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VeroStar: A Novel Full GNSS Band Rover Antenna

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Who we are

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

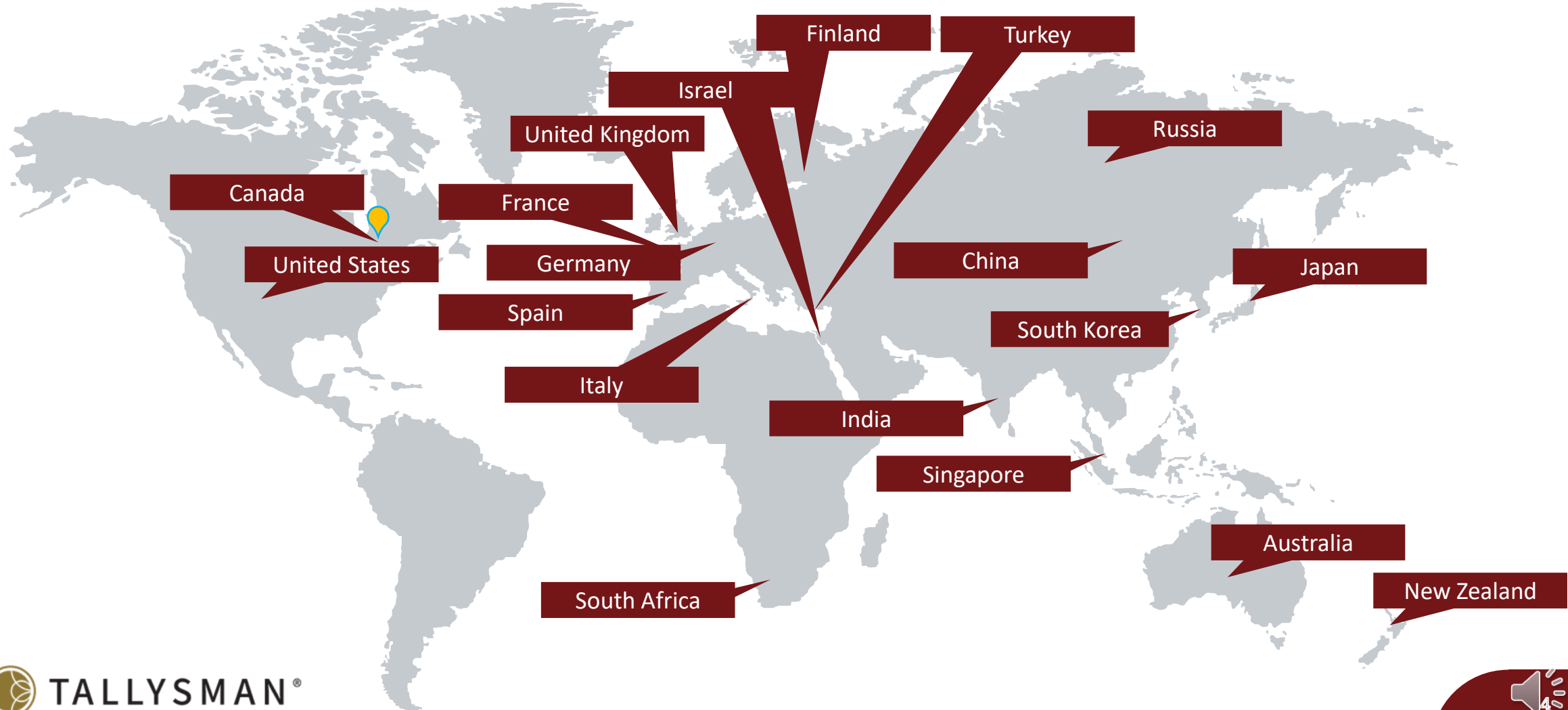


What we do

- 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**



Global Distribution





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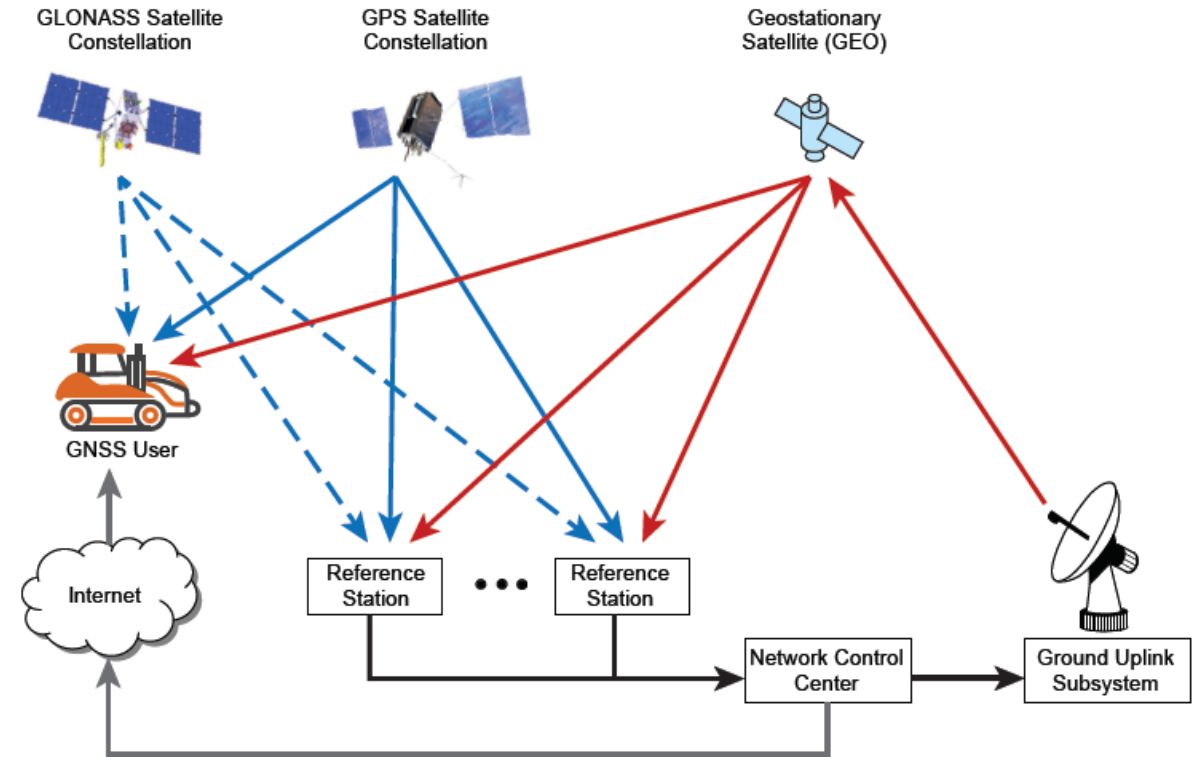
- GNSS Rover antenna requirements



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

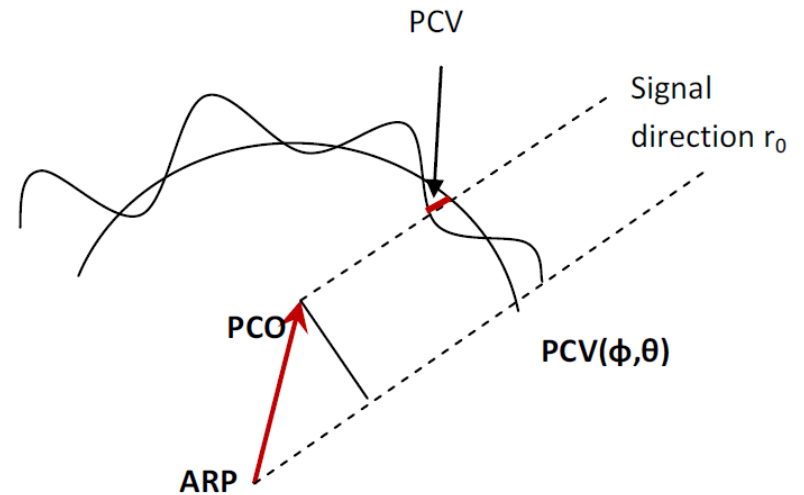
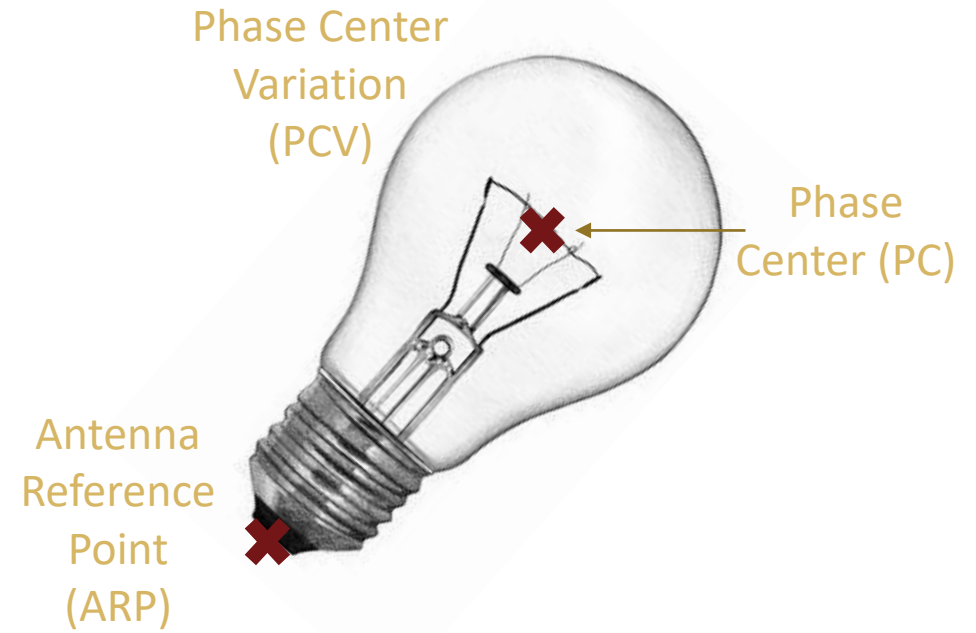


Antenna requirements

- 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

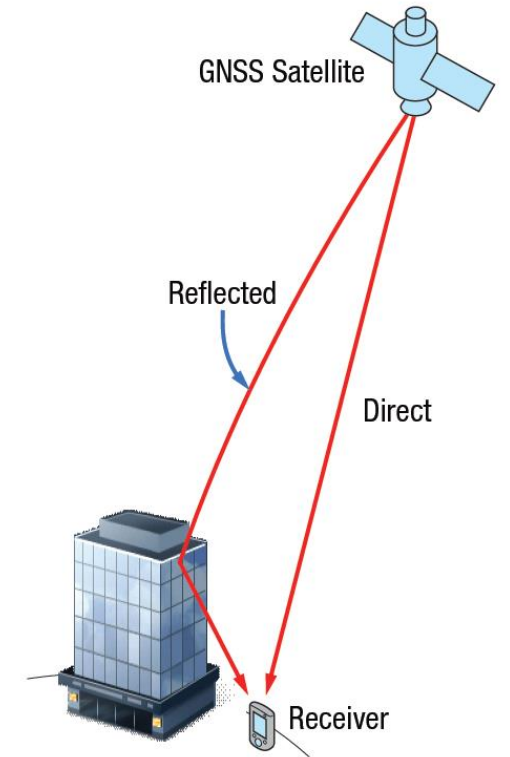


Antenna requirements

- 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)

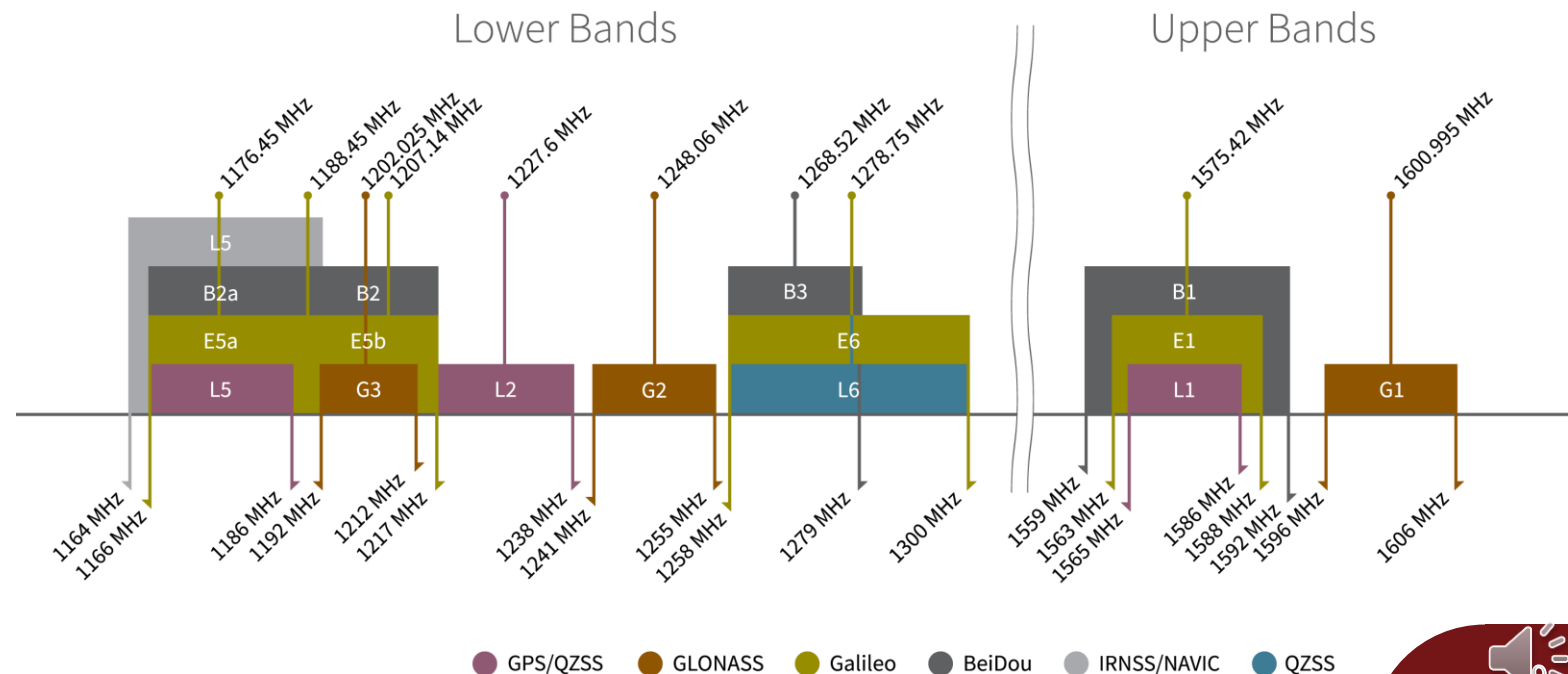


- Low axial ratio / up-down ratio ➡ high purity of circular polarization ➡ multipath mitigation
- Axial ratio objectives:
 - 0.5 dB typical at zenith
 - 3 dB or better at horizon



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

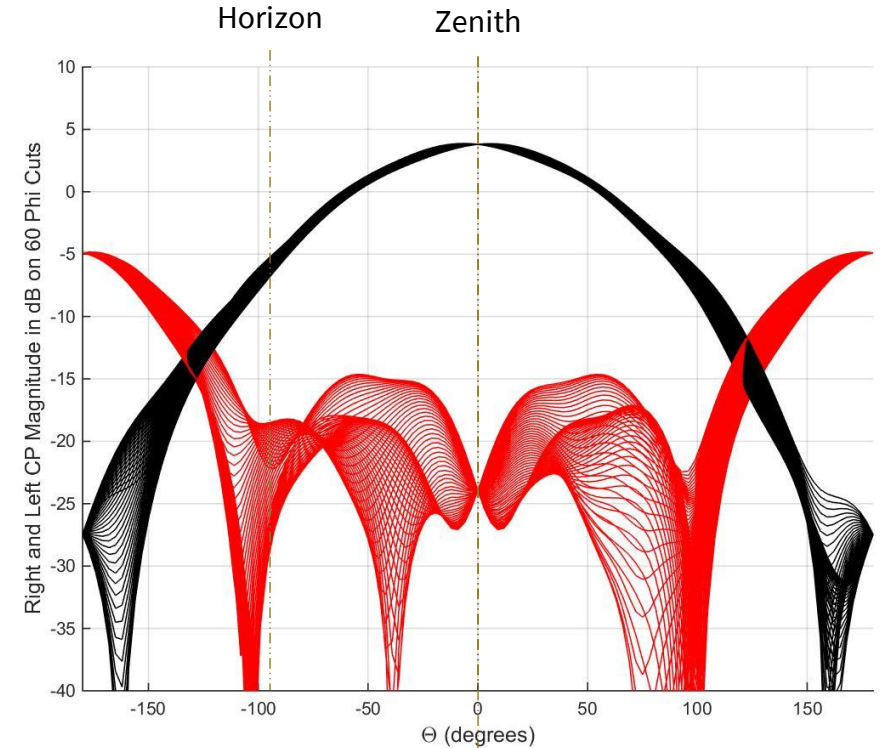
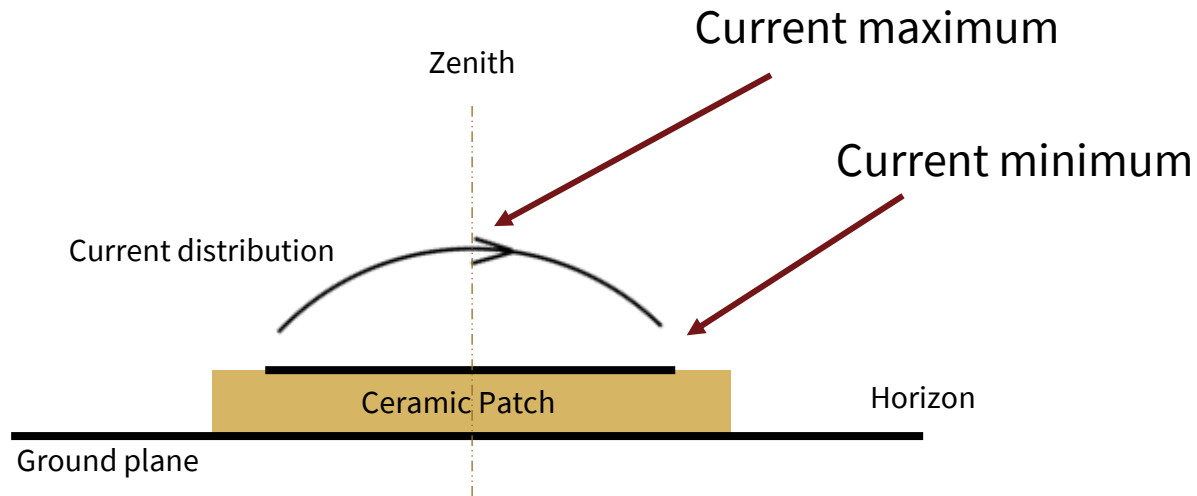
- Typical L1 gain values (dBic):

	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:



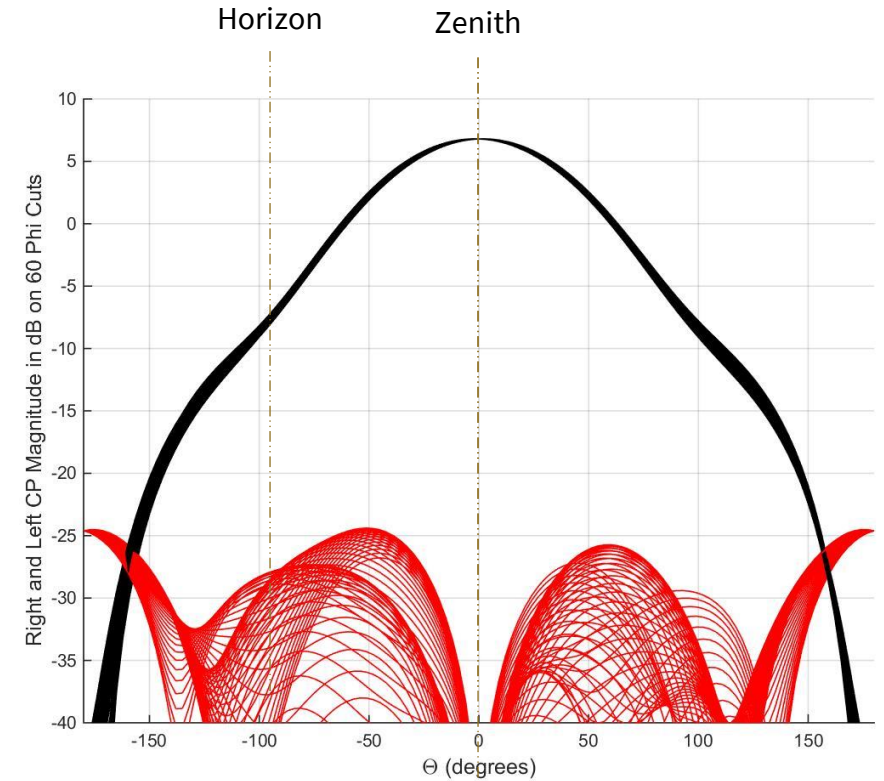
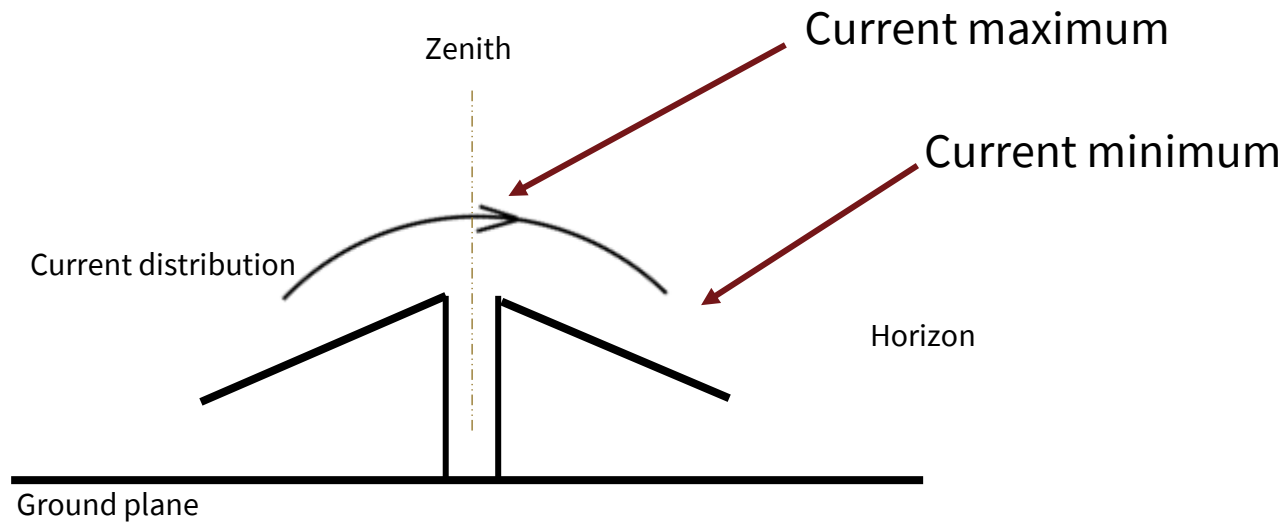
- Current maximum in the middle of the antenna
- Current minimum on the edges of the antenna

- ➔ High gain at zenith
- ➔ Low gain at horizon
- ➔ 10 dB of gain roll-off



Current distribution

- $\lambda/2$ Dipole based antenna:

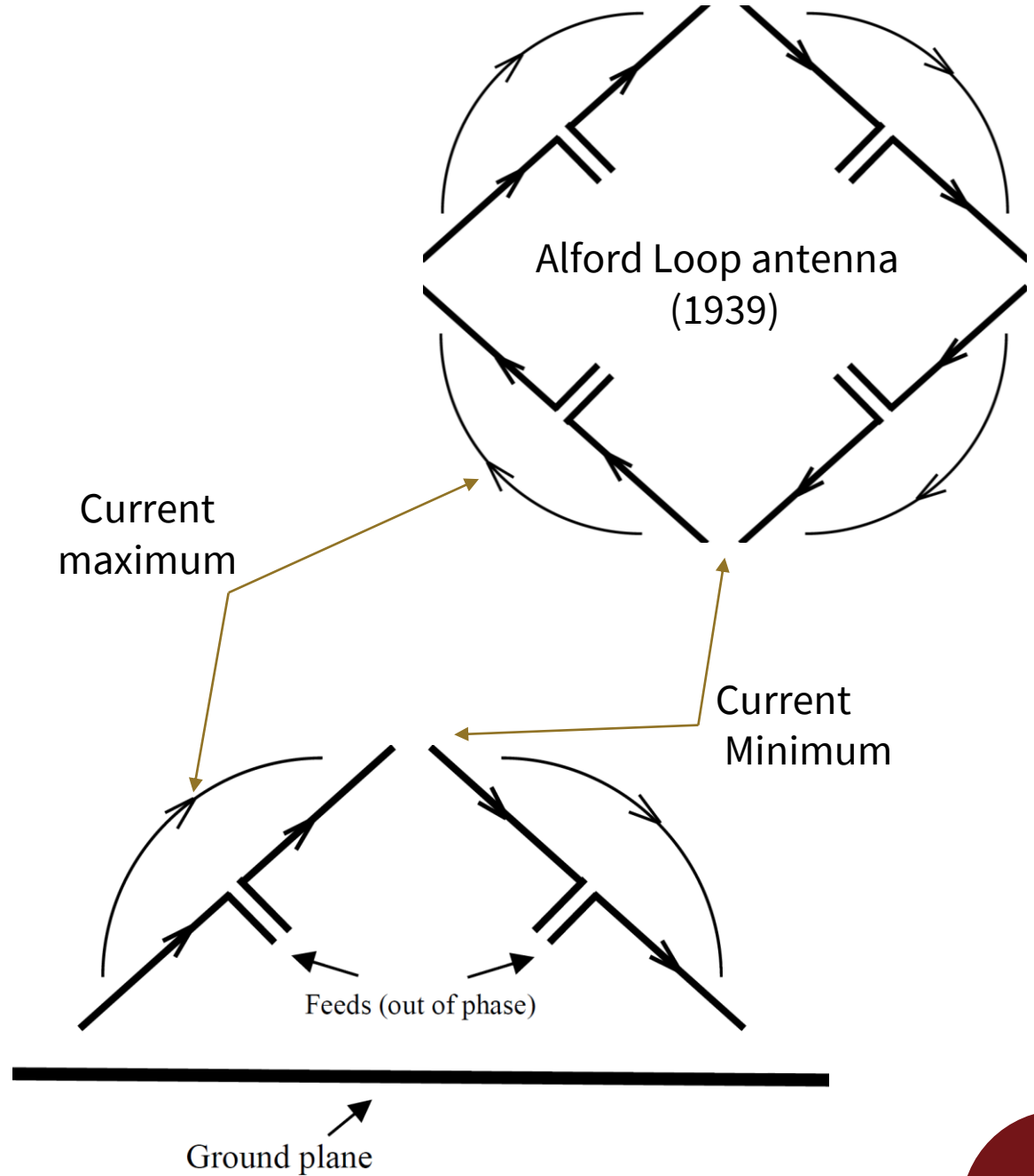


- Current maximum in the middle of the antenna \longrightarrow High gain at zenith
- Current minimum on the edges of the antenna \longrightarrow Low gain at horizon
- \longrightarrow Up to 14 dB of gain roll-off



Antecedents

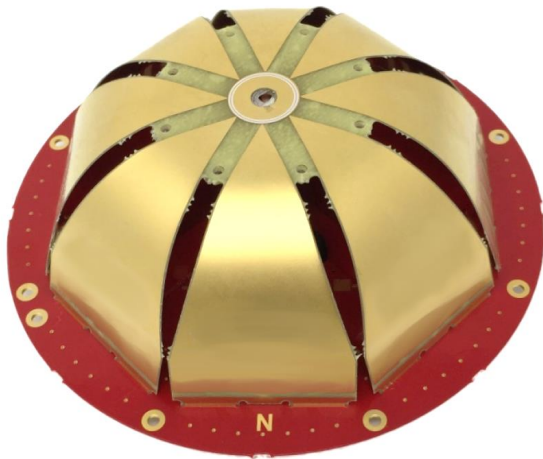
- Dorne & Margolin C146 reference antenna
 - Higher gain at low elevation angles
 - Current maximum offset from the center
 - Complex and costly to build
 - Poor axial ratio and PCV repeatability



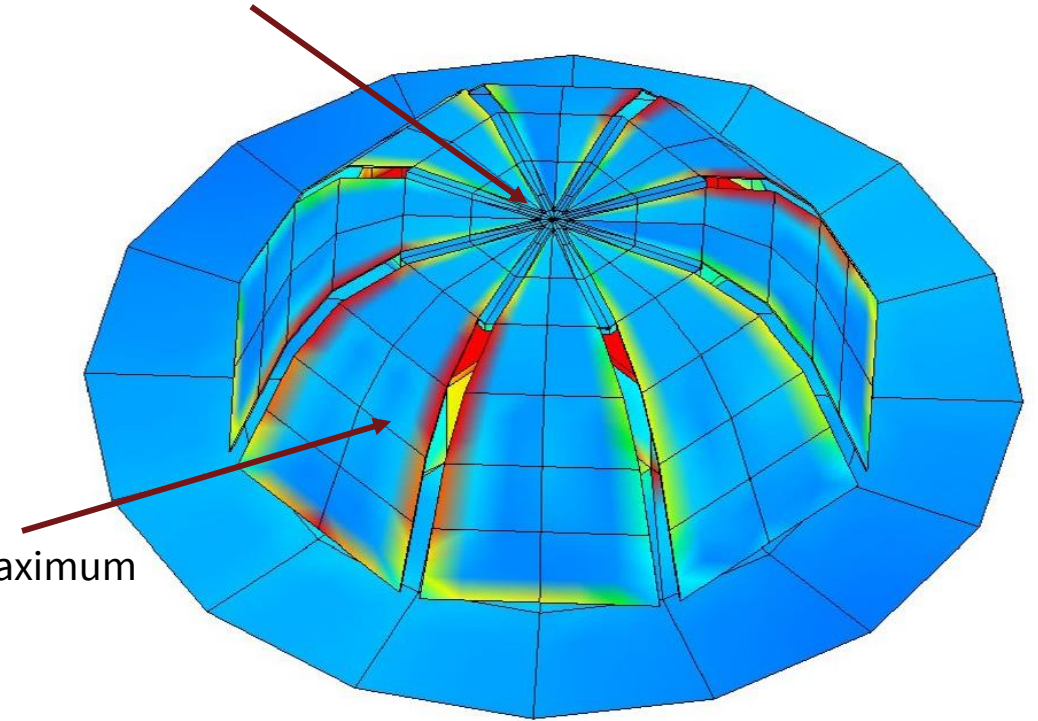
VeroStar

- 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



Current minimum



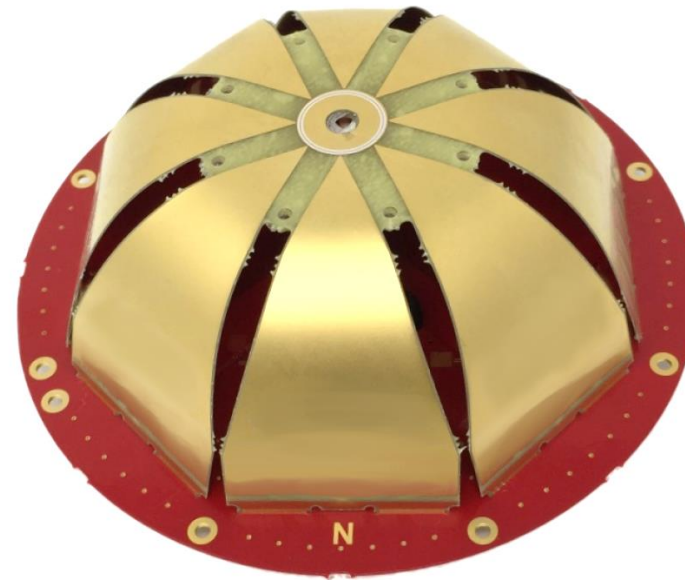
Current maximum

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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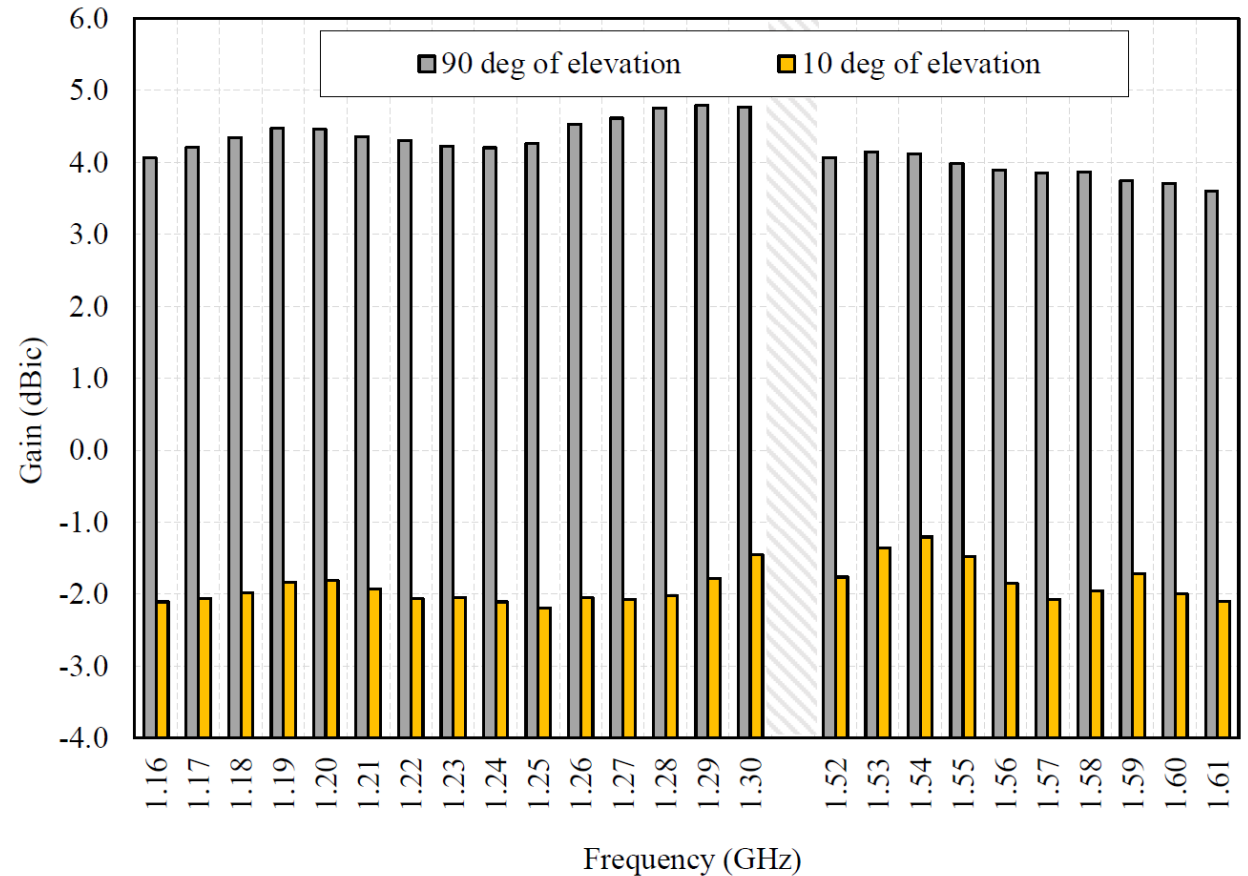
- Measurement results

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



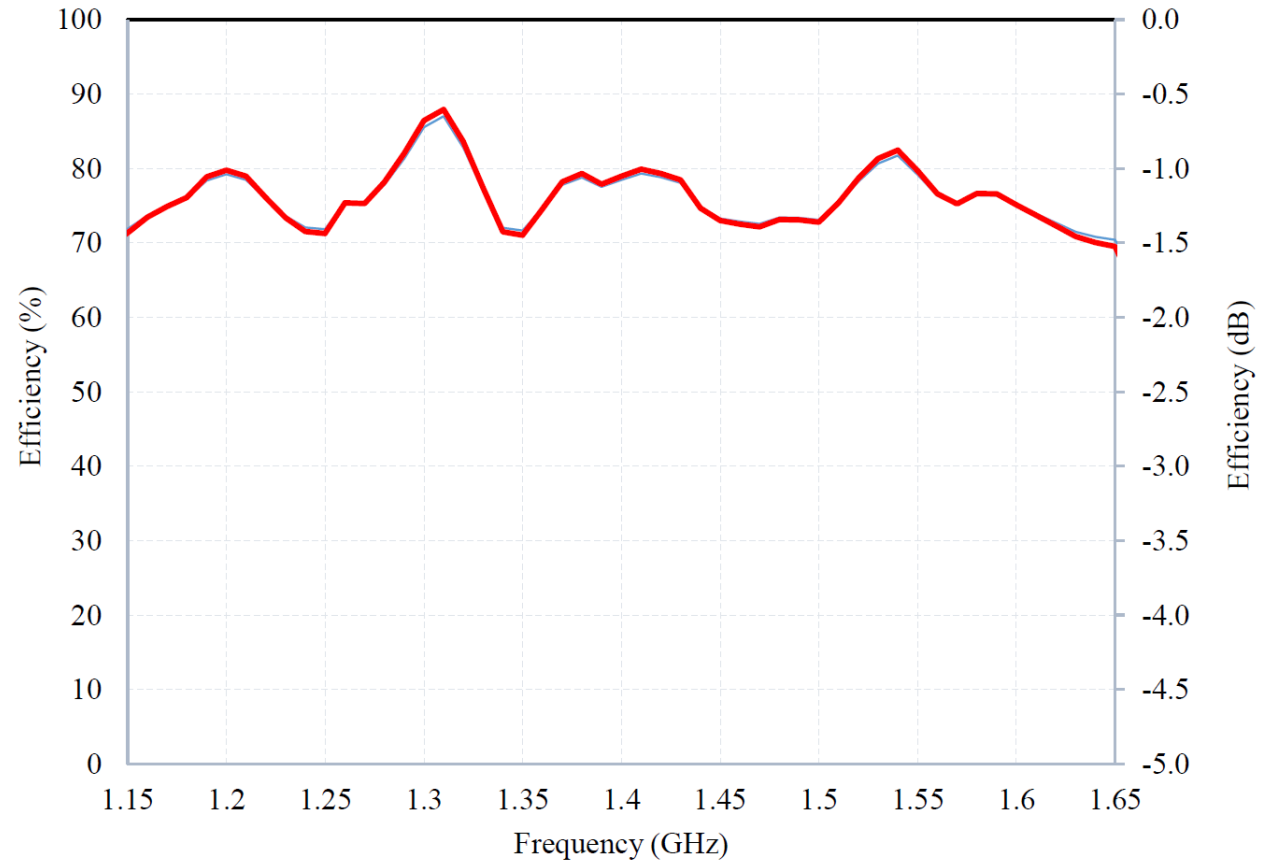
Antenna Gain

- 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



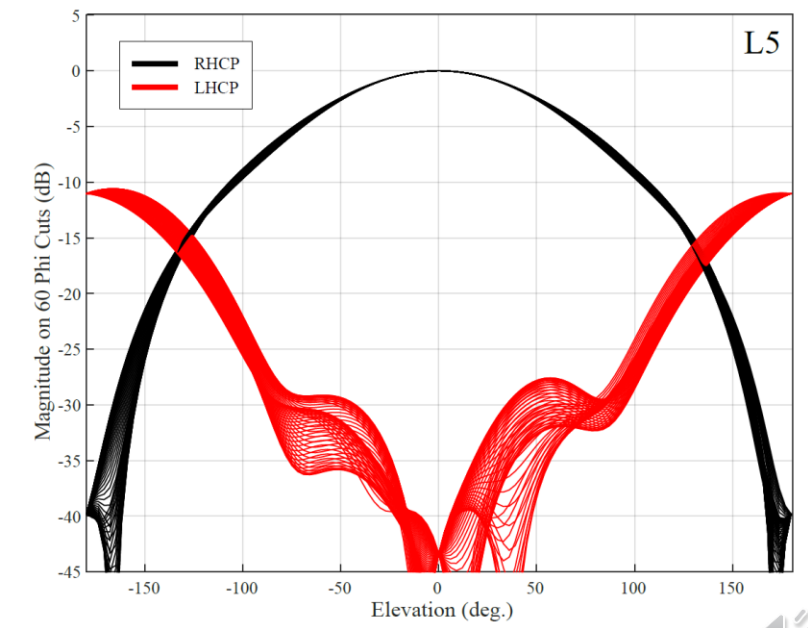
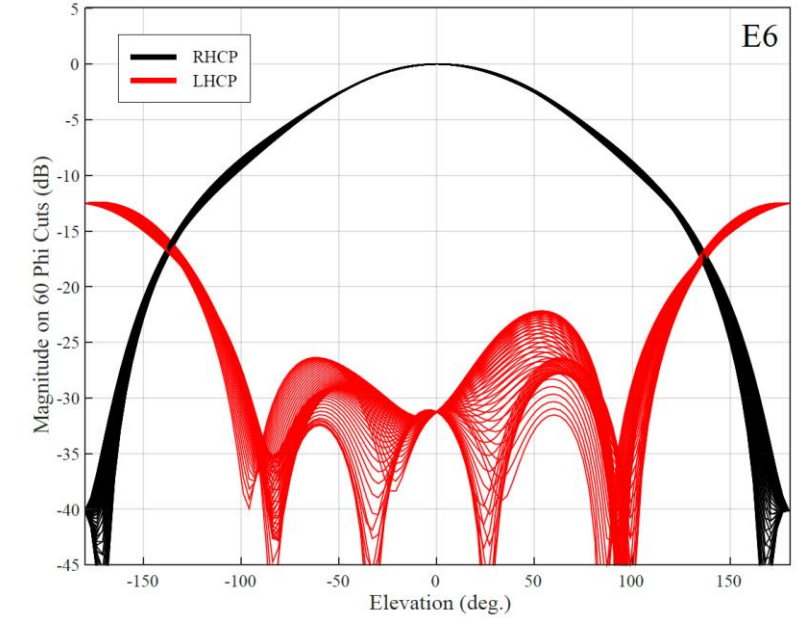
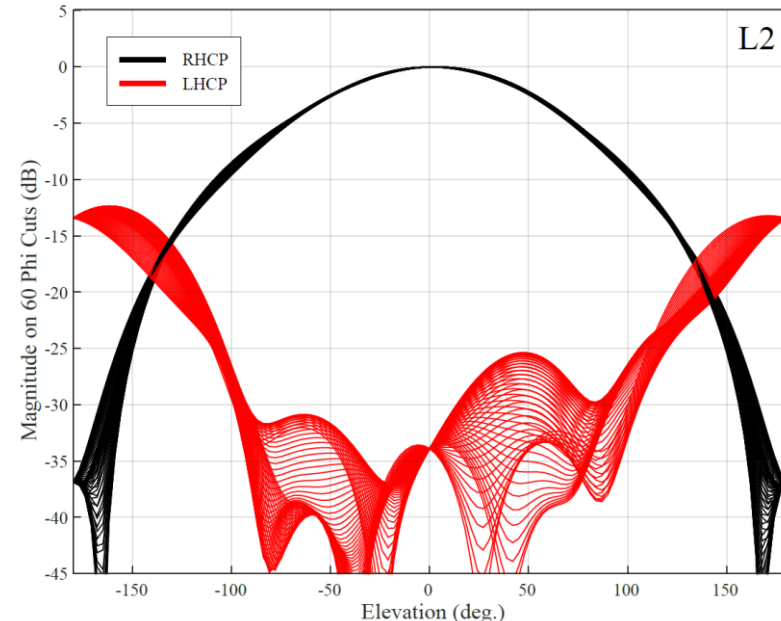
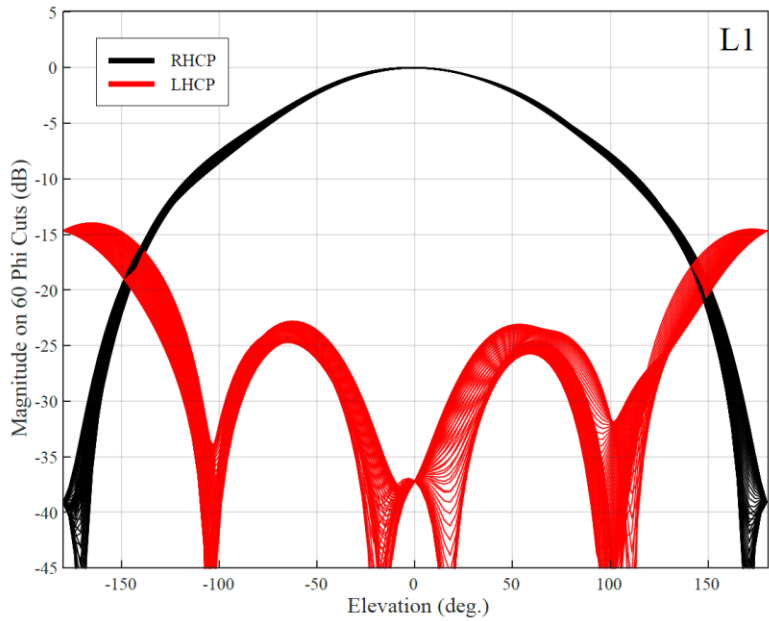
Antenna Efficiency

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



Radiation Patterns

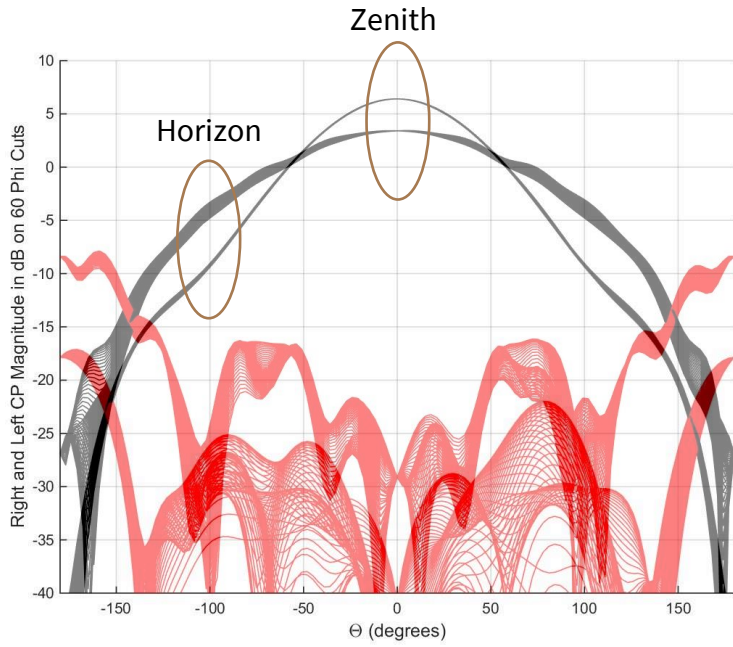
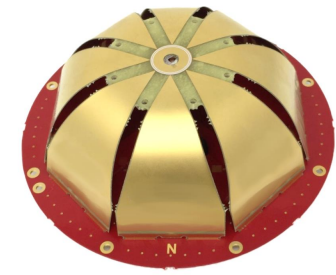
(60 azimuth cuts)



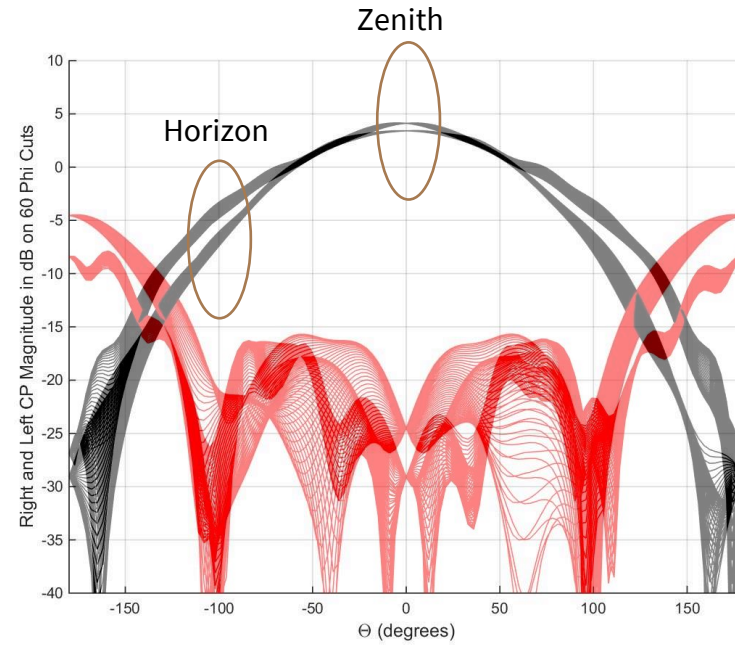
- Homogenous results over the full GNSS spectrum
- Stable RHCP gain vs azimuth → Minimized PCV
- Low LHCP gain → Excellent axial ratio



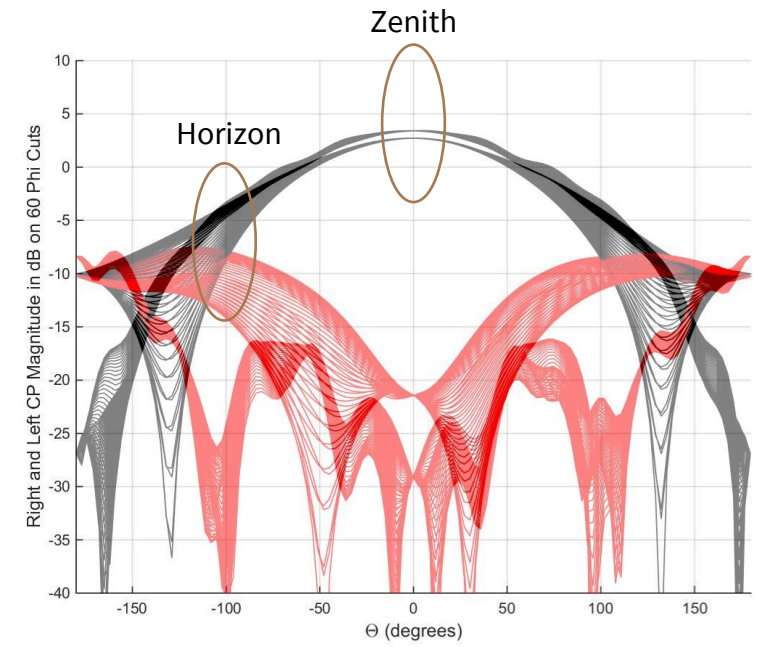
Gain Roll-off Comparison



VeroStar
VS
VeraPhase



VeroStar
VS
Patch antenna TW3972

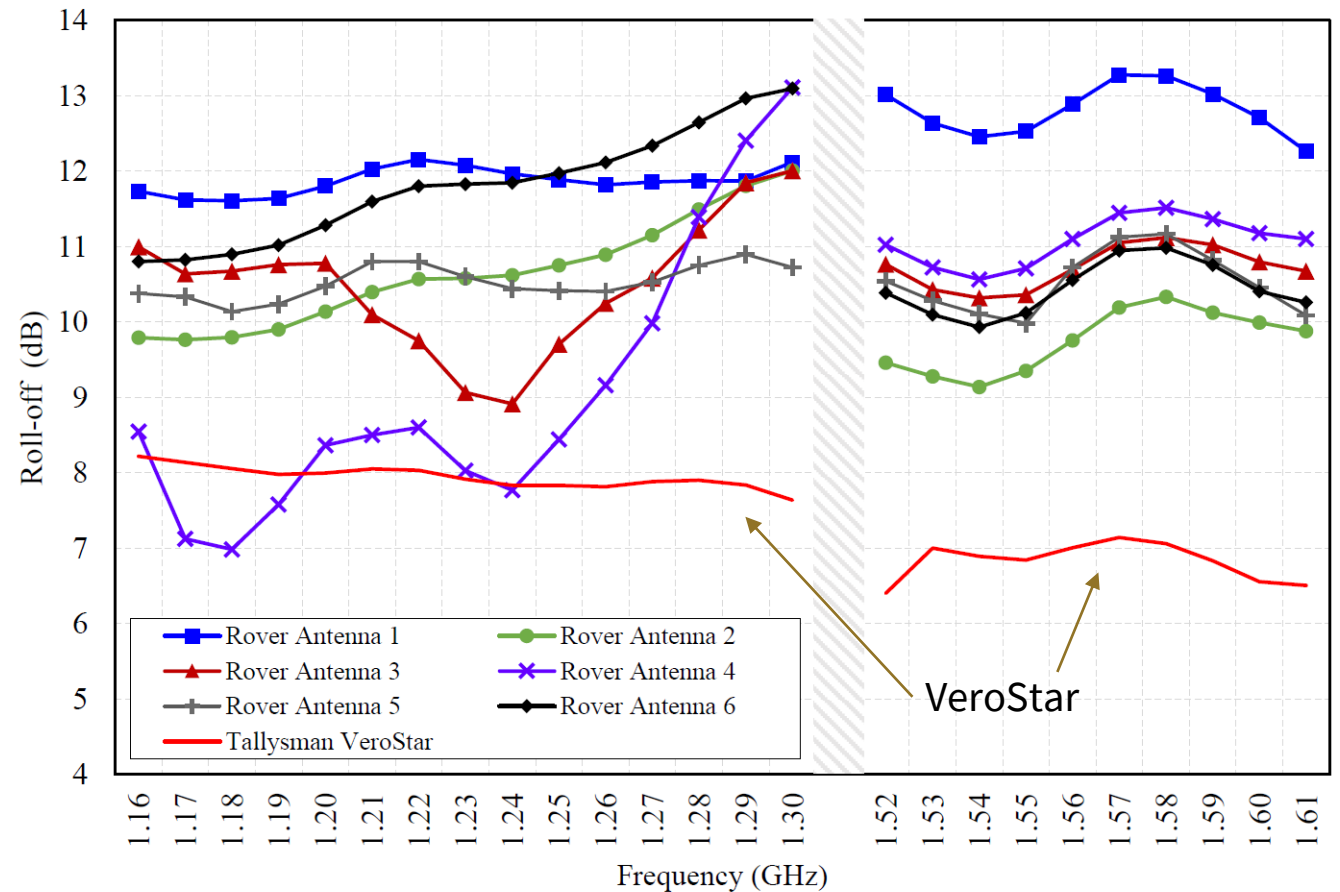


VeroStar
VS
Helical antenna HC977



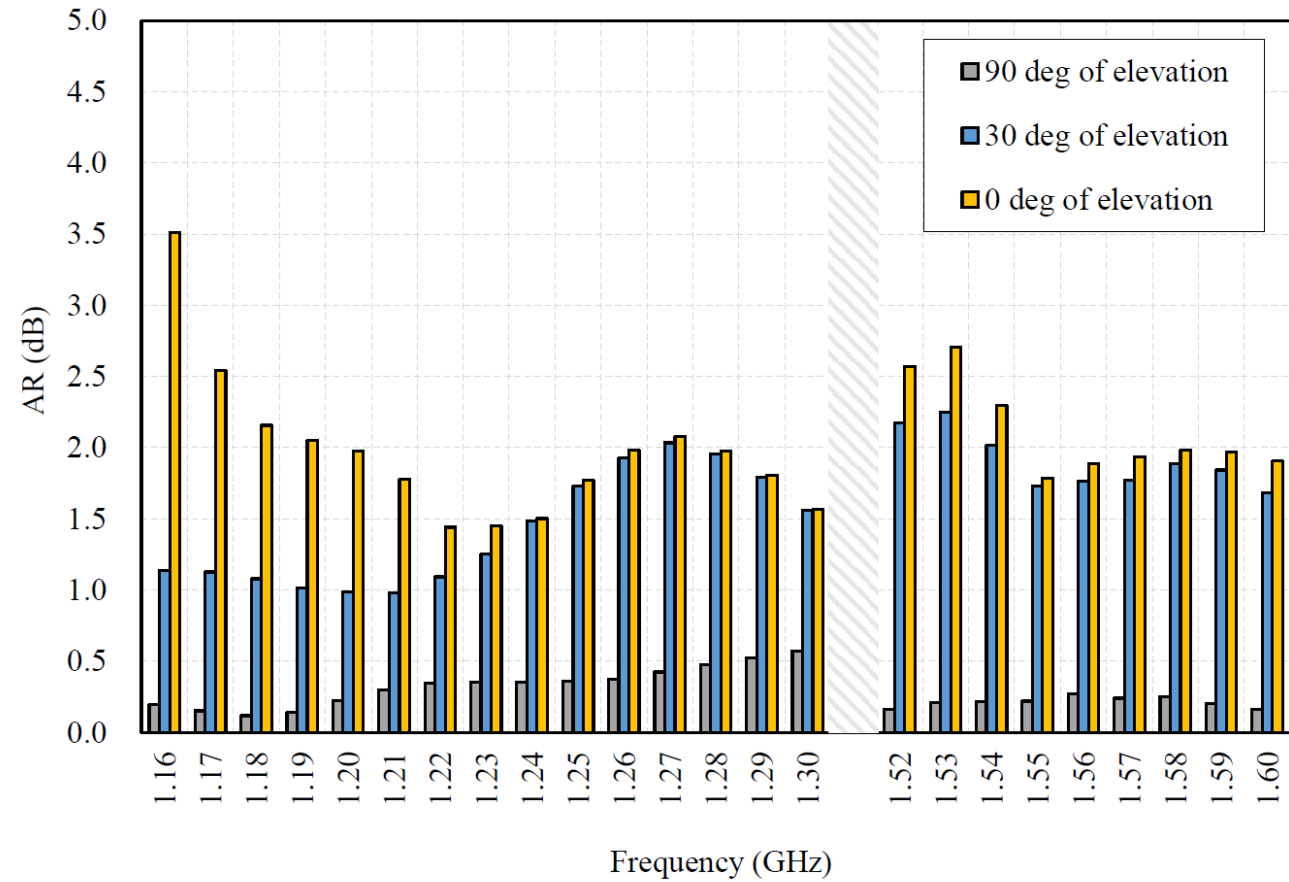
Antenna Gain Roll-off

- 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



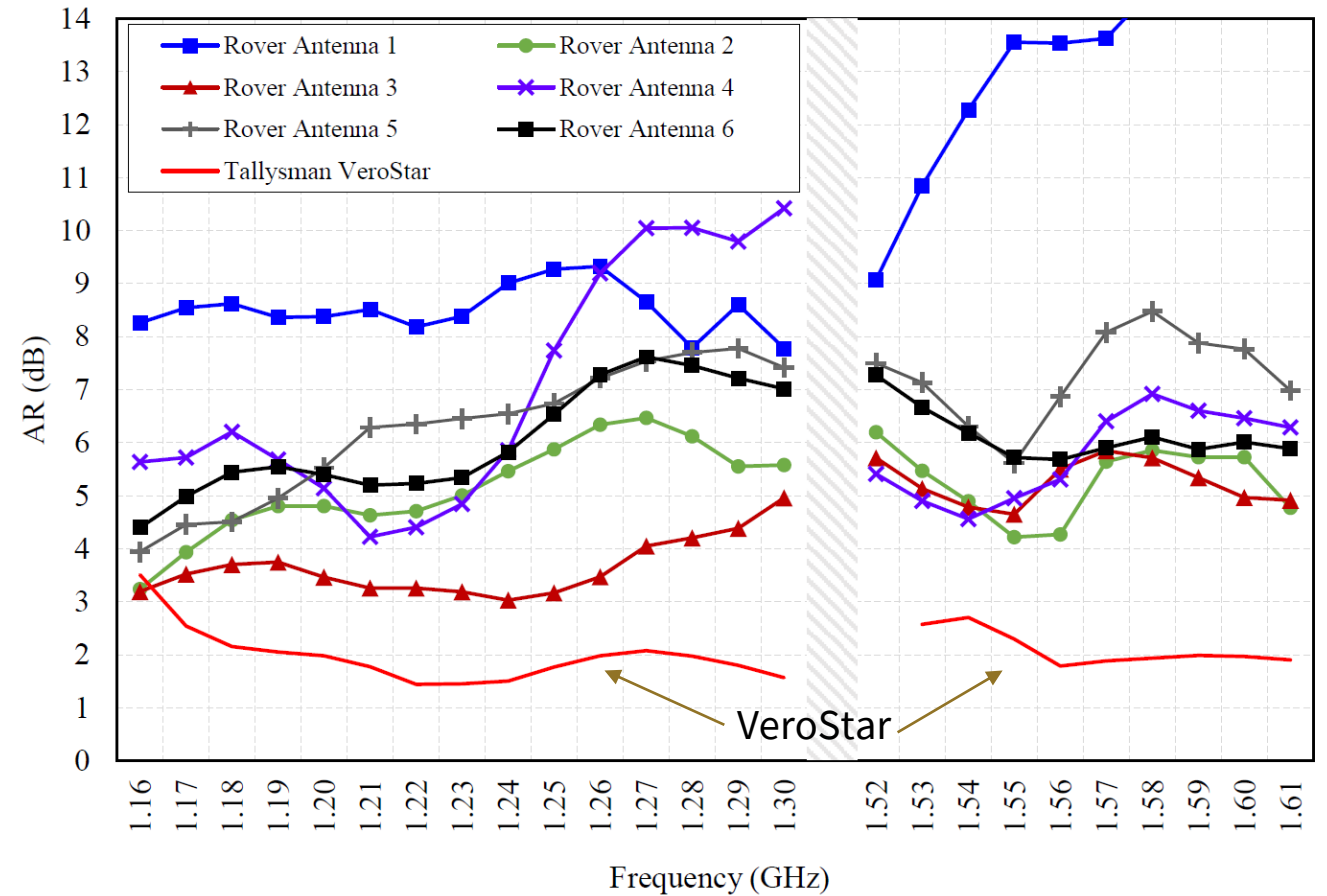
Antenna Axial Ratio

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



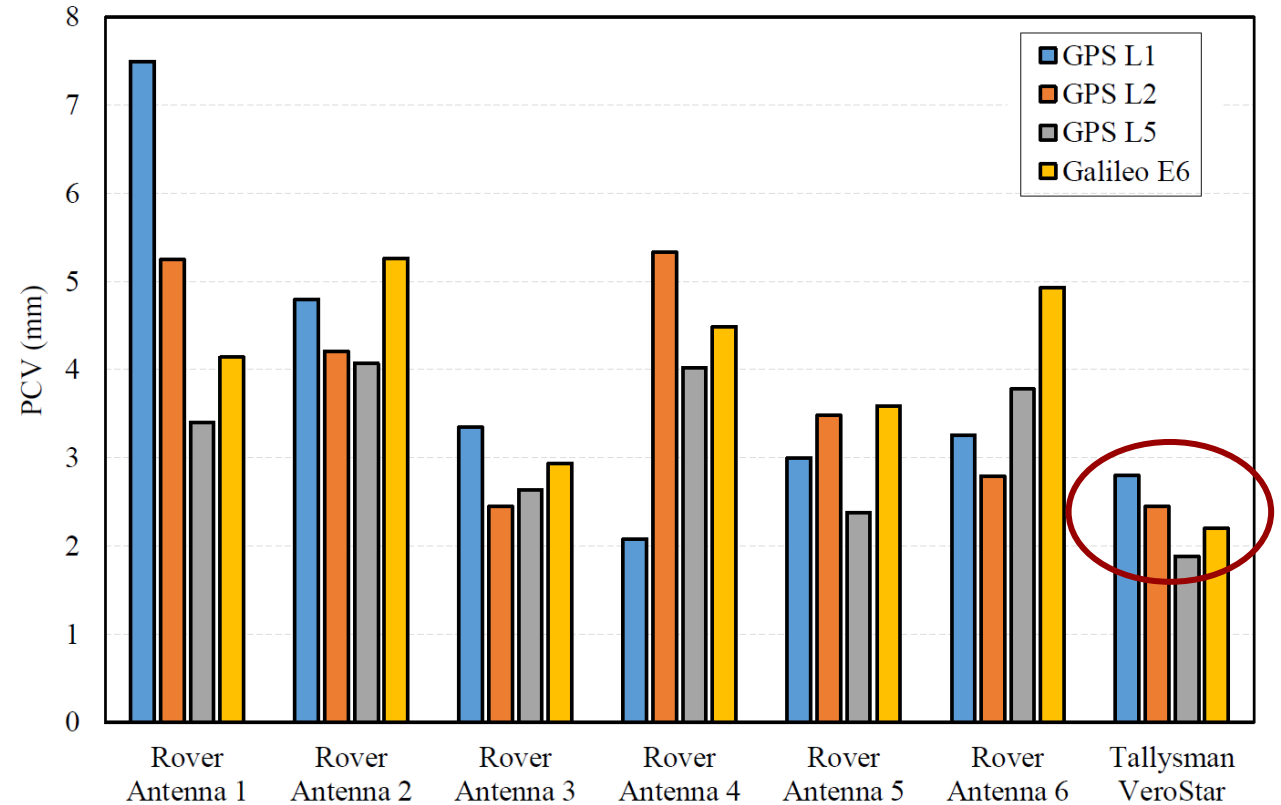
Antenna Axial Ratio

- 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



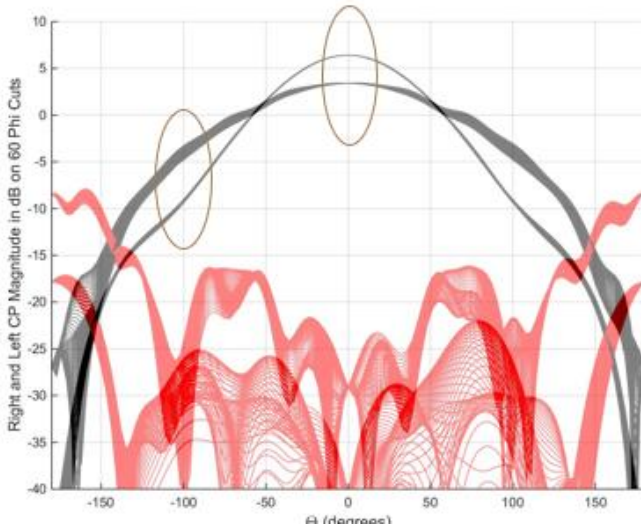
Antenna PCV

- 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

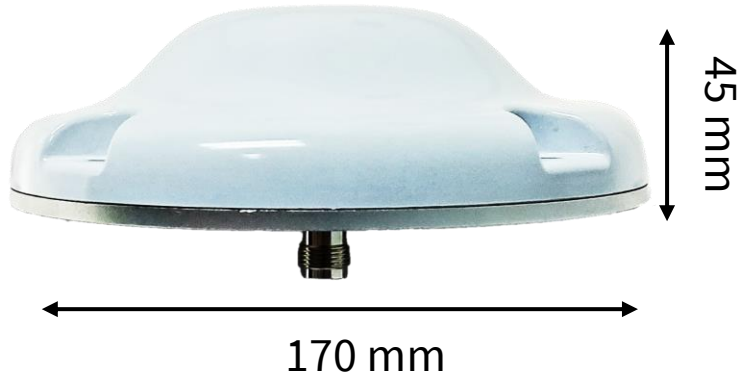


VeroStar

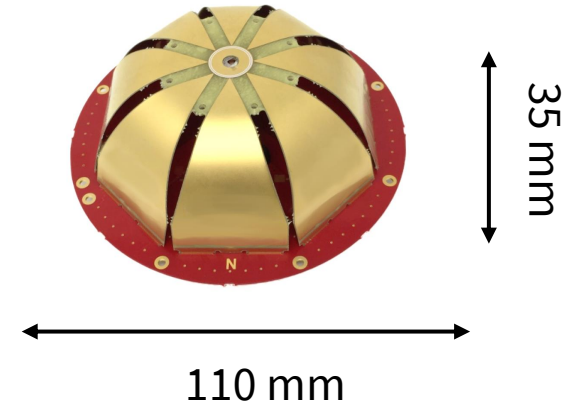
A new family of antennas



500 g
TNC Connector
1" or 5/8" mount



340 g
TNC Connector
4 x M6 Screws



80 g
Flying Lead





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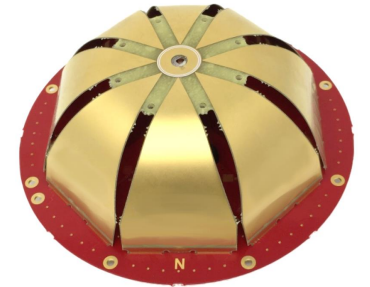
- Conclusion



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 ($\geq 70\%$) for better carrier to noise ratio
- Low axial ratio (3 dB max at horizon) for high multipath rejection
- Tight Phase Center Variation ($\pm 2\text{mm}$) for precise positioning
- LNA: Advanced Filtering with optimised Noise Figure for high G/T
- Light weight and compact



Questions ?

