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# VeroStar: A Novel Full GNSS Band Rover Antenna

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Director of GNSS Product R&D



# Who we are

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

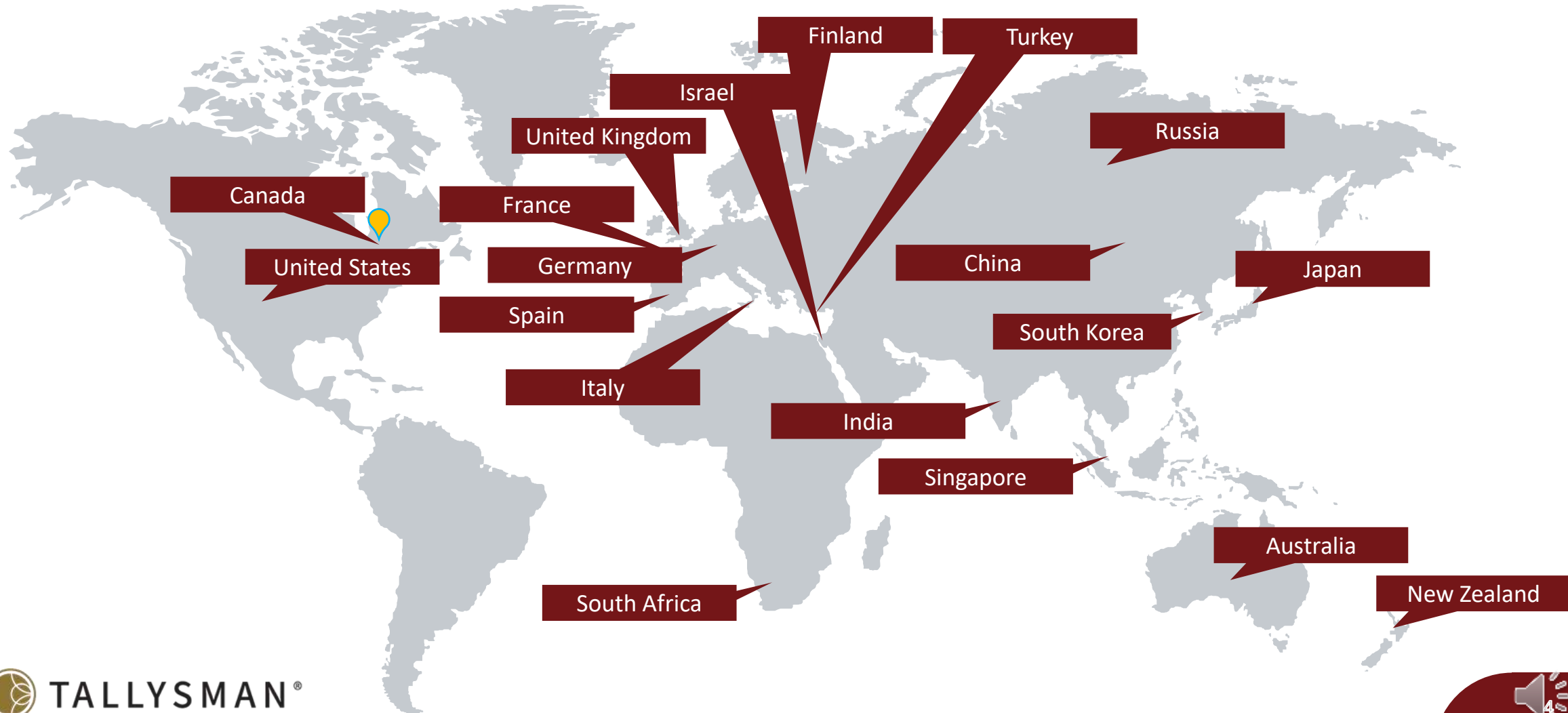


# What we do

- 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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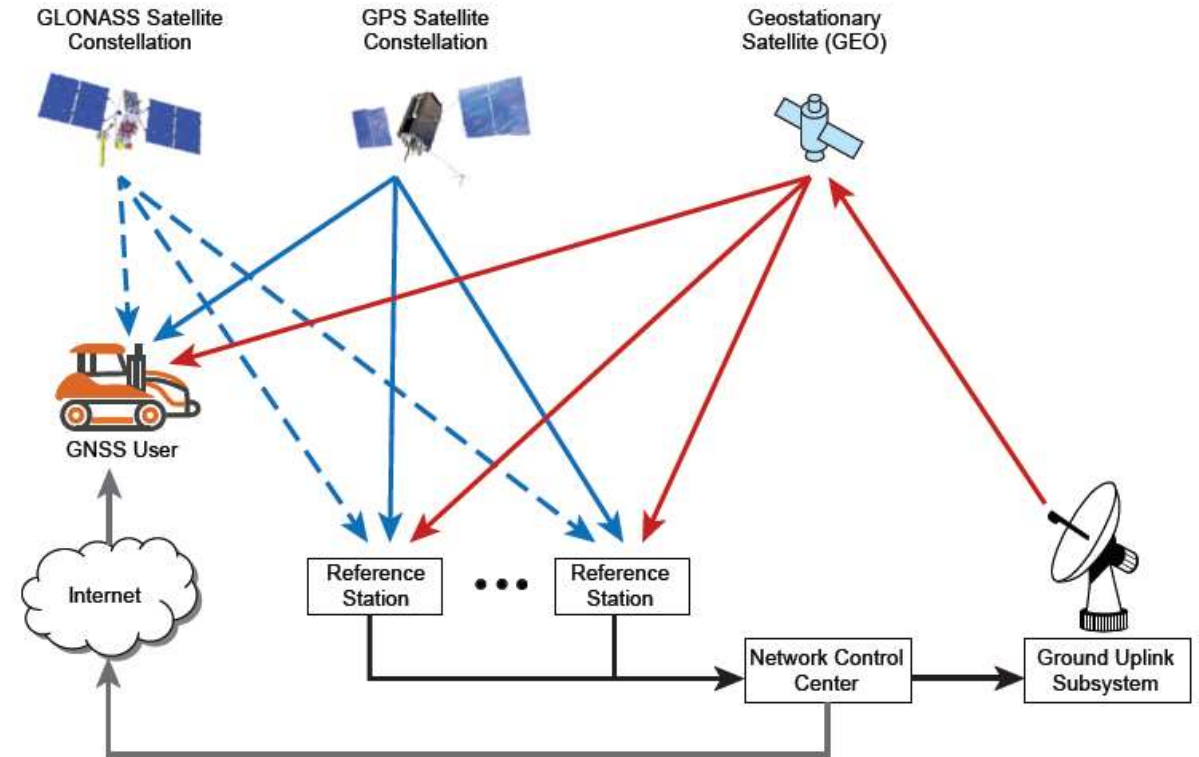
- GNSS Rover antenna requirements



# 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

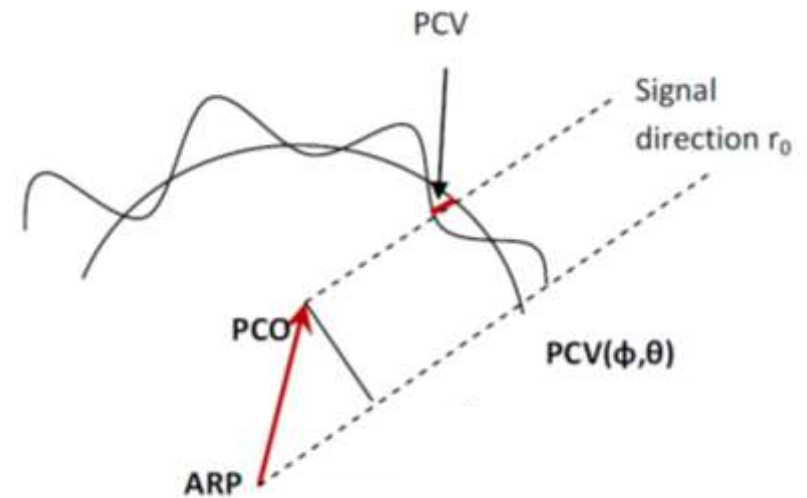
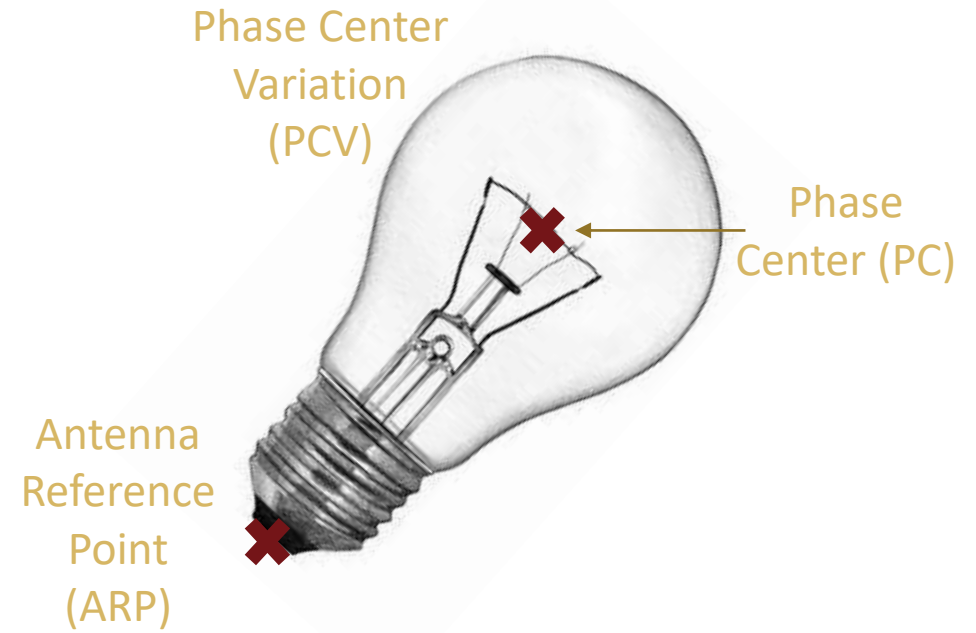


# Antenna requirements

- 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

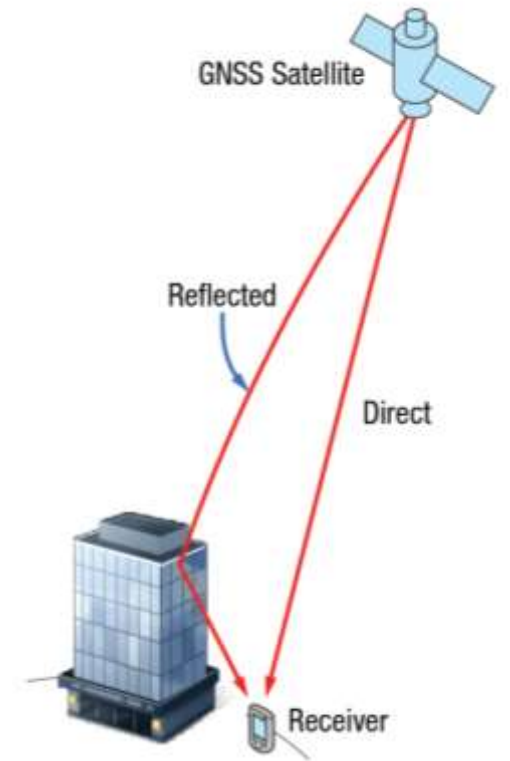
PCV  $\longrightarrow$  phase shift  $\longrightarrow$  tape measure variation

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



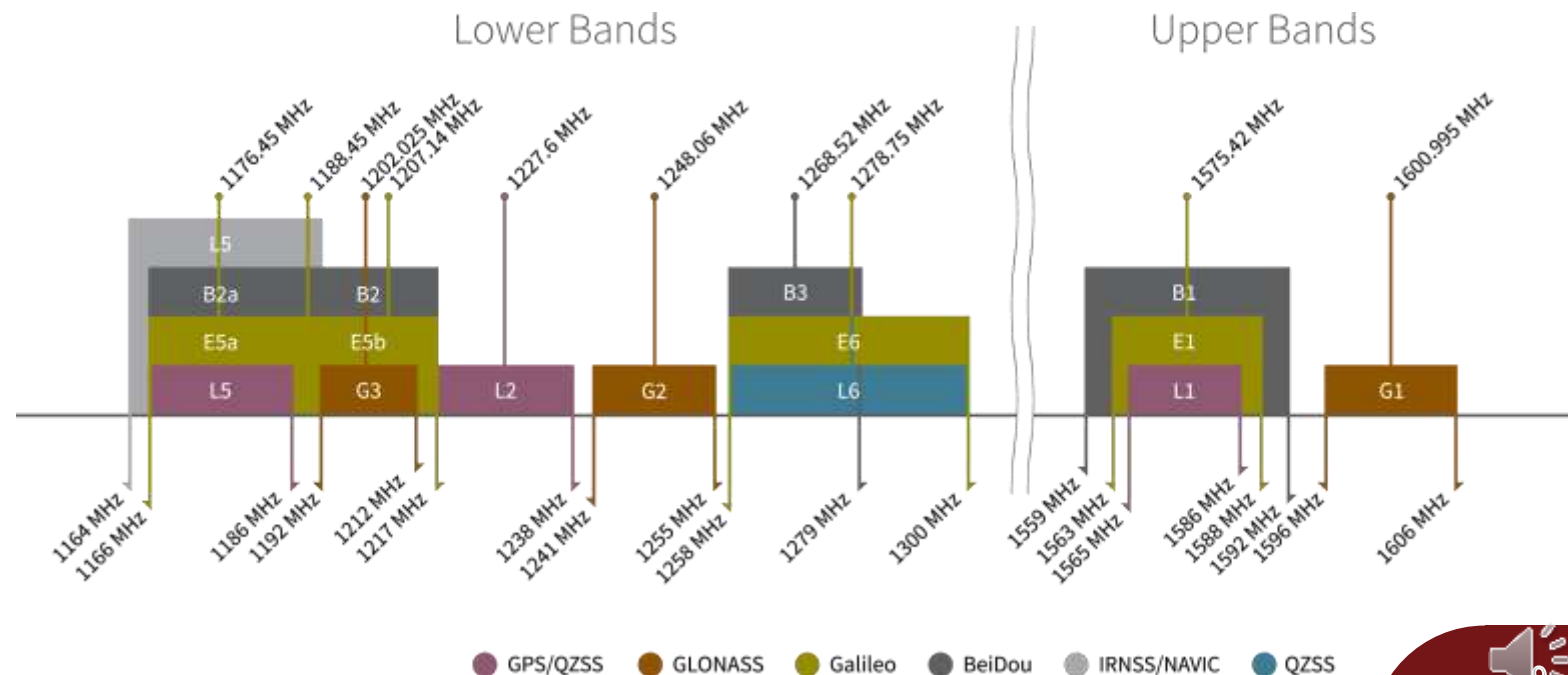
# Antenna requirements

- 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

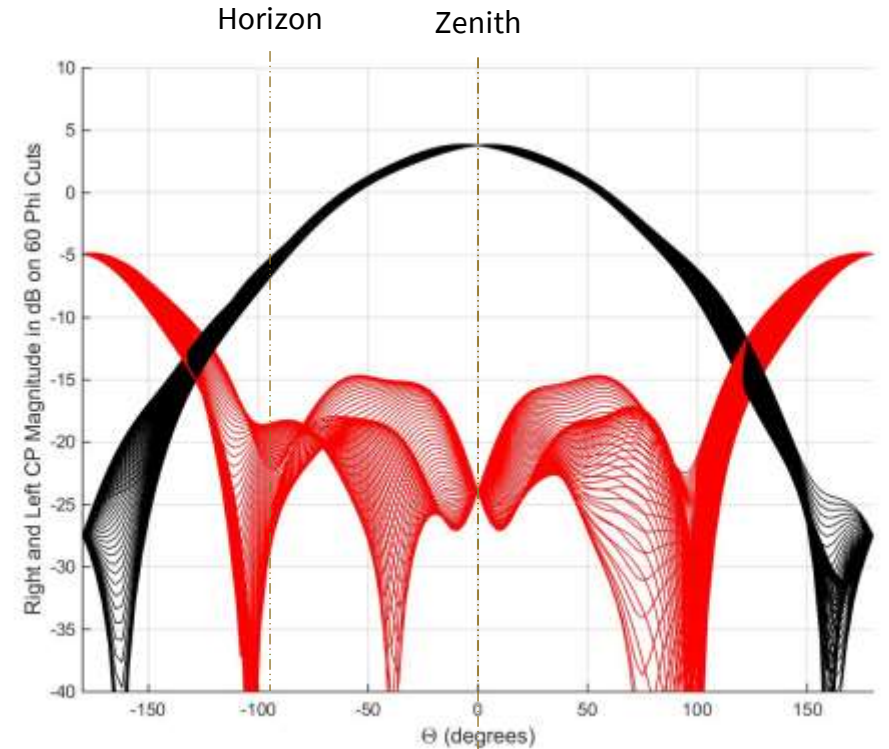
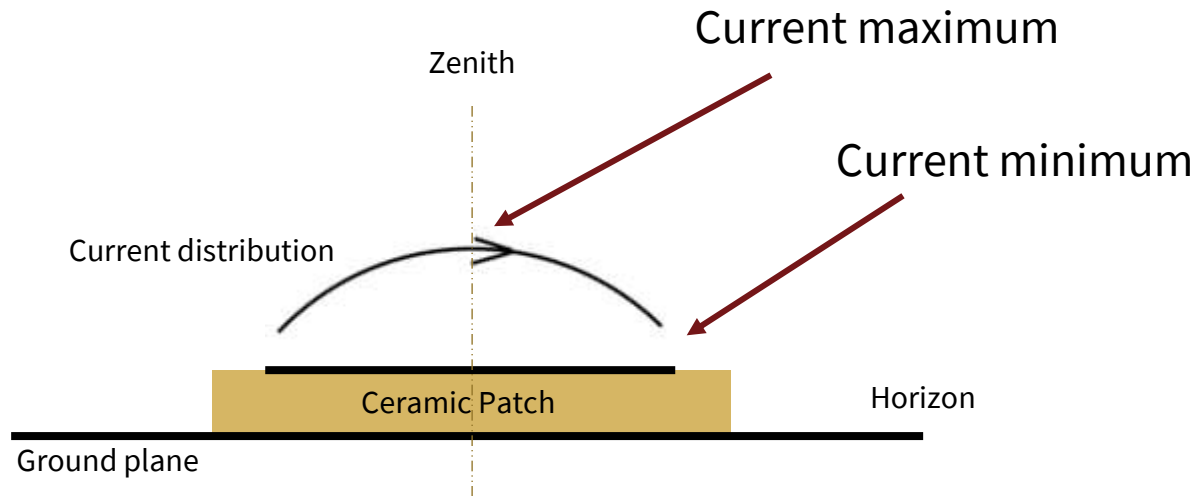
- Typical L1 gain values (dBic):

	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:

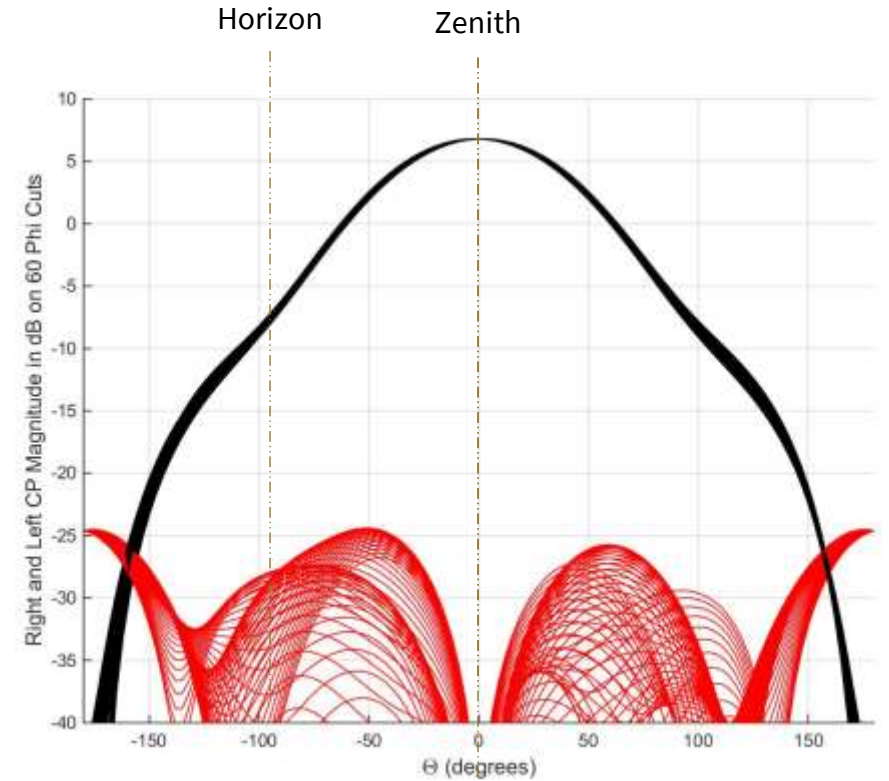
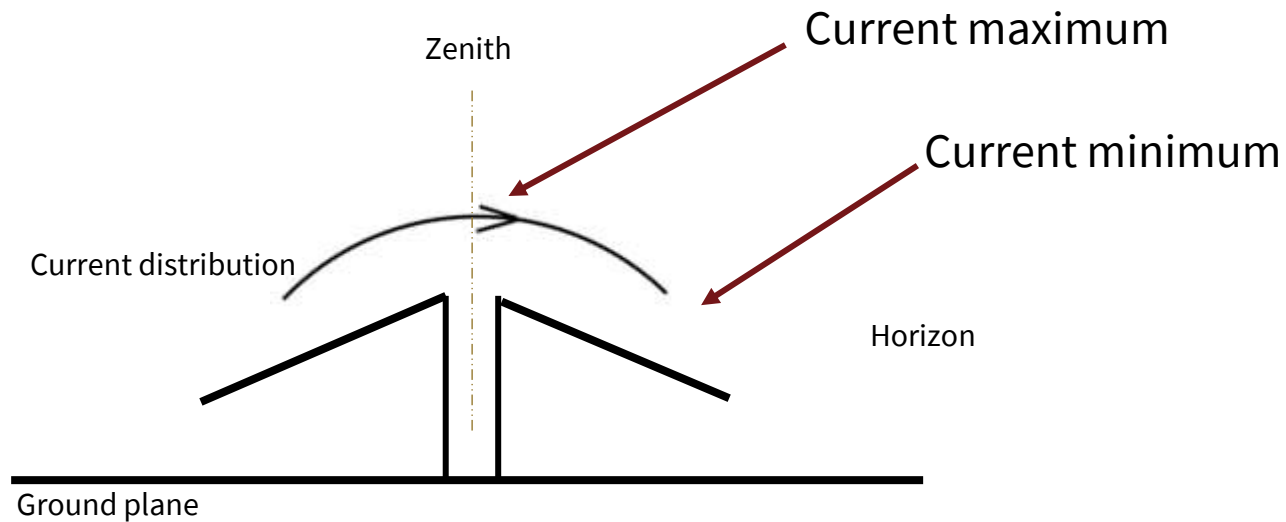


- Current maximum in the middle of the antenna  $\longrightarrow$  High gain at zenith
- Current minimum on the edges of the antenna  $\longrightarrow$  Low gain at horizon
- $\longrightarrow$  10 dB of gain roll-off



# Current distribution

- $\lambda/2$  Dipole based antenna:

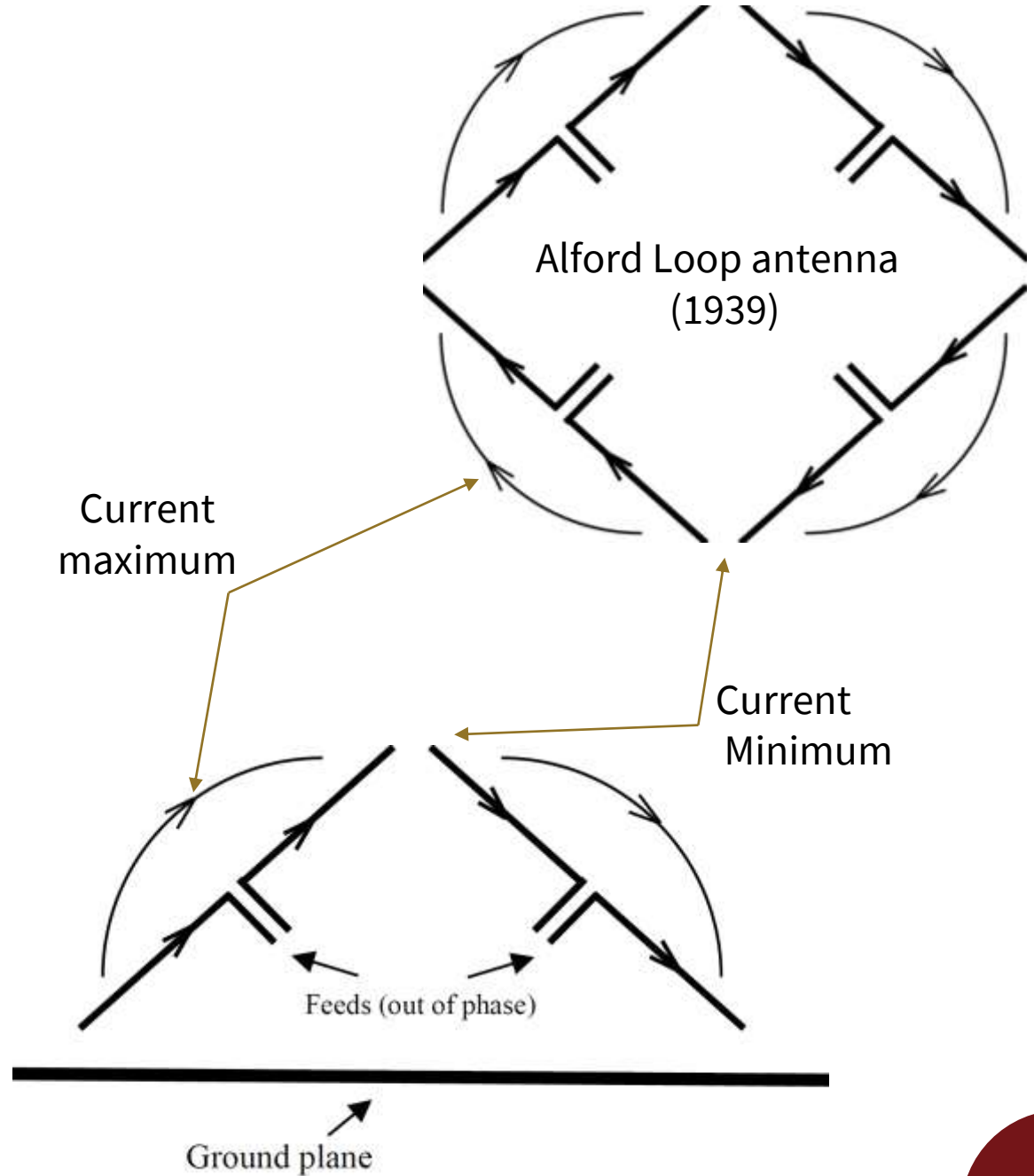


- Current maximum in the middle of the antenna  $\longrightarrow$  High gain at zenith
- Current minimum on the edges of the antenna  $\longrightarrow$  Low gain at horizon
- $\longrightarrow$  Up to 14 dB of gain roll-off



# Antecedents

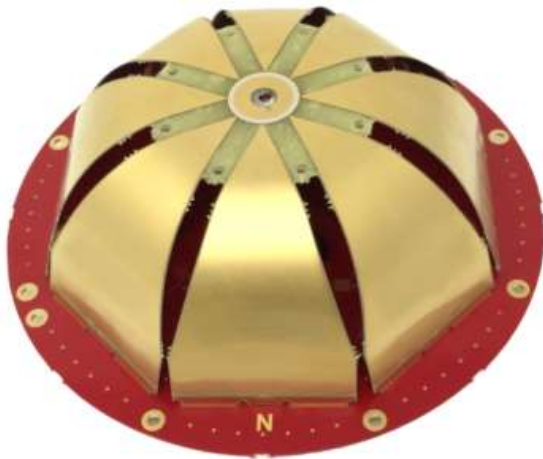
- Dorne & Margolin C146 reference antenna
  - Higher gain at low elevation angles
  - Current maximum offset from the center
  - Complex and costly to build
  - Poor axial ratio and PCV repeatability



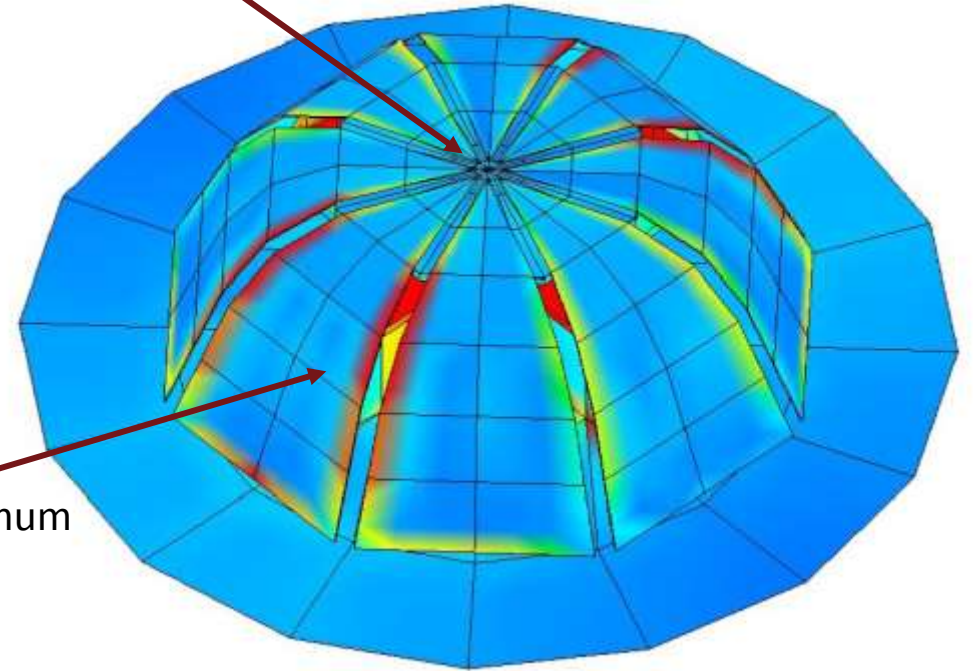
# VeroStar

- 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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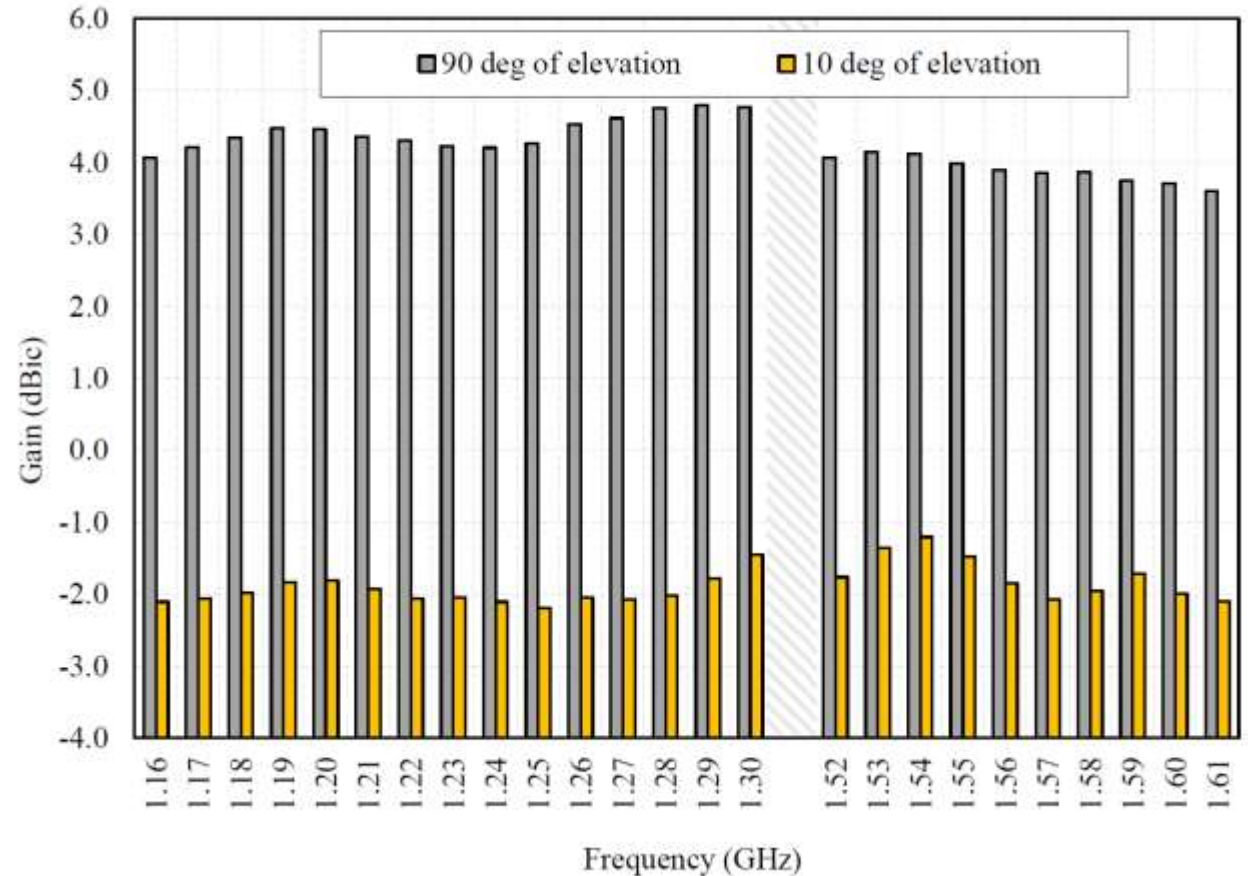
- Measurement results

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



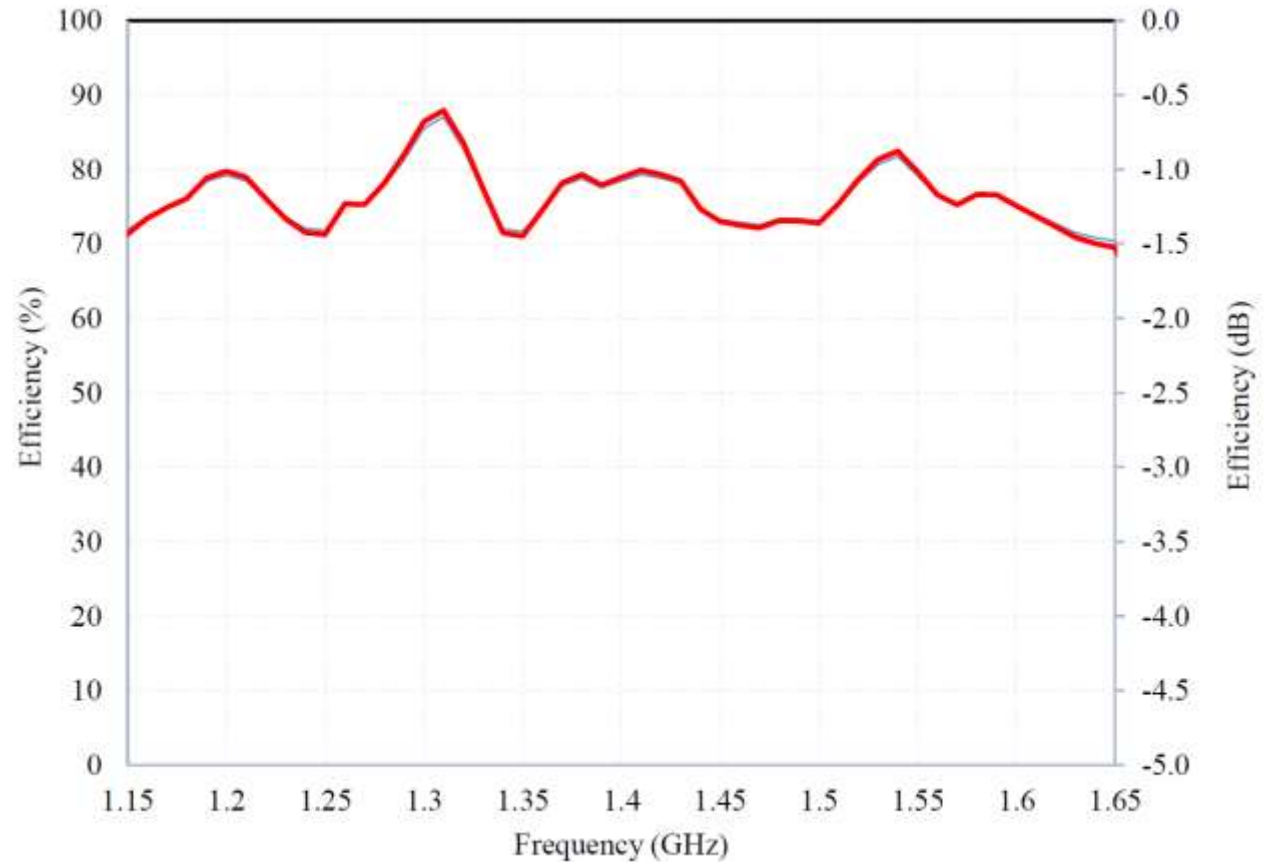
# Antenna Gain

- 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



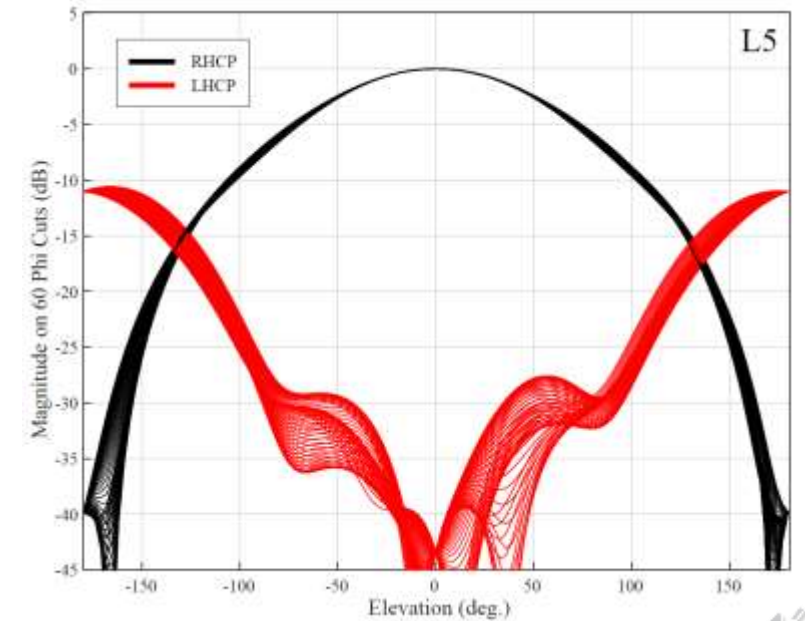
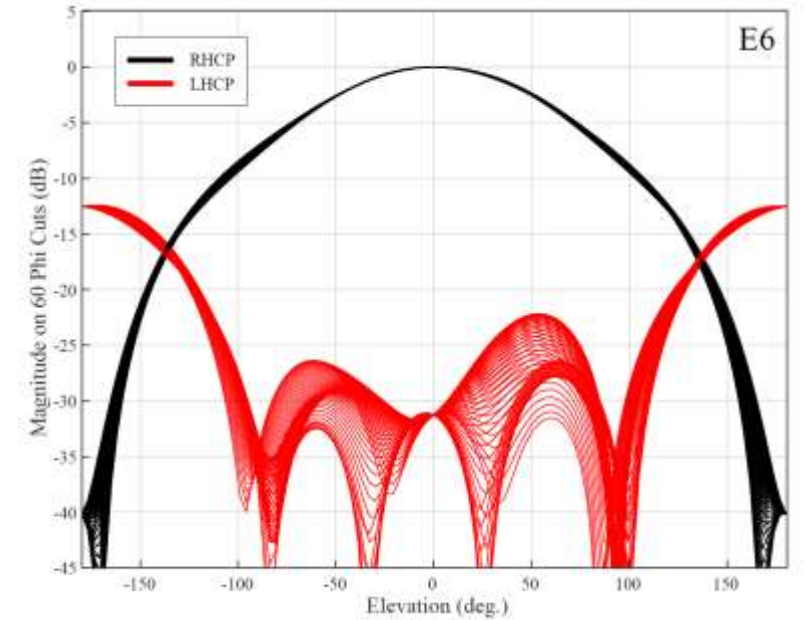
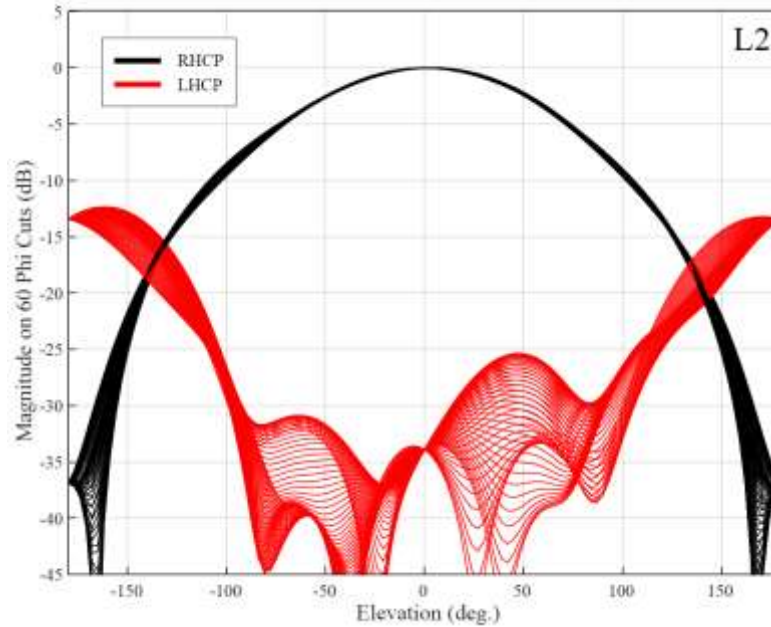
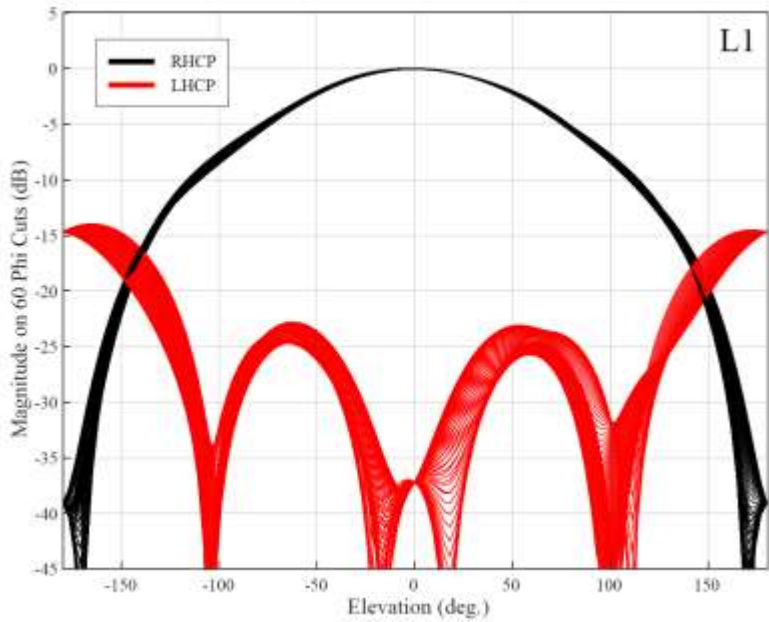
# Antenna Efficiency

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



# Radiation Patterns

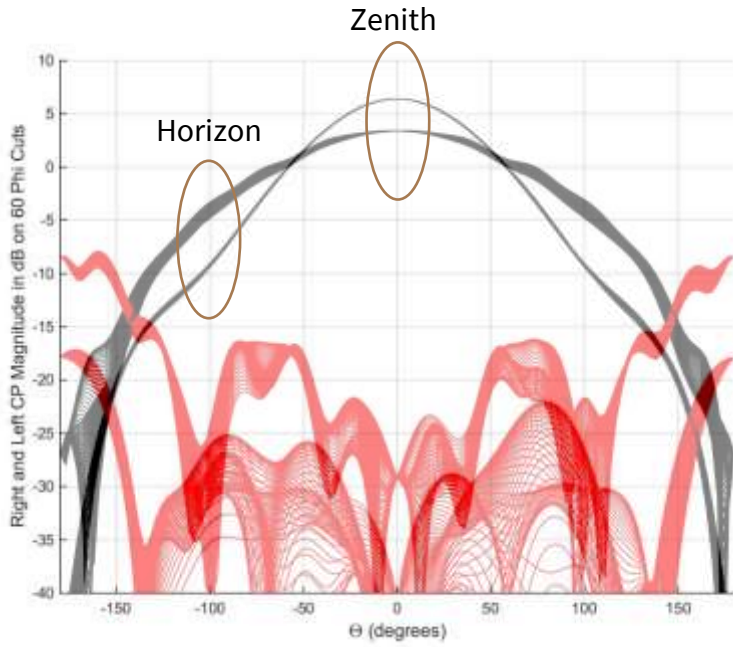
(60 azimuth cuts)



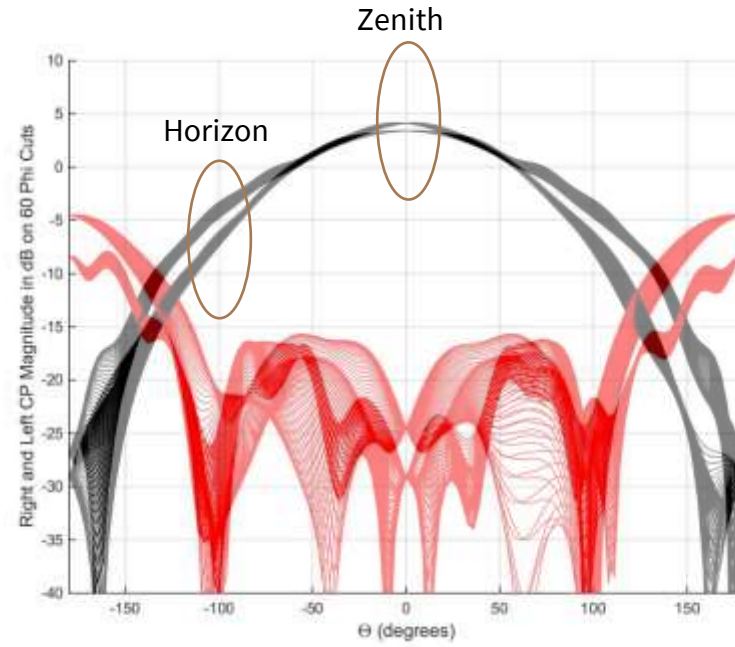
- Homogenous results over the full GNSS spectrum
- Stable RHCP gain vs azimuth  $\longrightarrow$  Minimized PCV
- Low LHCP gain  $\longrightarrow$  Excellent axial ratio



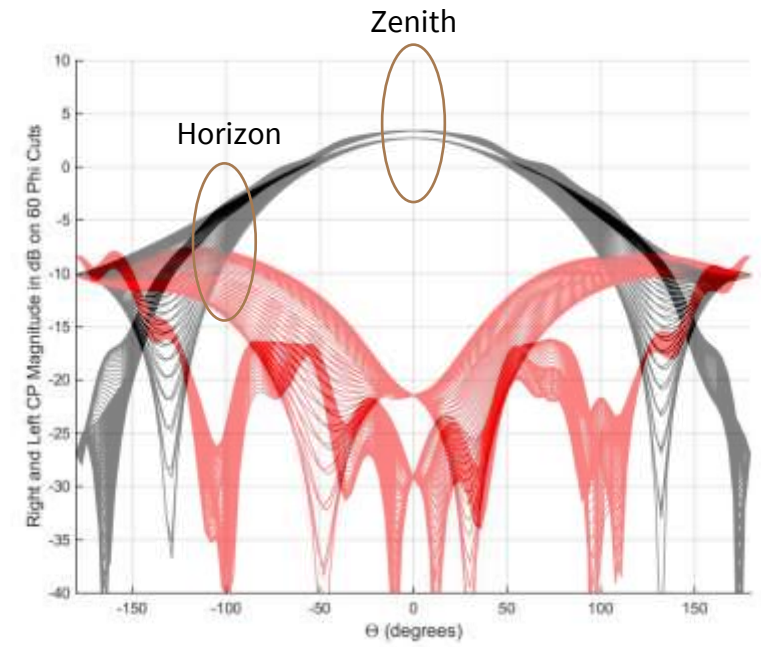
# Gain Roll-off Comparison



VeroStar  
VS  
VeraPhase



VeroStar  
VS  
Patch antenna TW3972

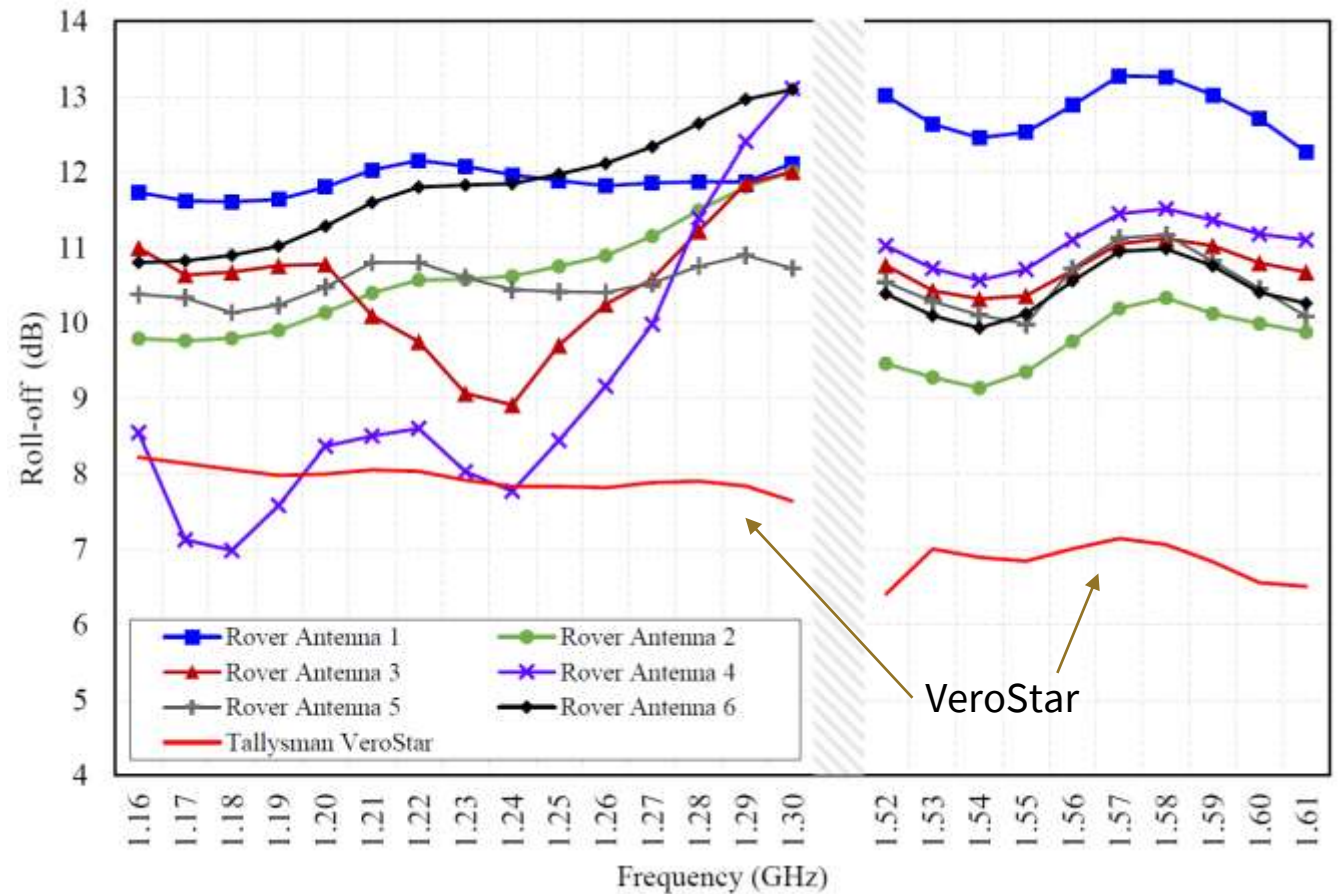


VeroStar  
VS  
Helical antenna HC977



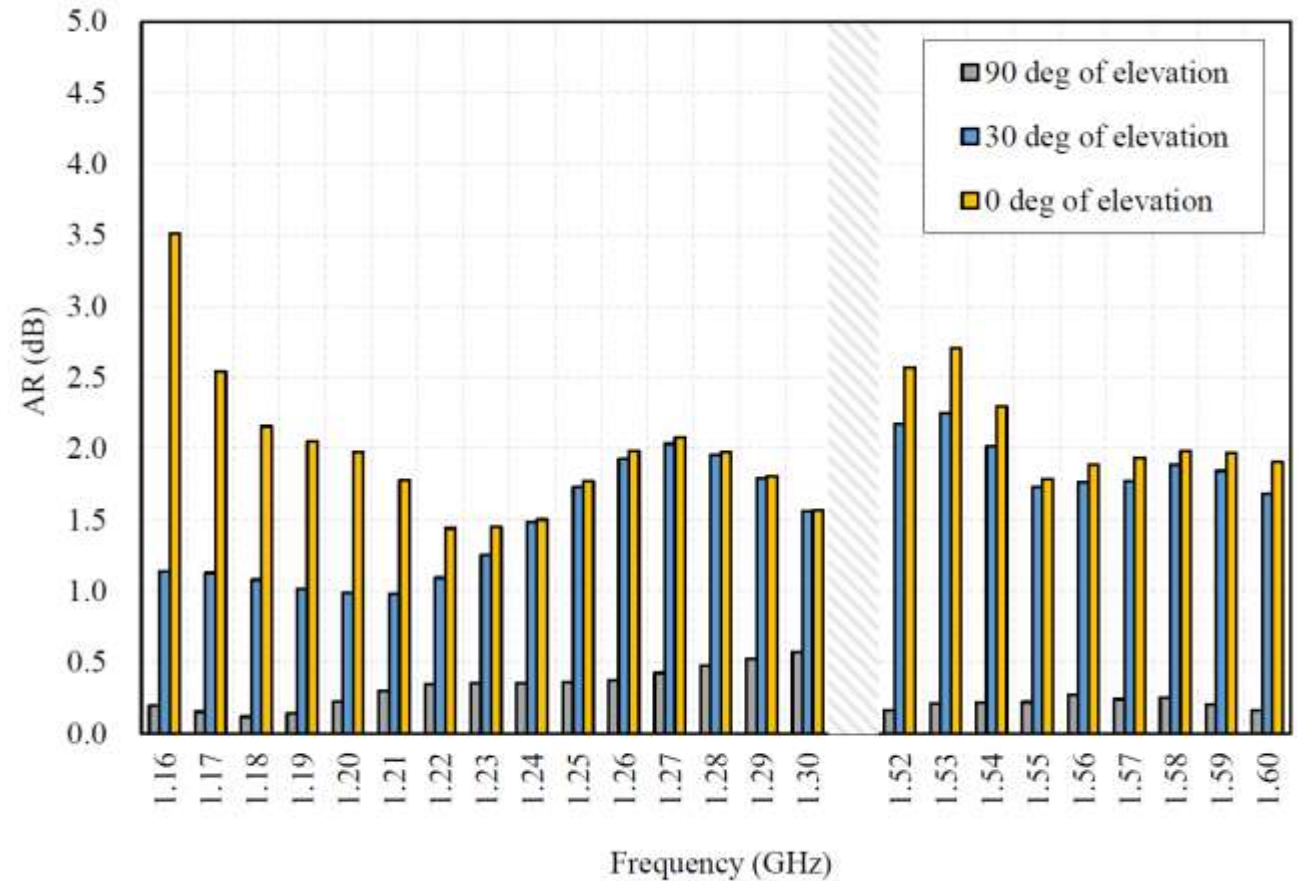
# Antenna Gain Roll-off

- 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:  $\geq -25$  dB/K at 10 deg



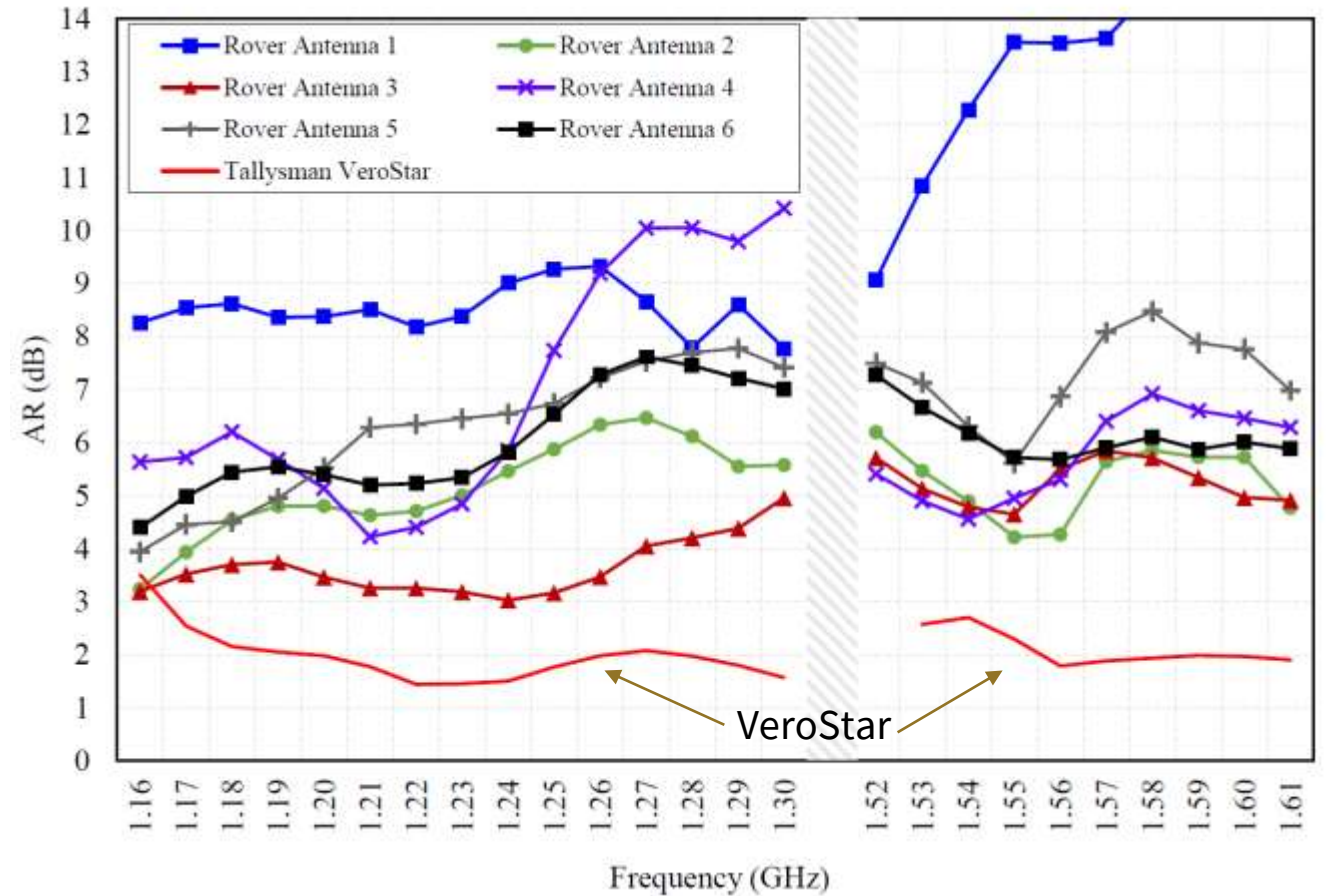
# Antenna Axial Ratio

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



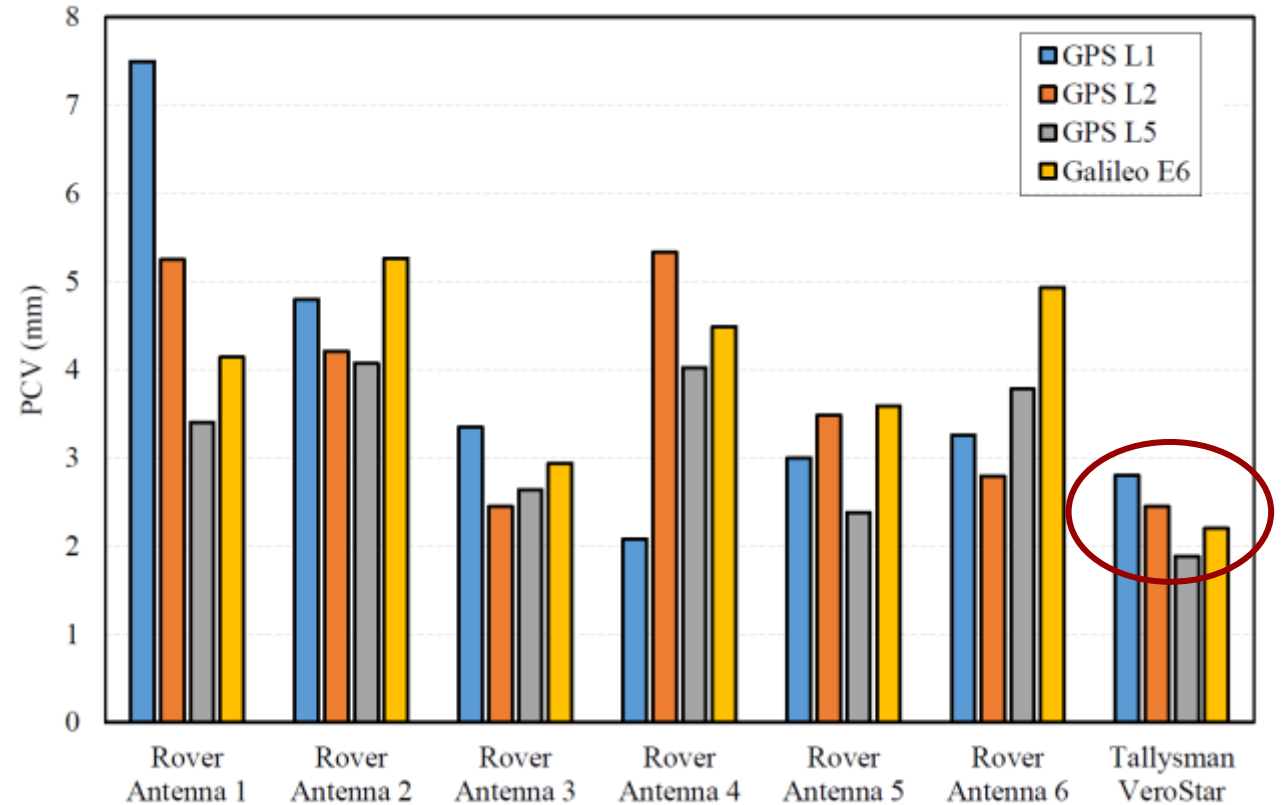
# Antenna Axial Ratio

- 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



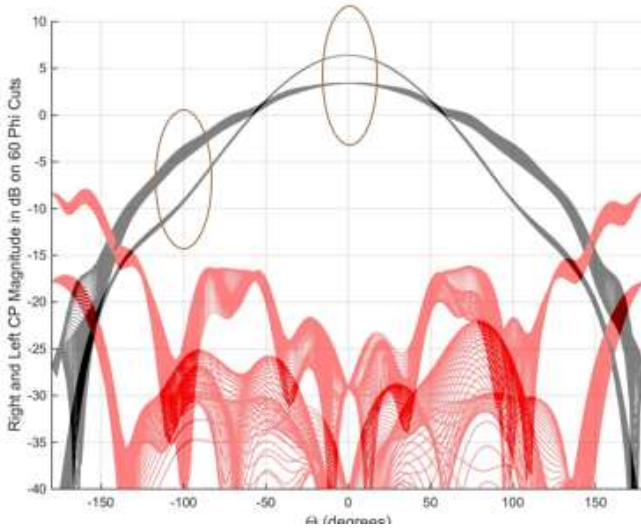
# Antenna PCV

- 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

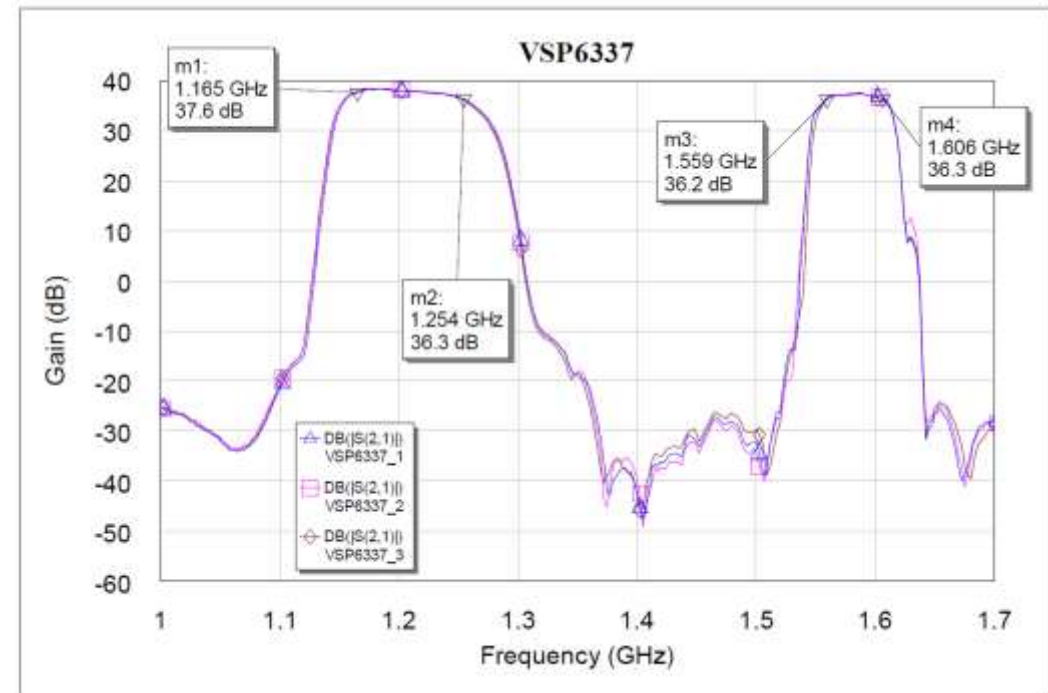
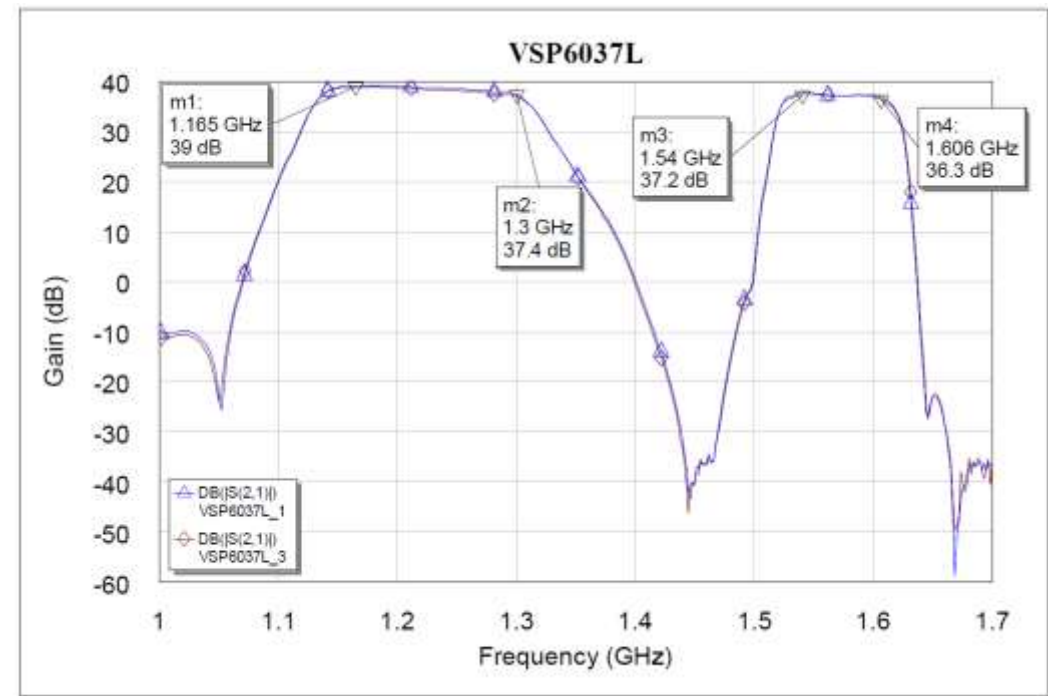
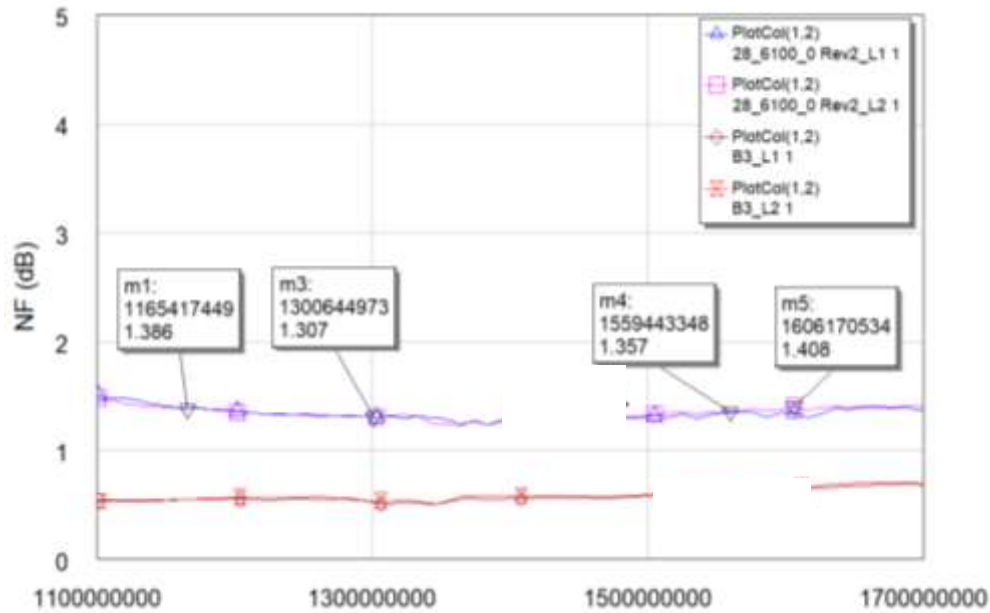


- Better low elevation tracking

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

# LNA and Filtering

- LNA optimisation
  - Lower Noise Figure
  - Filter options





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- Market Snapshot



VeroStar

# A new family of antennas



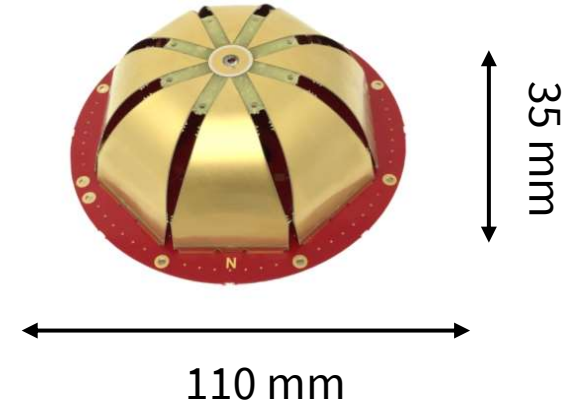
## Pole Mount

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



## Flat Mount

340 g  
TNC Connector  
4 x M6 Screws



## OEM Element

Standard (shown)  
& Mini  
(45% volume  
reduction)

# Market Snapshot

## VeroStar: Premium Performance – Mid-range Price

- 250 Units sold to date
- Advanced discussions to supply a customer with a multi-thousands/year requirement
- RTK and PPP capability important as both interference and accuracy requirements increase
- Mini Super Element designed for arrayed antenna designs. Prototype sales to European customer to evaluate potential
- Mini Super Element also opens up the aviation market via AIRINC enclosures
- Light weight and lower cost opens up the burgeoning drone market with the accuracy required for upcoming “beyond line of sight” operation
- Relationship with European receiver manufacturer to develop a “smart” antenna continues





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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
- High precision and low costs mean significant market potential

