RUAG GNSS Receivers and Antennas

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GNSS Receiver Development

RO

GRAS MetOp A B C

Operational

RO

GPSOS NPOESS

EDU

POD

SWARM

Production Phase
6 units

New Generation:
- Modular
- Compact
- Front end RFASICS
- UART i/f
- Compact antenna

POD

Sentinel-1 A
Sentinel-2 A
Sentinel-3 A

Development Phase
6 units

New Features:
- 1553 i/f
- Dynamic Nav solution
- Choke ring antenna
- S/C multipath analysis

POD

Sentinel-1 B
Sentinel-2 B
Sentinel-3 B

Projected
2:nd generation

RO

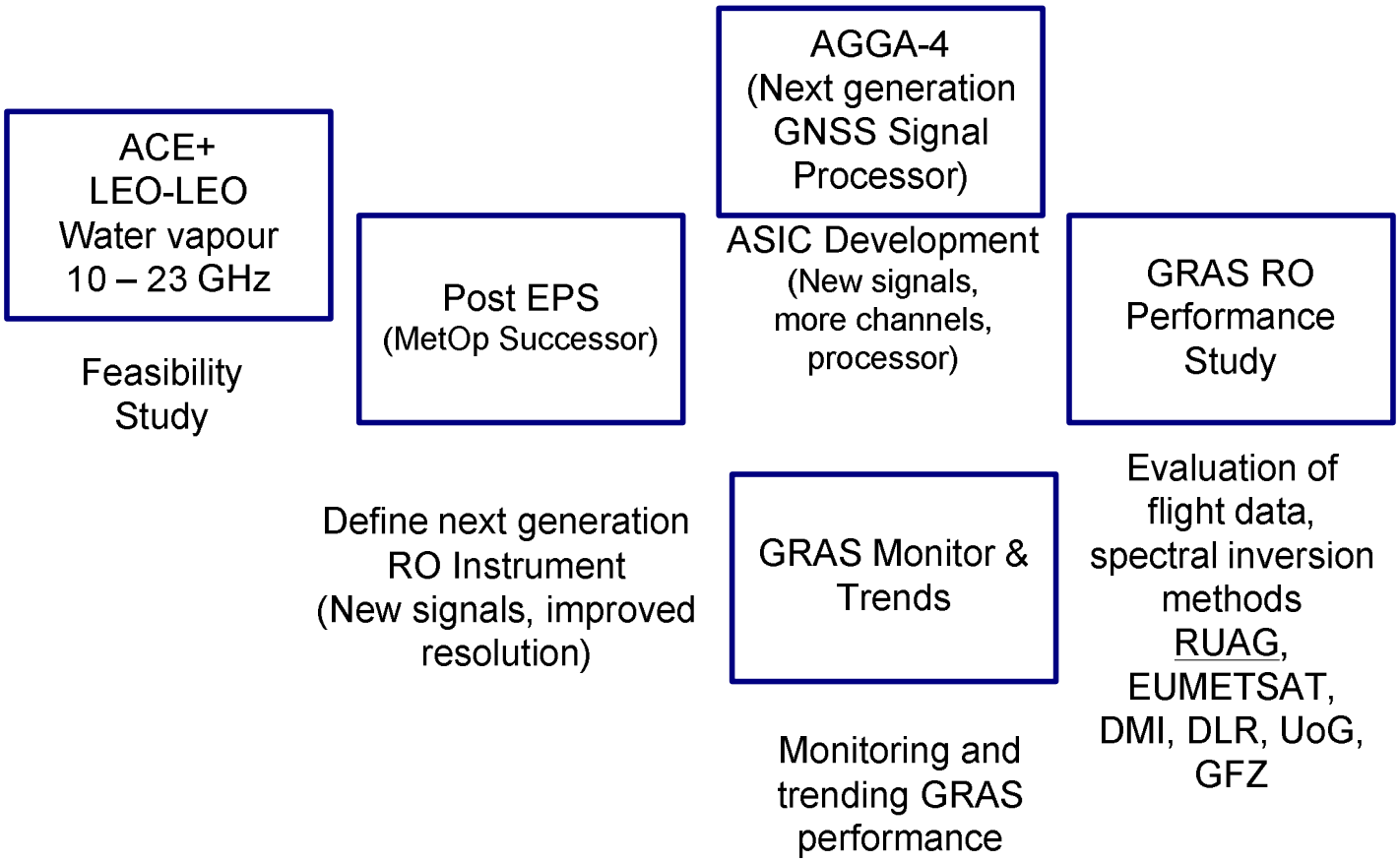
Post EPS

Next Generation

GPS: L1 C/A + L2 Codeless tracking

GPS: L2C +L5
Galileo, Compass

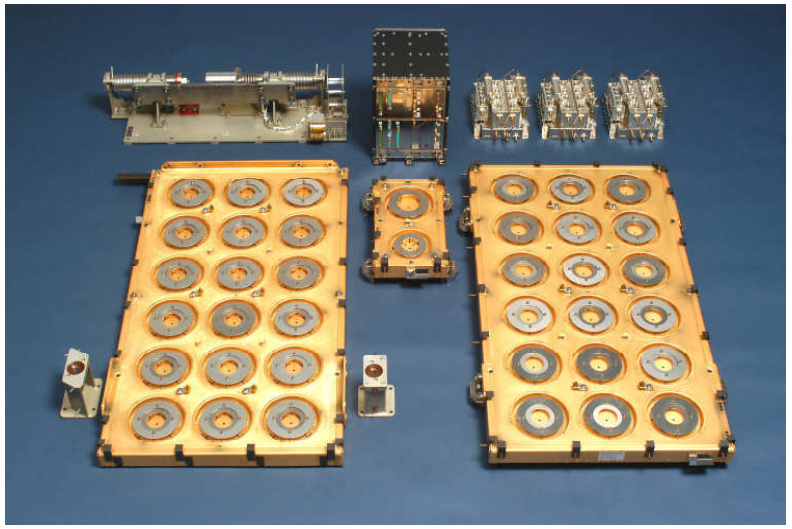
GNSS Related Studies and Developments



GRAS Receiver

Main Characteristics:

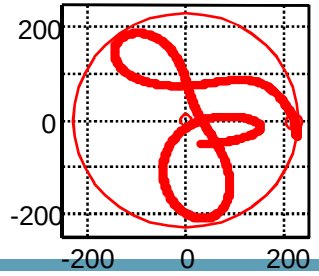
- 650 occultation/day rising and setting
- Ultra Stable oscillator (USO) stab. < 10^{-12}
- Wide coverage high gain antenna
- Excellent RFI rejection
- Closed Loop (CL) sampling 50 Hz
- Open Loop (OL) sampling 1 000 Hz



Measurement Data:

- Code phase, NCO phase and correlator I/Q data are provided for all signals

⇒ High signal bandwidth and enable spectral inversion methods.

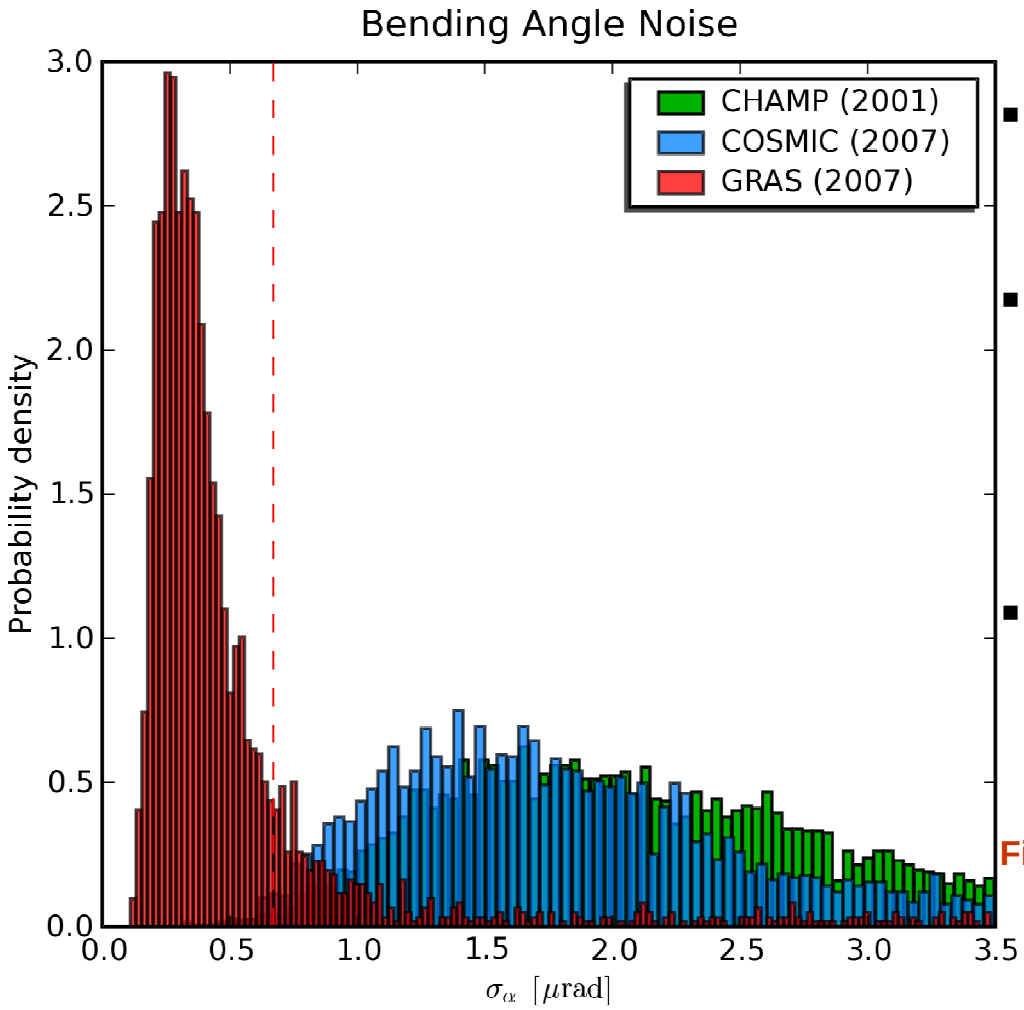


Auxiliary Data:

- L1 and L2 noise for each chain
- Gain and histograms
- Navigation solution
- Navigation data
- Temperature and voltages
- More on command…

=> High Instrument visibility.

Bending Angle Noise



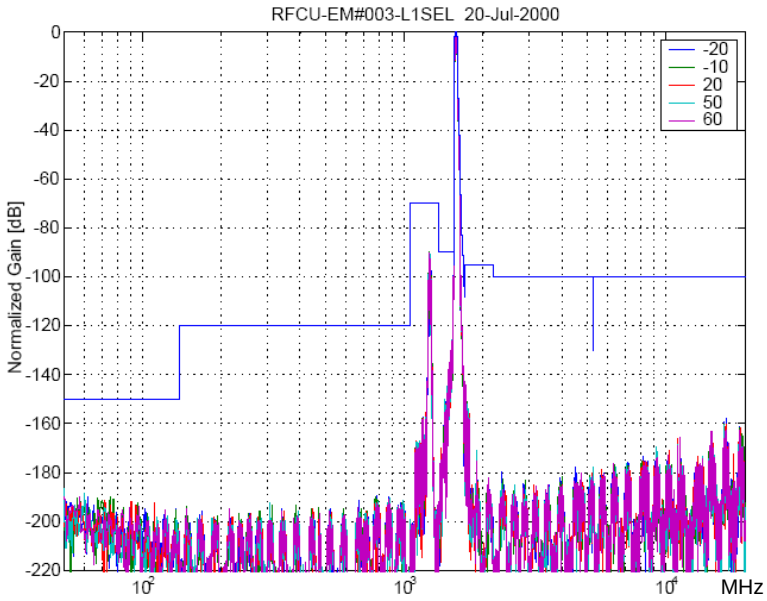
- GRAS Bending Angle requirement: σ < 0.64 µrad 30-80 km
- GRAS has very low measurement noise
  (Antenna gain + USO enabling zero differencing processing)
- All data processed by EUMETSAT, identical settings, noise estimates vs. CIRA / MSIS between 60 and 80 km

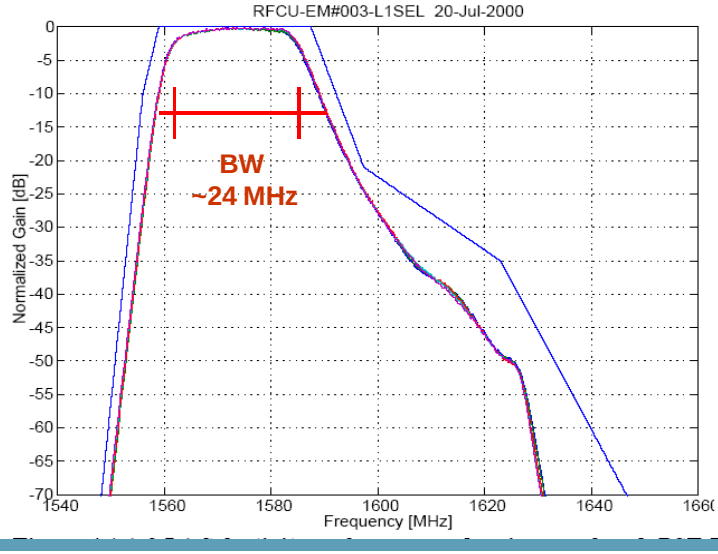
Figure courtesy of Christian Marquardt, EUMETSAT

GRAS Receiver Front End

Characteristics:

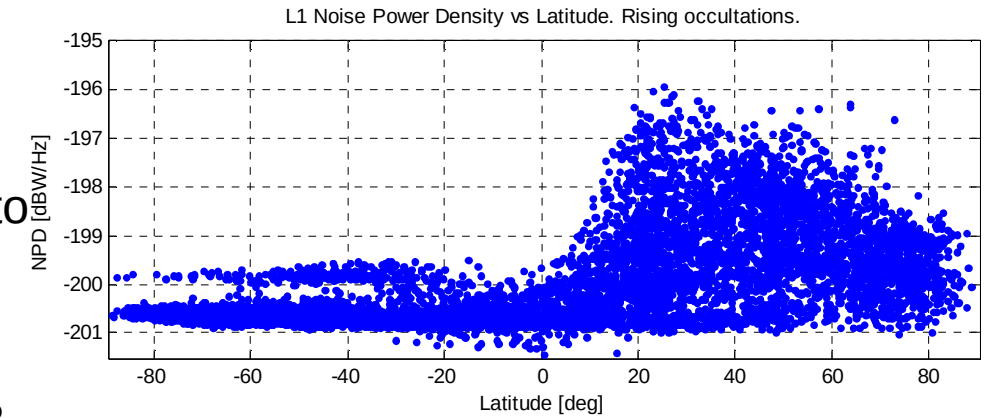
- Comprises preselection cavity filters, LNA, mixer, IF filter
- NF < 1.2 dB
- L1 suppresses S&R Tx, 10 MHz off by 80 dB
- General front end RFI rejection ~180 dB

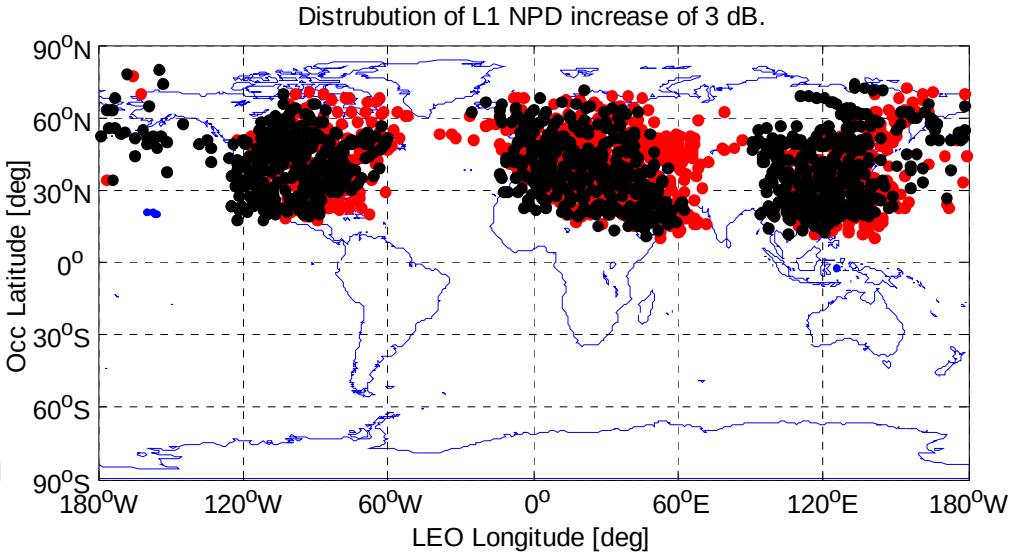




GRAS Noise Measurements

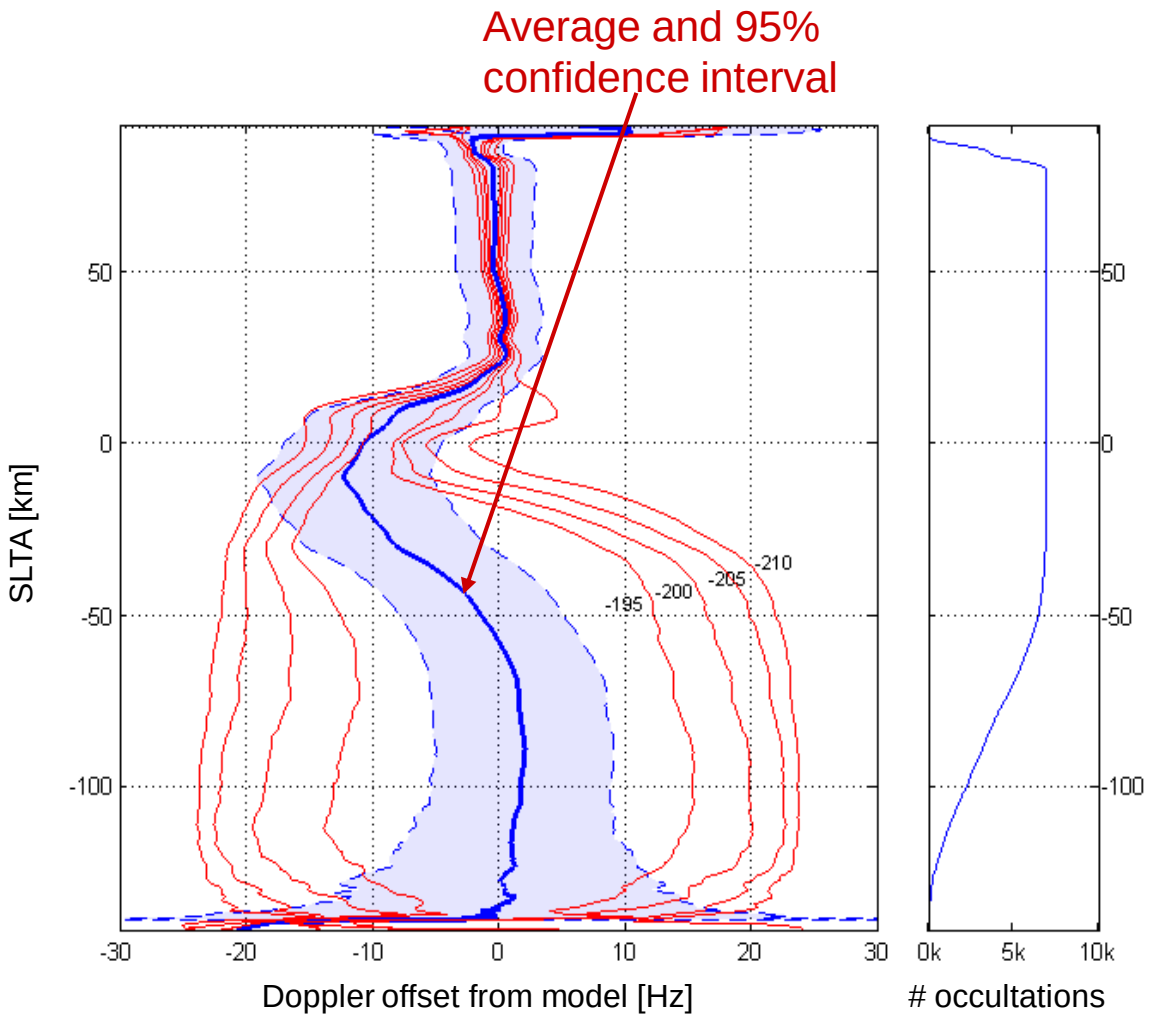
- GRAS low noise floor enables mapping of noise variations over Earth.
- Noise power density, NPD, is up to 6 dB higher in the northern hemisphere.
- The occultations with more than 3 dB higher noise coincide with population centres on earth.
- This in spite of good filtering properties.
- Red and black dots represent rising and setting occultations
- Dots mark centre of antenna beam





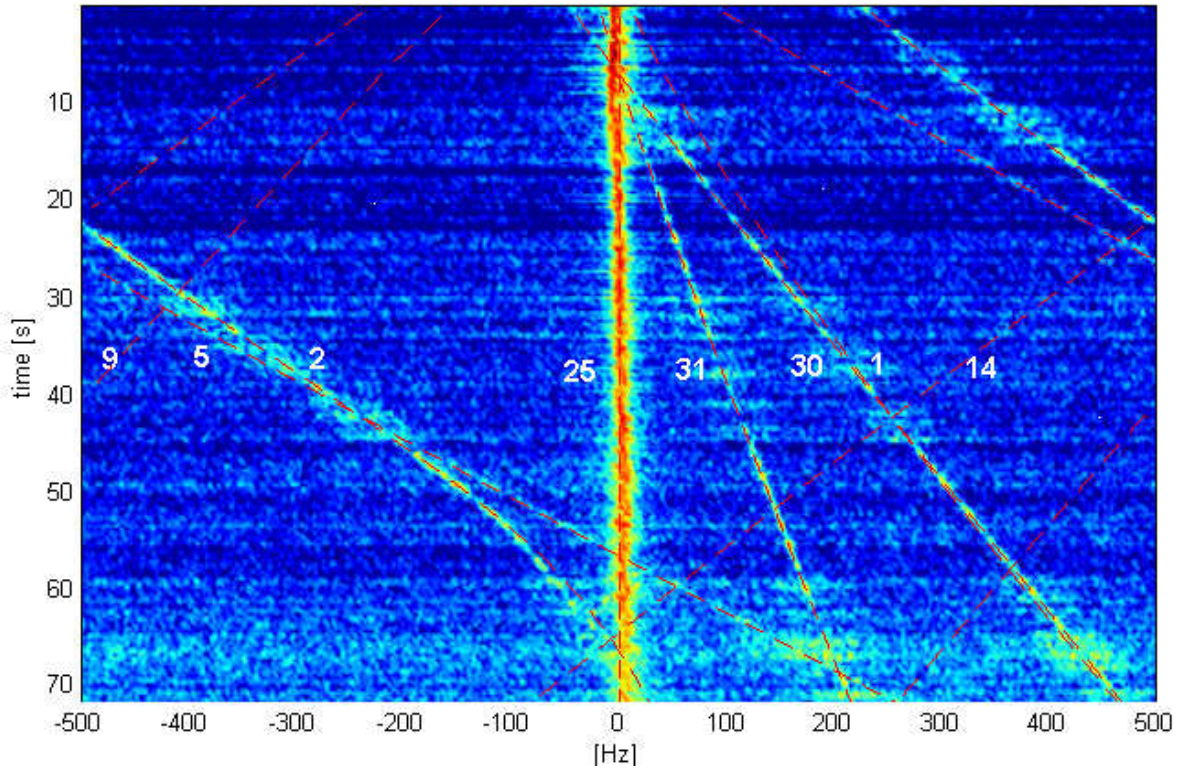
GRAS Doppler Model

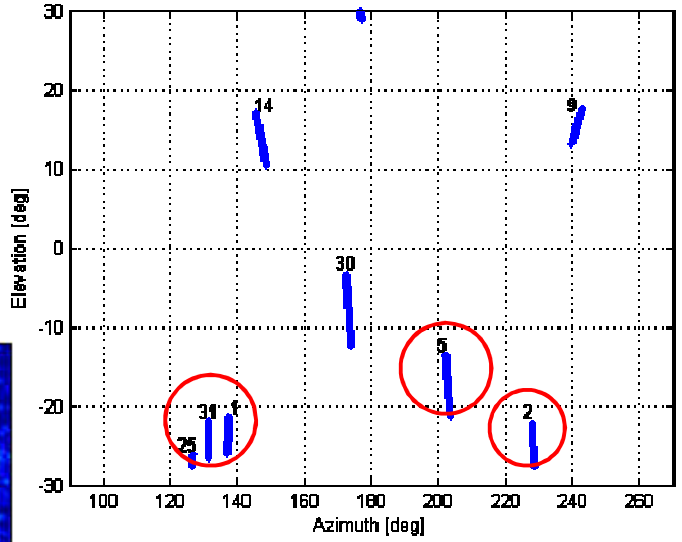
- On board Doppler model is evaluated on live data.
- Offset around -10 km RTH, due to unrealistic dry atm. assumption
- ±25 Hz captures most occultations down to very low PSD levels
- A slight modification of the Doppler model removes the skew.
- OL sampling rate of 100 Hz is sufficient



GRAS OL: 1 000 Hz Capability

- The low noise and high dynamics make traces of Co-Channel SVs visible in the OL data.
- The Doppler offsets can be derived from the GPS almanac (dashed in the figure)

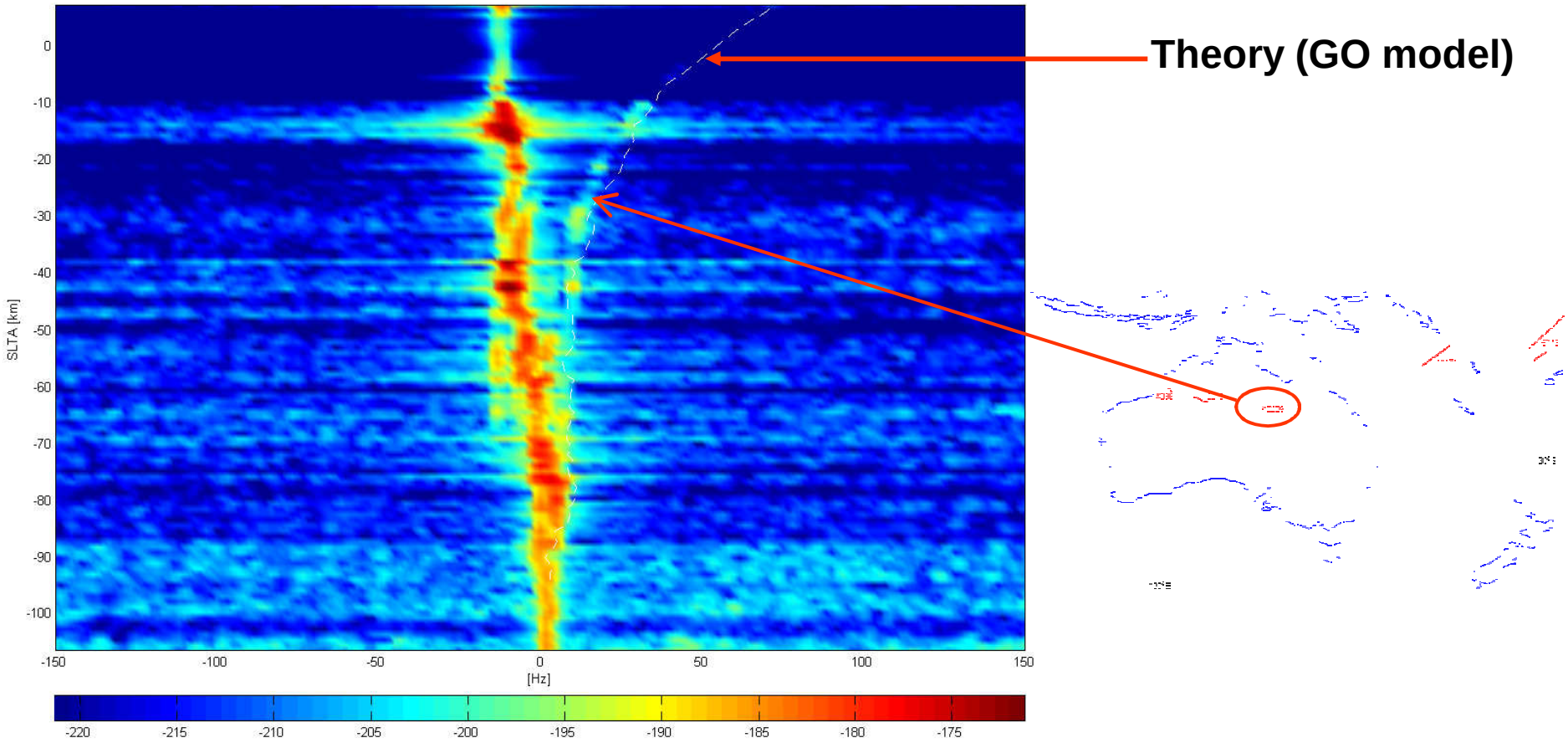




- SVs visible in the antenna beam are seen in the signal FFT
- Suppressed by the code orthogonality (24 – 30 dB)

GRAS OL: Surface Reflections (SR)

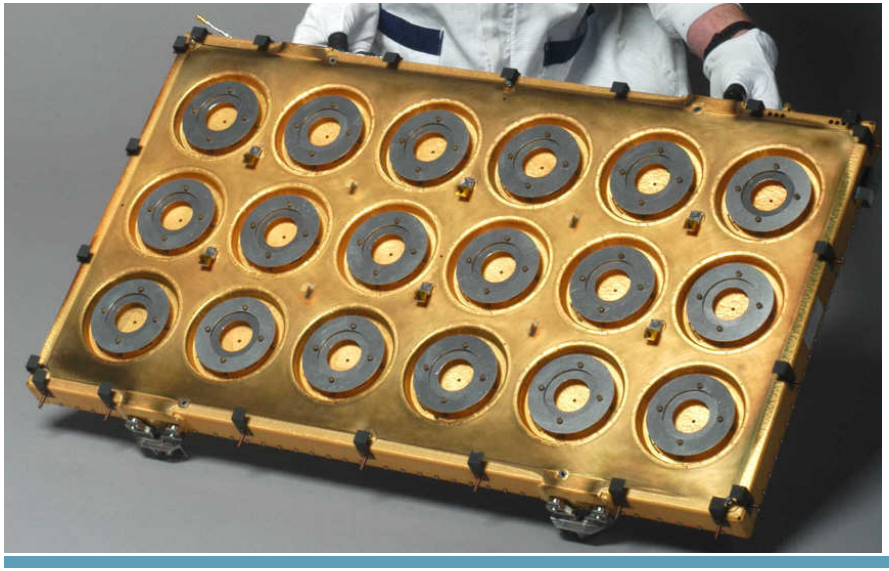
- SR are frequently observed, example of desert reflection from central Australia
- Total reflection at slant incidence due to temperature inversion close to ground?

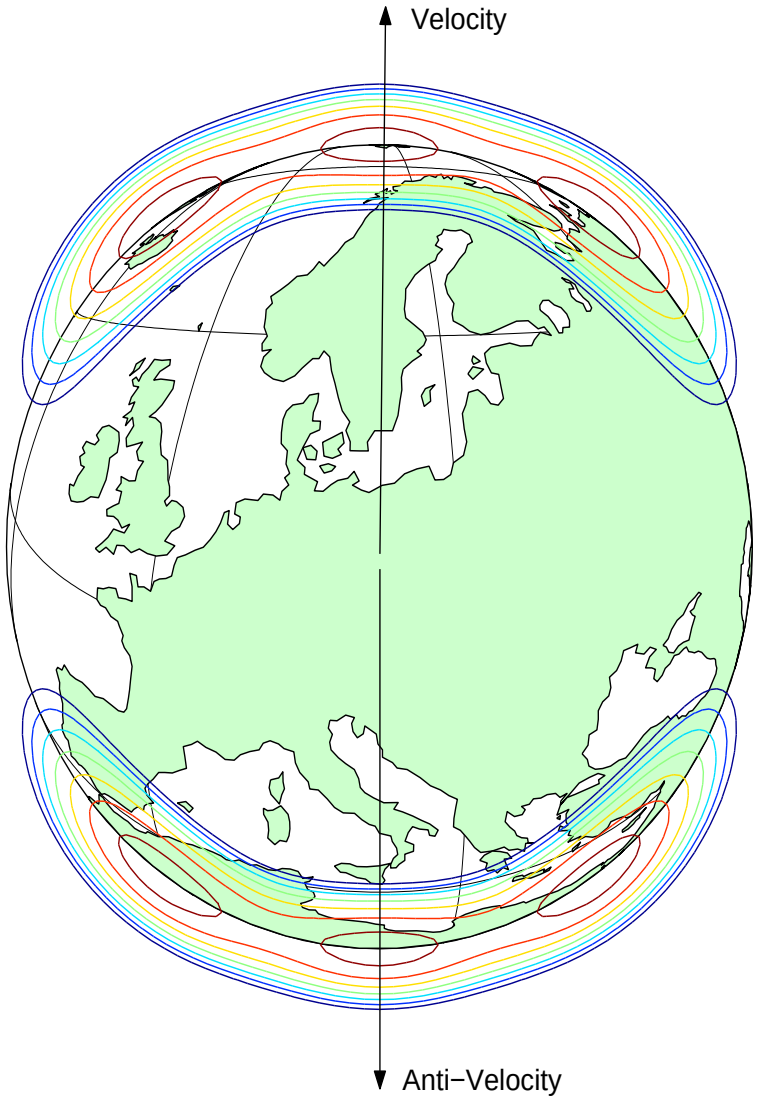


GRAS Occultation Antennas

Characteristics:

- 3 x 6 resonant ring array, shaped beam
- Pattern tailored to earth limb
- Azimuth coverage ±55º
- Gain >10 dBi over full coverage
- Dimension 480 x 870 mm (9’ x 34’)
- Mass 3 kg

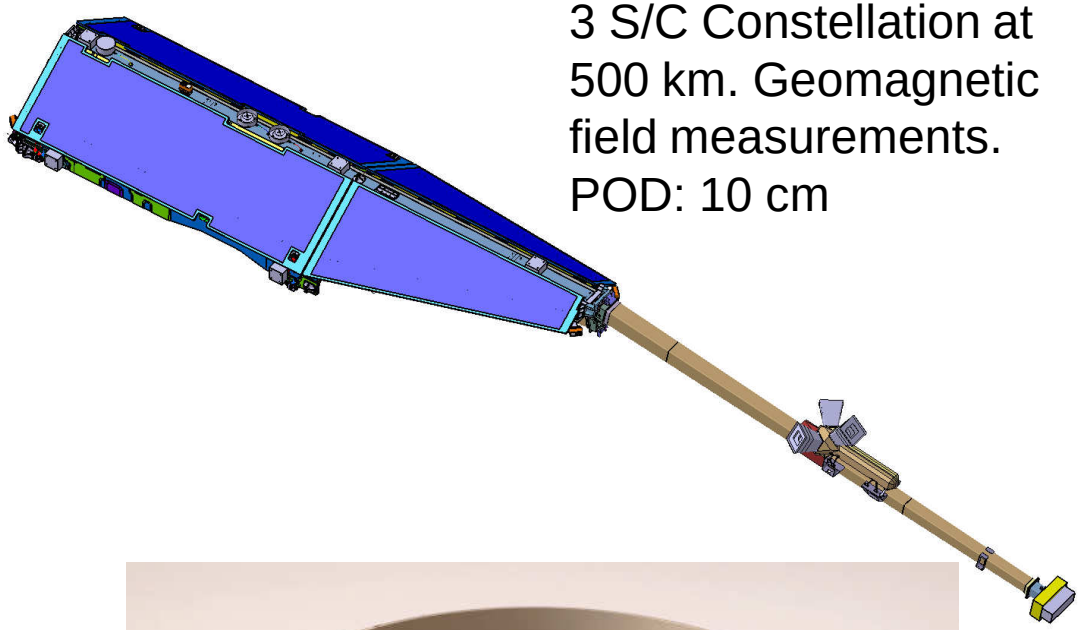




SWARM Antennas

RUAG

3 S/C Constellation at 500 km. Geomagnetic field measurements. POD: 10 cm



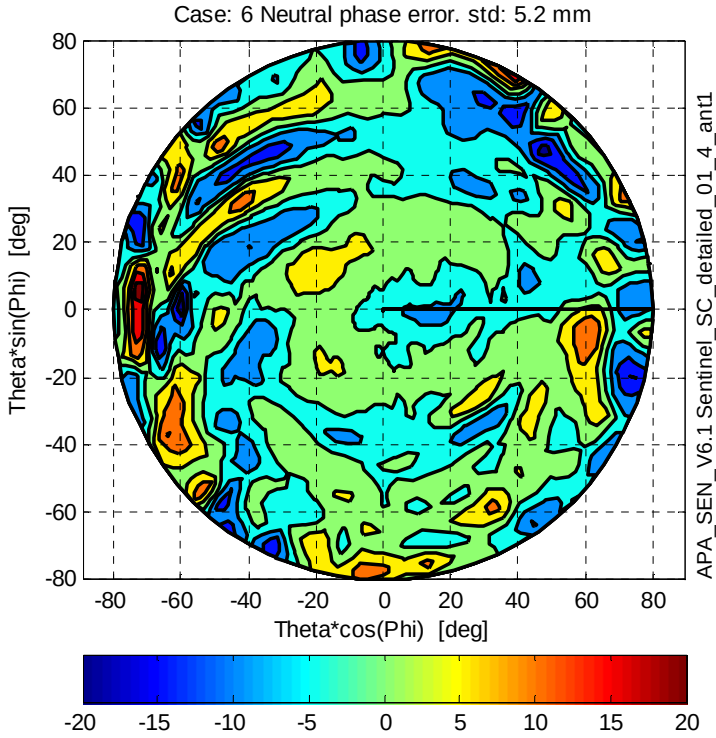
Characteristics:

- Patch excited cup
- High sensitivity, low loss
- Dimension Ø160 x 55 mm (6.3’ x 2.2’)
- Mass 350 g
- Designed to fit SWARM S/C (embedded in Solar Array structure)
- Supported by extensive S/C Multipath analyses and Mock-up measurements
- Suitable as array element

SENTINEL Antennas

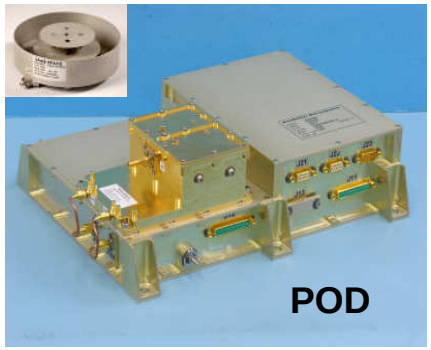
Characteristics:

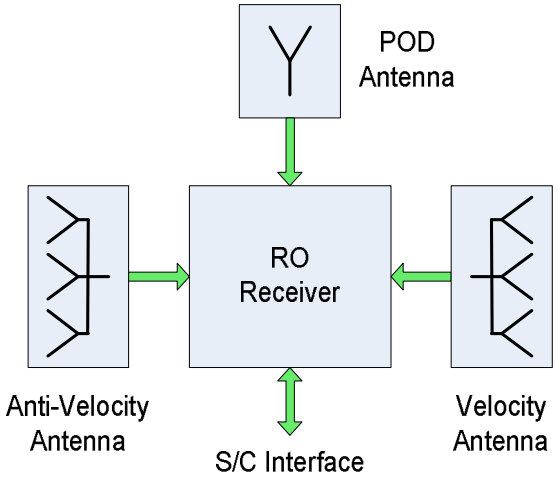
- Patch excited cup with choke rings
- High sensitivity, low loss
- Dimension Ø200 x 87 mm (7.9’ x 3.4’)
- Mass 750 g
- Designed to support cm precision POD
- On farm performance supported by extensive S/C Multipath analyses and mock-up measurements.



Sentinel-3:
Neutral carrier phase variation.
([mm] steps of 5 mm)

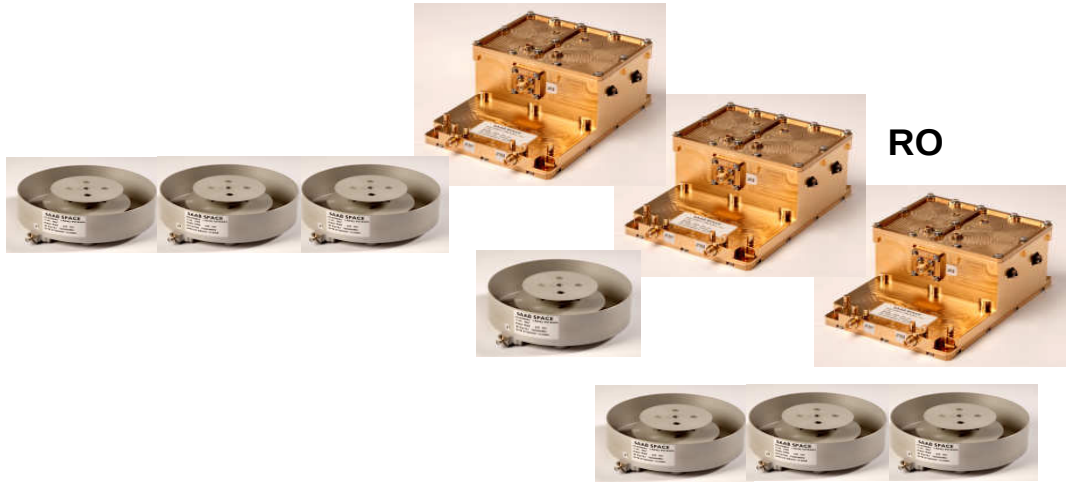
Next Generation RO

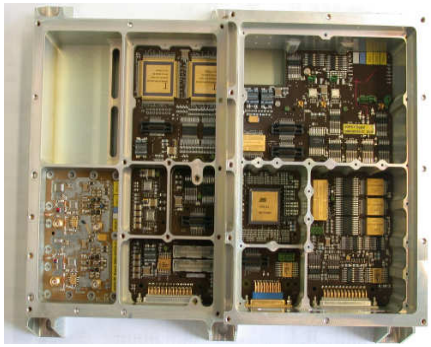




- GPS L1, L2, L5
- GALILEO E1, E5
- COMPASS
- GLONASS CDMA

>2 500 occultations per day





Conclusions

- The GRAS MetOp is providing excellent results.
- RUAG has developed a next generation instrument for SWARM targeting POD application.
- A further development is being made for Sentinel.
- The POD instrument is modular and is well suited also as a RO instrument.
- RUAG has developed a family of RO and POD antennas with the capability to perform accurate multipath analysis and mock-up measurements.