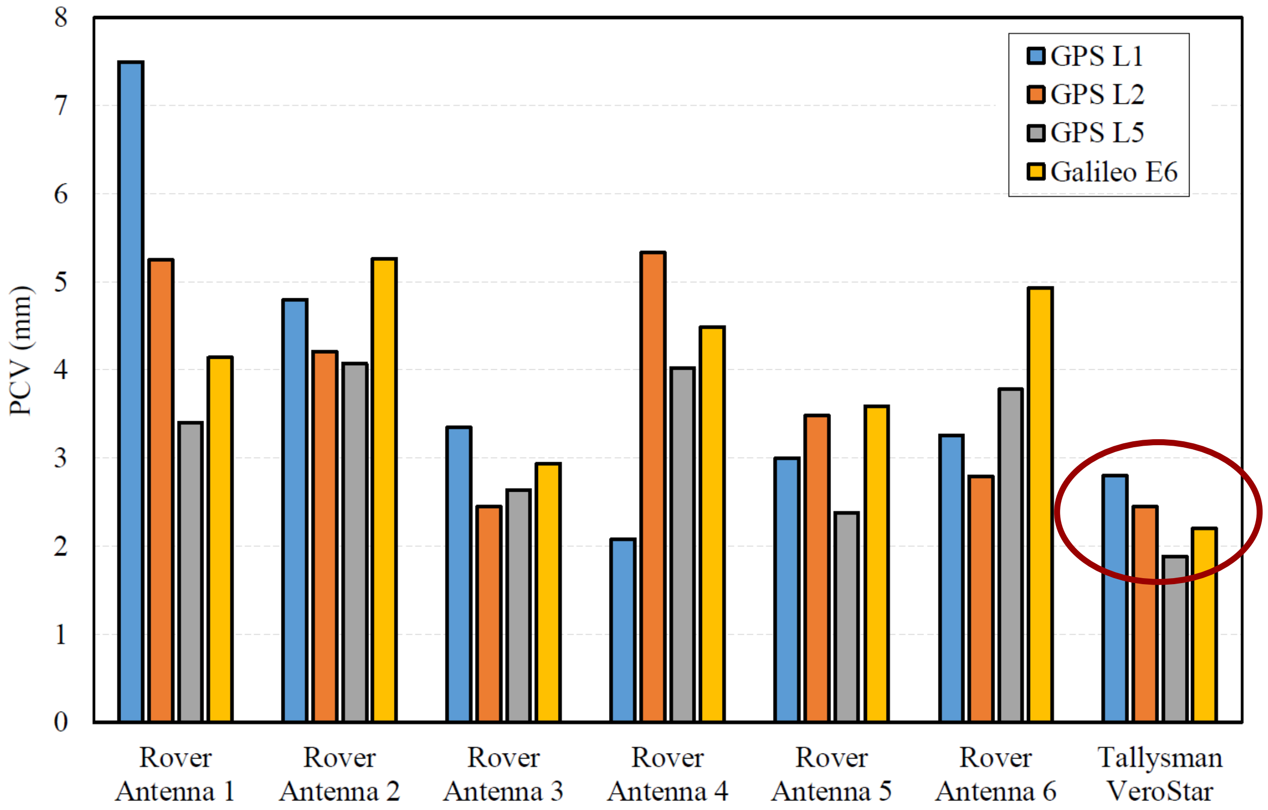
Antenna PCV

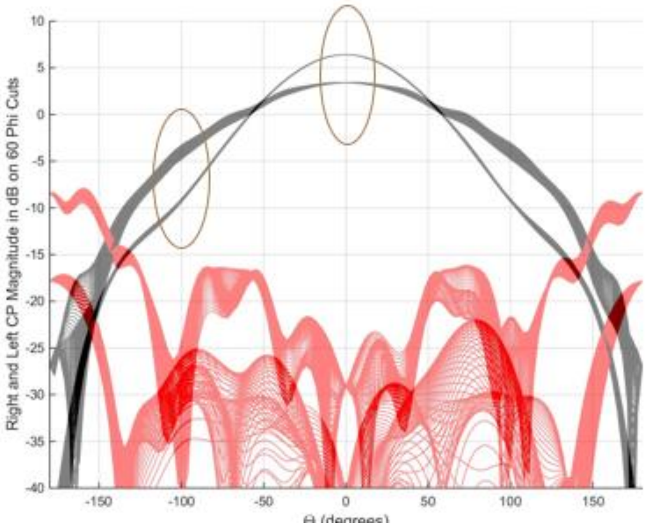
- Very low PCV over the GNSS spectrum
- Comparison with 6 commercially available rover antennas
- All measured at the same time
- Under 3 mm
- Typically smaller than competition

- Geo++ Calibration results:
  - No Azi < 2 mm



Antenna Field Test

- C/N0 (dBHz)comparison with VeraPhase antenna



- Better low elevation tracking

Elevation	Antenna	L1	L2C	L2P
2	VS	41.5	35.5	22.7
	VP	-	30.7	-
4	VS	43	25	36.5
	VP	-	-	-
15	VS	43	24	35
	VP	40	25	38
18	VS	45	44	34
	VP	40	42	28
85	VS	50	48	45
	VP	53	49	48
87	VS	50	45	48
	VP	52	48	49

VeroStar

A new family of antennas

75 mm

170 mm

500 g
TNC Connector
1” or 5/8” mount

45 mm

170 mm

340 g
TNC Connector
4 x M6 Screws

35 mm

110 mm

80 g
Flying Lead

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- Conclusion

Conclusion

VeroStar:
A Novel Full Band GNSS Rover Antenna

- Optimisation of the radiation patterns for low elevation tracking:
  - L-Band correction
  - More satellites
- Low loss cross dipole fed bowtie technology
- High efficiency (≥70%) for better carrier to noise ratio
- Low axial ratio (3 dB max at horizon) for high multipath rejection
- Tight Phase Center Variation (± 2mm)for precise positioning
- LNA: Advanced Filtering with optimised Noise Figure for high G/T
- Light weight and compact

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