The RO Instrument for MetOp-SG
Engineering Model Test Results

Anders Carlström, Joel Rasch, Jacob Christensen, Thomas Liljegren

RUAG Space, Göteborg, Sweden

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Introduction

- Instrument overview
- Main characteristics
- Open Loop Tracking using 10 Correlators
- RO Engineering Model Results
  - Antennas, LNAs, Receiver Modules
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- Conclusion

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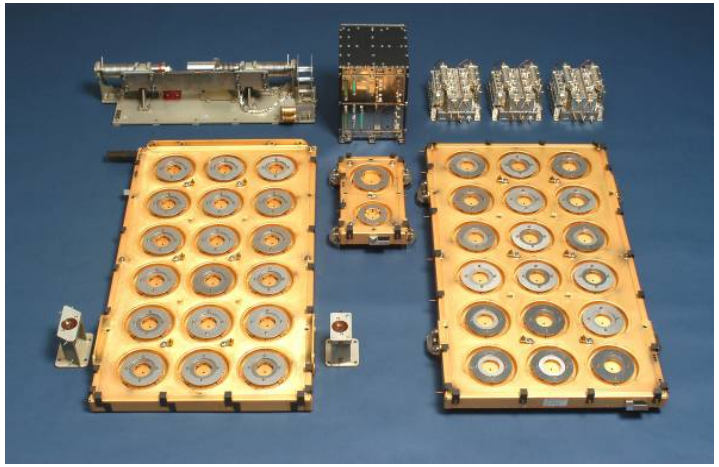
Two Instrument Generations

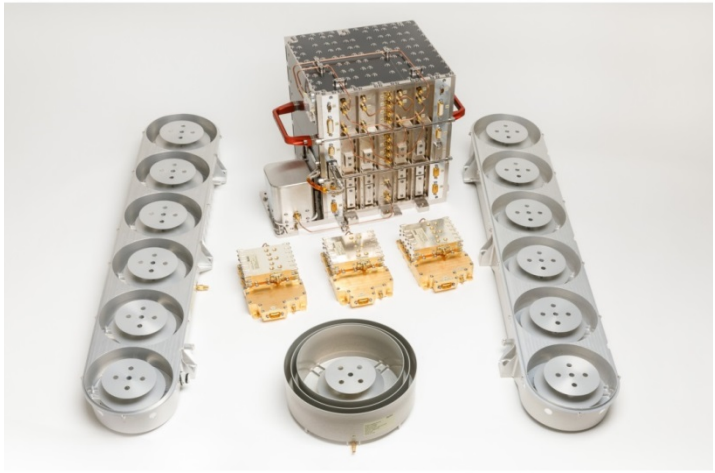
GRAS on MetOp

- 700 occultation measurements per day (GPS L1&L2)
- Altitude coverage: 0 to 85 km
- MetOp-A Launch: Oct 2006
- MetOp-B Launch: Sep 2012
- MetOp-C Launch: Sep 2018
- Design life time: 5 years (+ long term storage)



GRAS-2 : RO on MetOp-SG

- 2500 occultations per day (GPS/Galileo/Beidou/QZSS L1&L5)
- Altitude coverage: 0 to 500 km
- MetOp-SG A1 / A2 / A3 Launch: 2022 / 2030 / 2037
- MetOp-SG B1 / B2 / B3 Launch: 2023 / 2031 / 2038
- Design life time: 7.5 years (+ long term storage)



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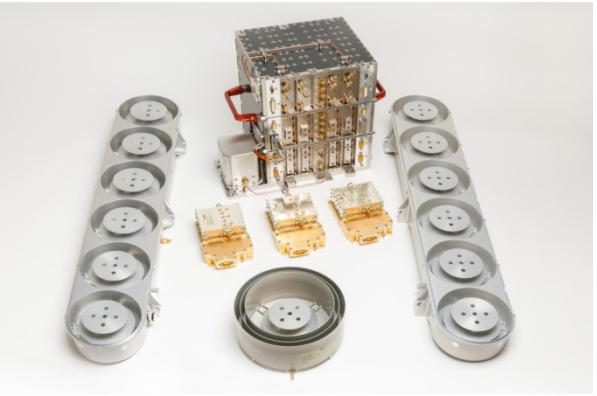
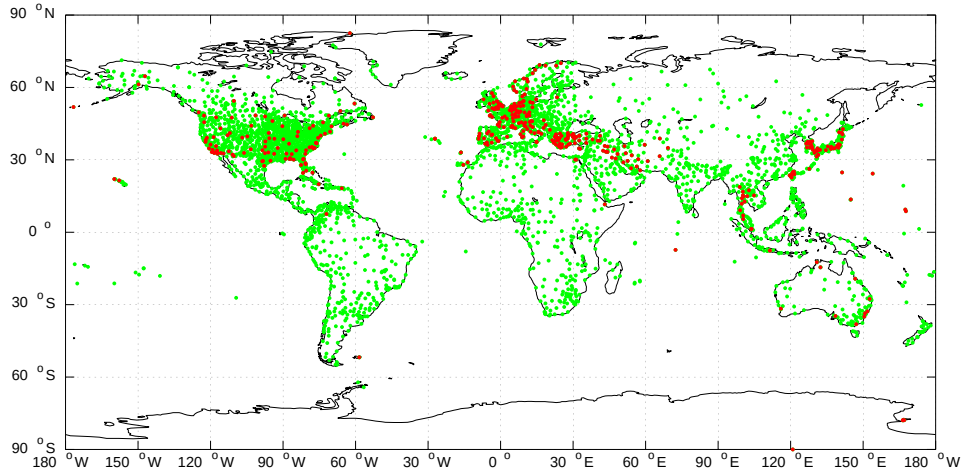
MetOp-SG RO
Main Characteristics



- Galileo, GPS, Compass/BeiDou & QZSS Occultations:
  - Glonass K may replace QZSS in the future
  - Modernized GNSS signals: L1, L5
  - 2500 occs/day per instrument
- Bending angle accuracy <0.5 μrad
- Altitude coverage: 0 to 500 km
- Full open loop tracking with 10 correlators in lower troposphere
- “Frodo” device for DME/TACAN protection

	DME (green)	TACAN (red)
Peak pulse power (W)	1000	3500
Antenna peak gain (dBi)	9.5	9.5
Frequency range (MHz)	962-1213	962-1213
Number of stations	3826	417



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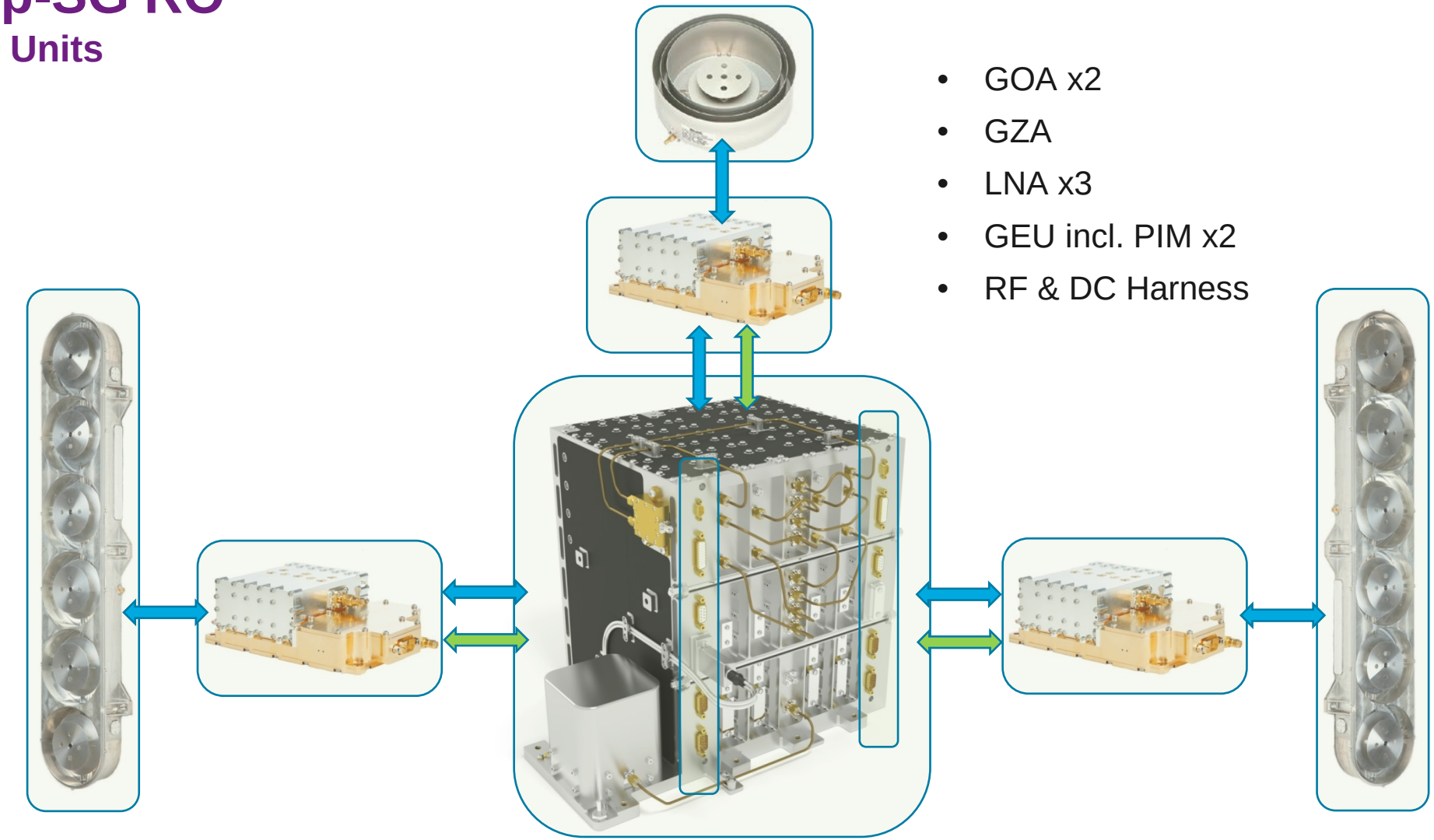
MetOp-SG RO
Internal Units



- GOA x2
- GZA
- LNA x3
- GEU incl. PIM x2
- RF & DC Harness

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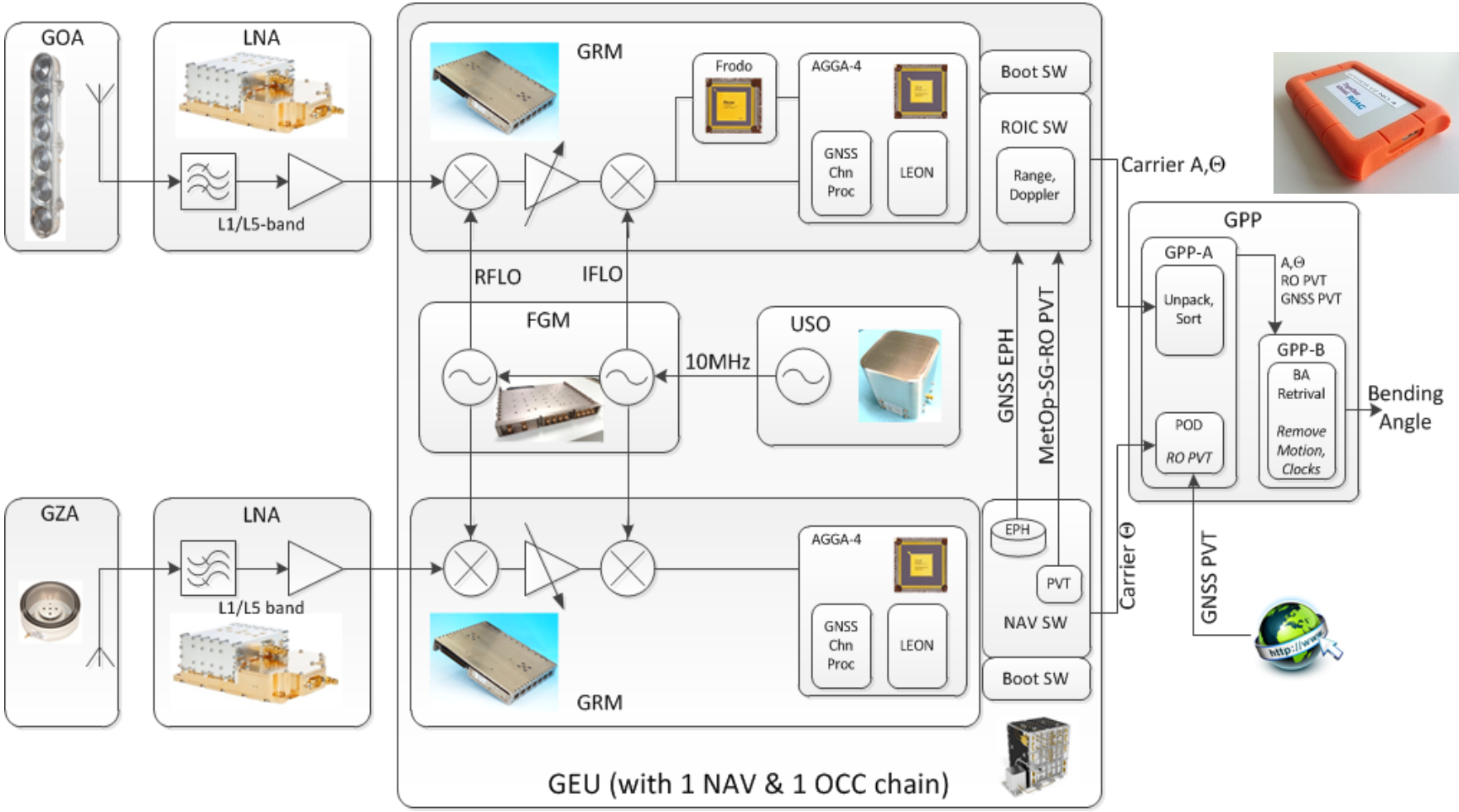
RO: From Antenna to Bending Angle



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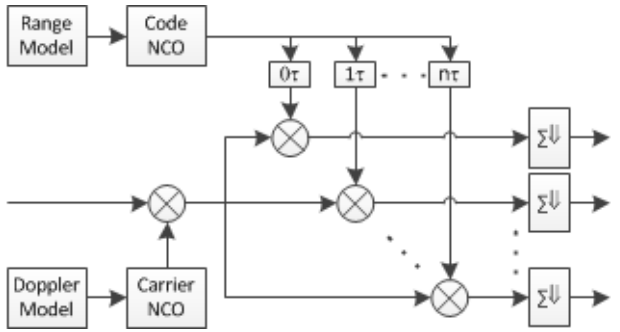
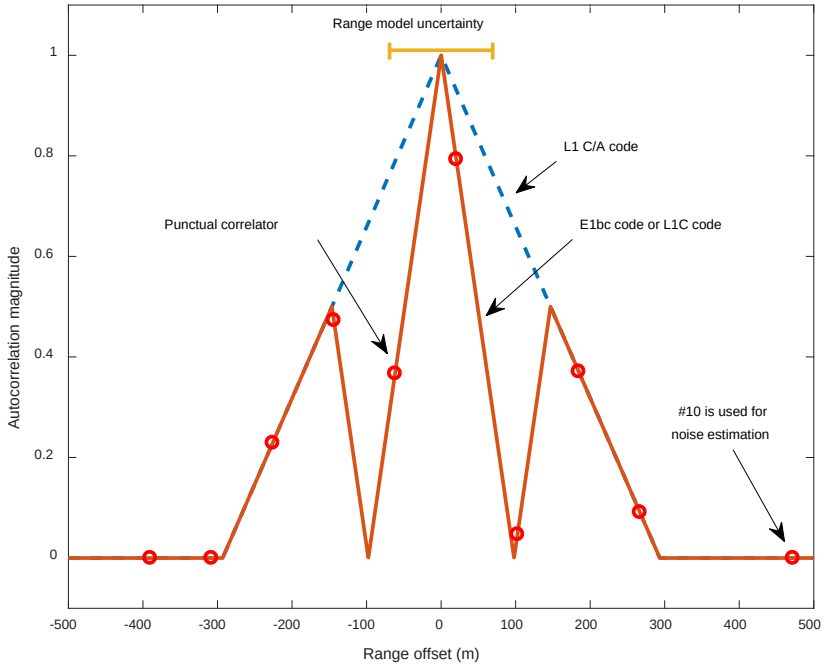
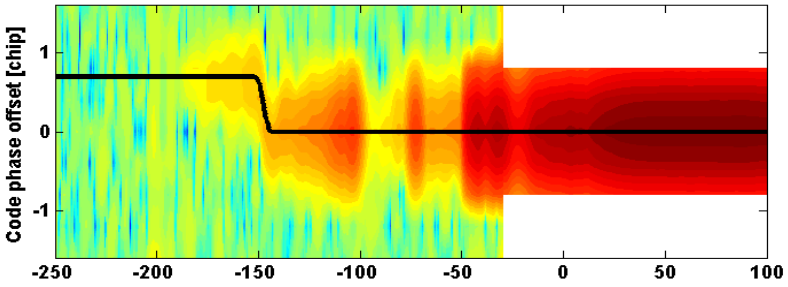
Open Loop Tracking using 10 Correlators

- Model based tracking:
  - On-board algorithms incl. Doppler & Range models
  - Open loop tracking where data from 10 correlators are output (the standard method is to output 1 correlator)
- Algorithm to retrieve the correlation peak from 10 correlators is implemented in ground processing
- Allows for rising signal tracking from the surface
- Advanced tracking: is especially useful to cope with:
  - Large range uncertainty (e.g. ionosphere)
  - Signals with narrow autocorrelation function (i.e. GPS L1C, L5, Galileo E1bc, E5a & Beidou B1C, B2a)







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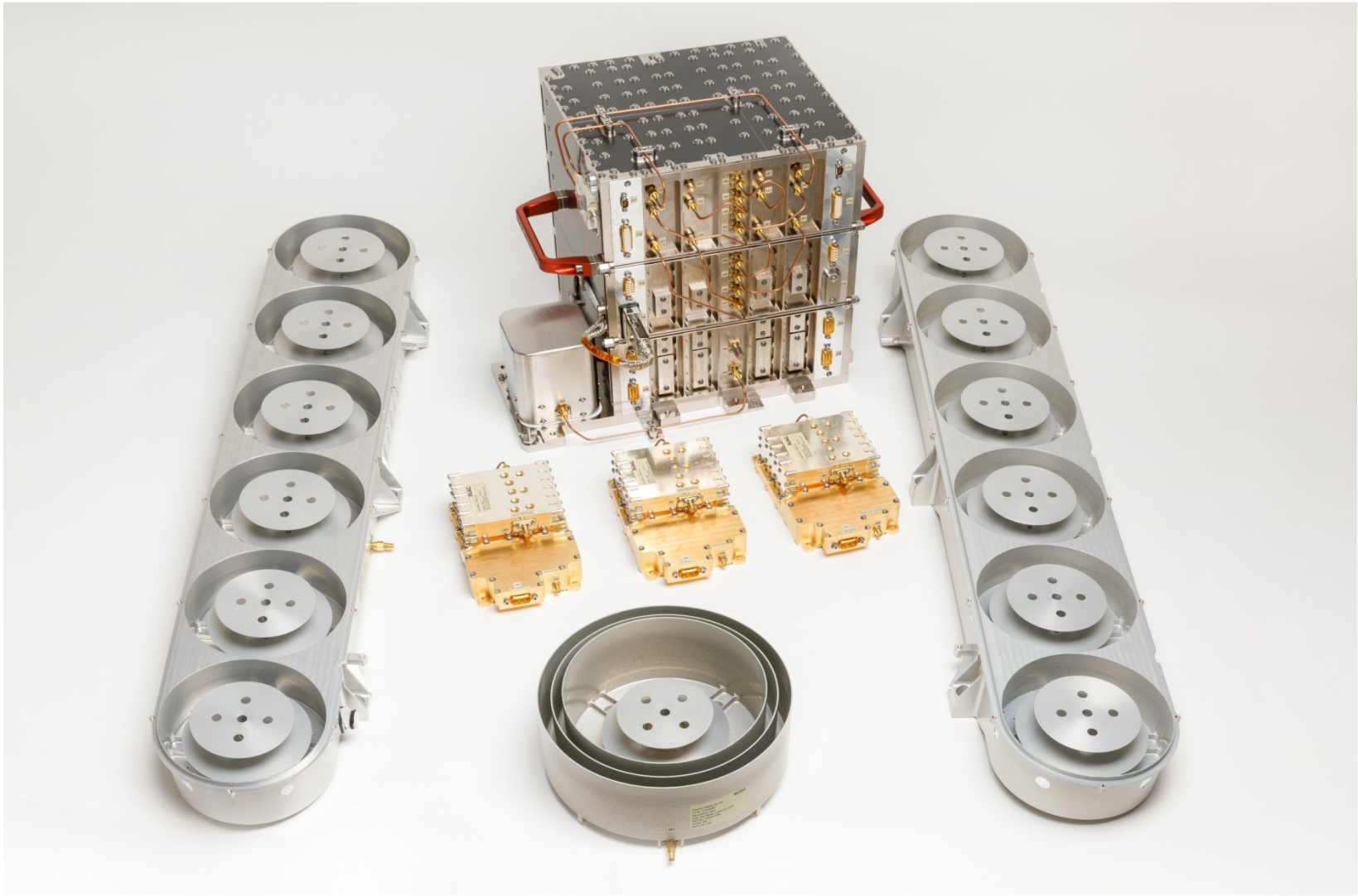
RO Engineering Model Results



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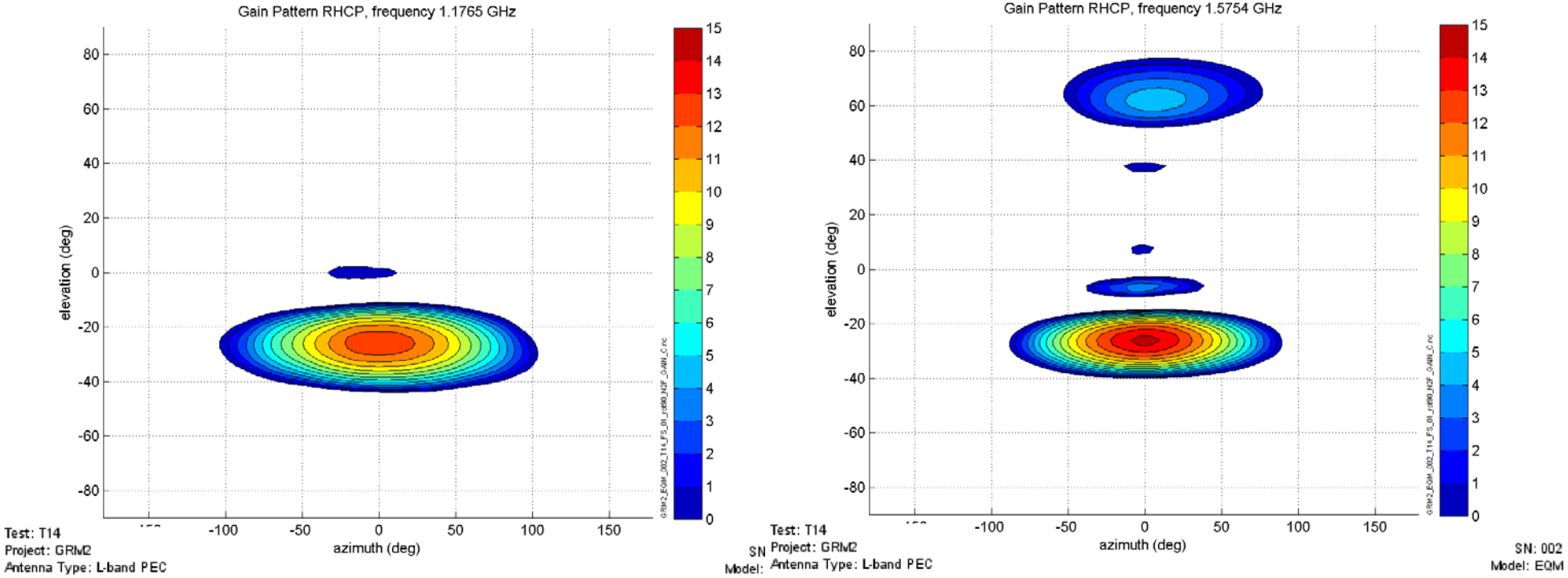
Antenna Gain Pattern Results



	Req.	BB	SN001 (EM)	SN002 (EQM)
GOA gain margin L1	>0 dB	0.56 dB	0.39 dB	0.36 dB
GOA gain margin L5	>0 dB	0.87 dB	0.47 dB	0.43 dB

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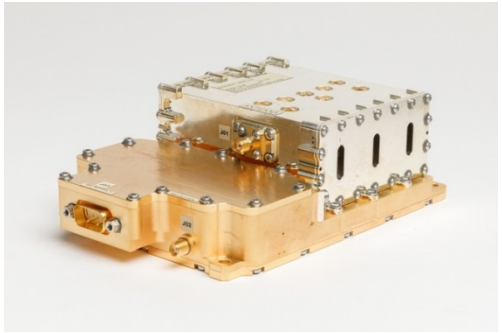
Low Noise Amplifier (LNA) Results



RO IHBB

RO EM

	Req.	EBB01	EBB02	EBB03	SN101	SN102	SN103
LNA noise figure L1	<2.0 dB	1.56 dB	1.56 dB	1.60 dB	1.57 dB	1.57 dB	1.60 dB
LNA noise figure L5	<2.2 dB	1.98 dB	1.95 dB	1.96 dB	2.01 dB	2.02 dB	1.99 dB

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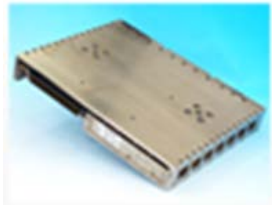
GNSS Receiver Module Results



RO IHBB

RO EM

	Req.	SN02	SN03	SN05	SN07	SN08	SN09	SN10
Implementation loss L1	<1.3 dB	0.45 dB	0.75 dB	1.20 dB	0.55 dB	1.23 dB	0.25 dB	0.92 dB
Implementation loss L5	<1.7 dB	0.98 dB	1.25 dB	1.65 dB	1.08 dB	1.16 dB	0.82 dB	0.96 dB

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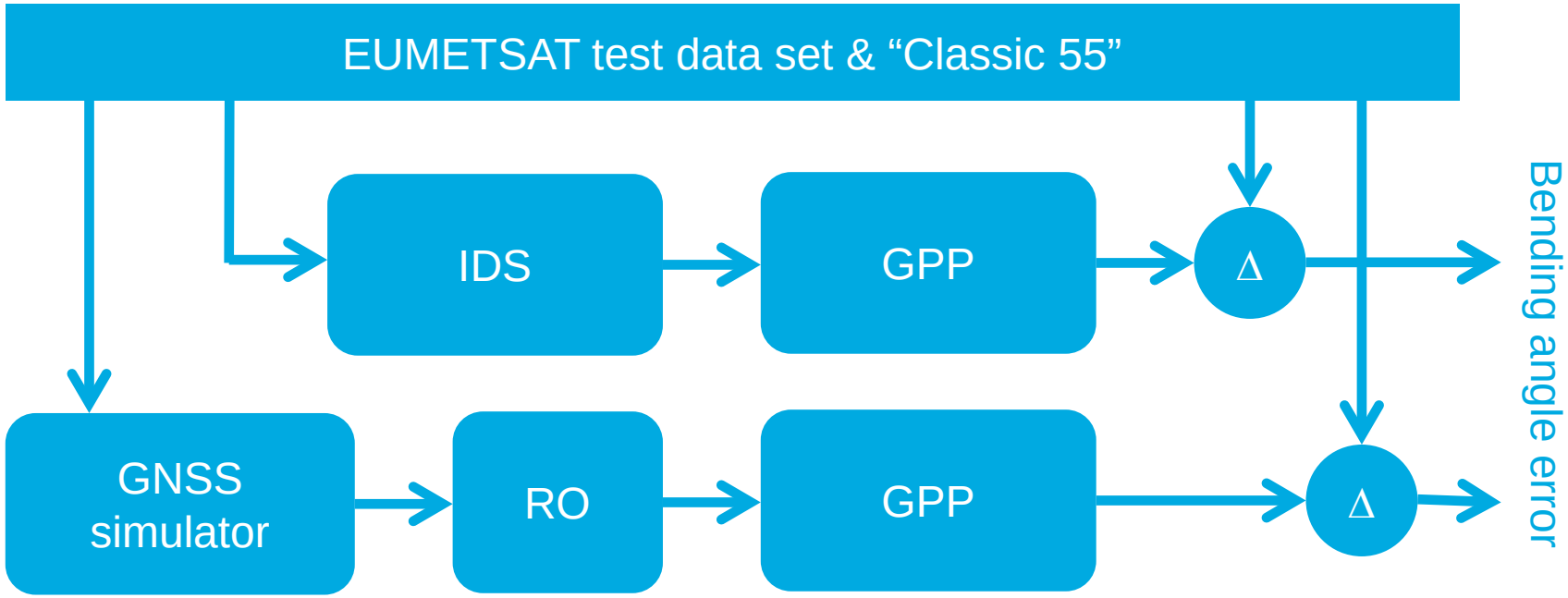
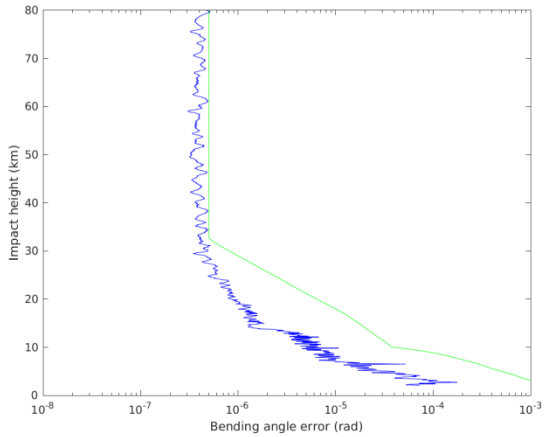
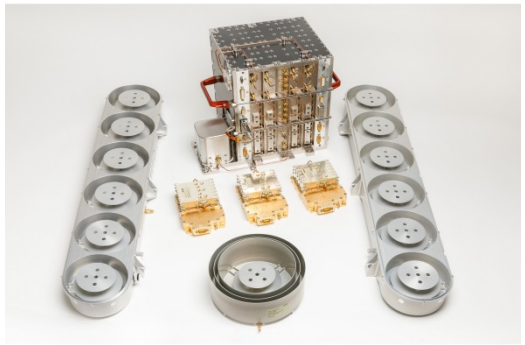
End-to-end Performance Evaluation







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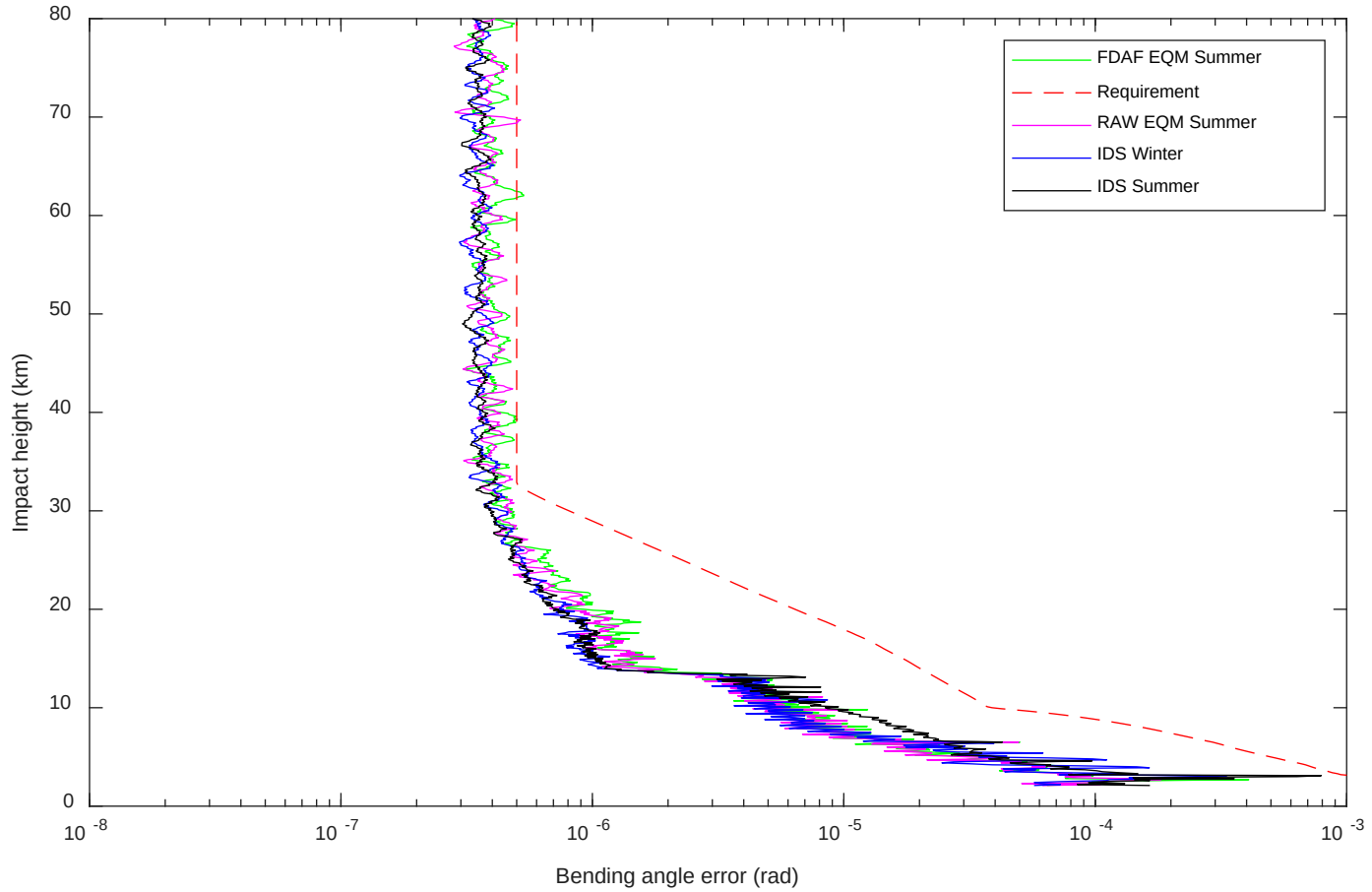
RO EM test results and IDS/GPP simulations



- **FDAF EQM:**
  Maximum DME/TACAN Interference is applied

- Budget analysis based on specified parameters:
  0.46 urad RMS (35-80 km)
- Analysis based on measured units:
  0.36 urad RMS (35-80 km)

- Environmental tests (Vibration , shock, TV, EMC) were successfully performed. No performance degradation

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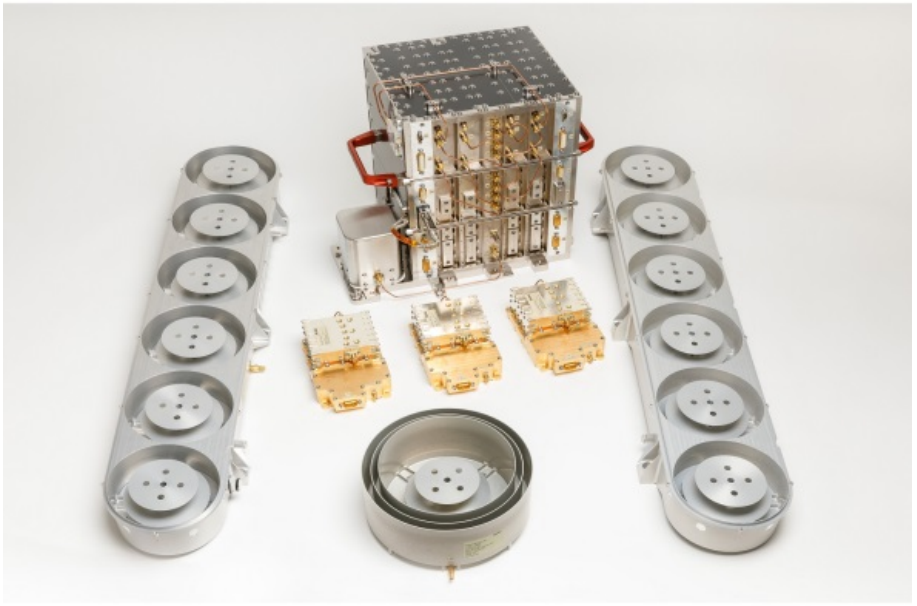
Conclusion

- MetOp-SG RO instrument Engineering Model testing is successfully completed
- Excellent performance of all tested units: antennas, LNAs, receiver modules
- End-to-end test demonstrates a bending angle accuracy of 0.4 urad RMS (at 35-80 km)
- PFM manufacturing is ongoing
- 6 flight-models to produce



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