X-BAND TT&C AND K-BAND DOWNLINK ANTENNAS FOR FUTURE LEO MISSIONS

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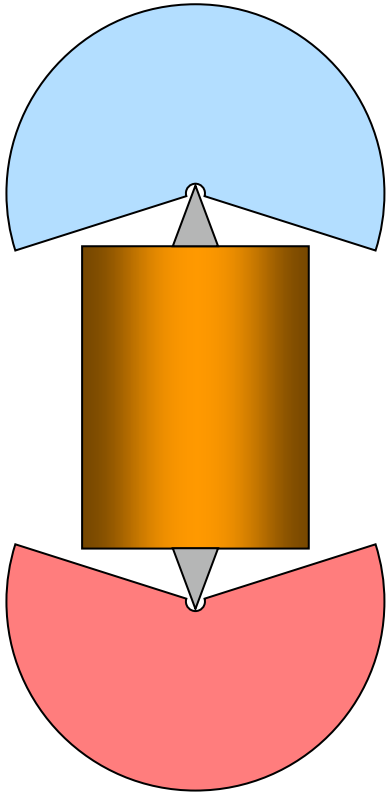
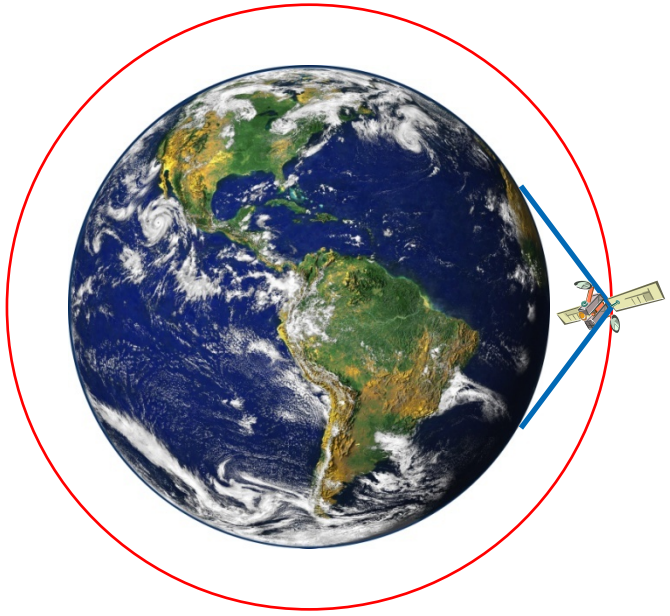
Presentation Outline

- Introduction
- Design Background and Heritage
- X-Band TT&C Antenna
- K-/Ka-Band Beacon/DDL Antenna
- Conclusion

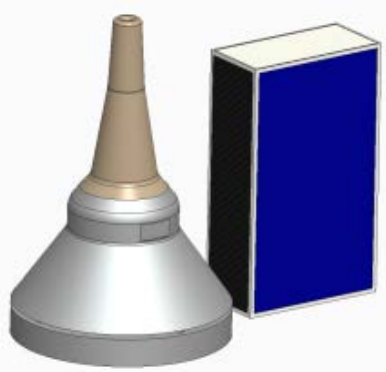




Introduction

- X-Band TT&C antenna
  - Designed and manufactured as an EM activity in an add-on to the original study
  - Novel dual band design

- K-/Ka-Band Beacon/DDL Antenna
  - Pre-development running in parallel with the X-Band continuing study

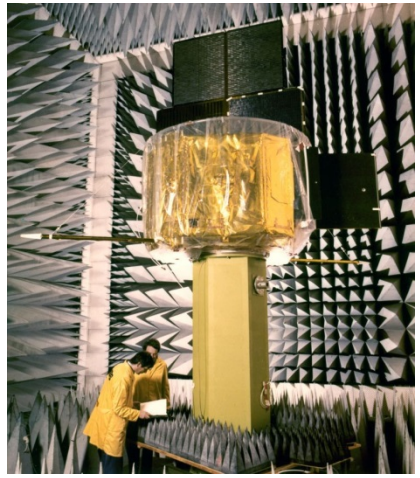


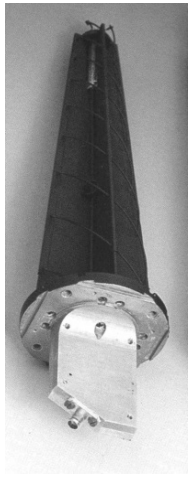
Design Background and Heritage – Ruag Space

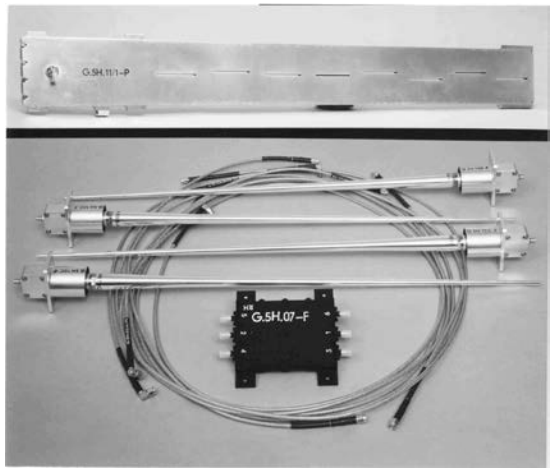
- Ruag space antenna activities started in the mid 70's within wide coverage antennas

  > 300 helix antennas delivered

- Other types of antennas are also designed and developed
  - Reflector antennas (JWST, SIRAL/Cryosat)
  - Array antennas (Array elements for telecom)
  - Slot antennas (ERS1/ERS2 , MetOp SG Scatterometer)







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Design Background and Heritage – Ruag Space

- Several variants are used for our helix antennas
- Three main variants
  - Wires - shaped to a helix radiator
  - Etched metallic strips on substrates - shaped to a helix radiator
  - Machined in one piece of metal - shaped to a helix radiator






X-Band TT&C Antenna

- The antenna main parts:
  - Radome assembly
    - Helix radiator inside
  - Strip-line polarizer, or
  - Septum polarizer assembly
- Two different electrical I/F

Total height: 256 mm
WG I/F or SMA I/F

Total height: 148 mm
SMA I/F

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X-Band TT&C Antenna

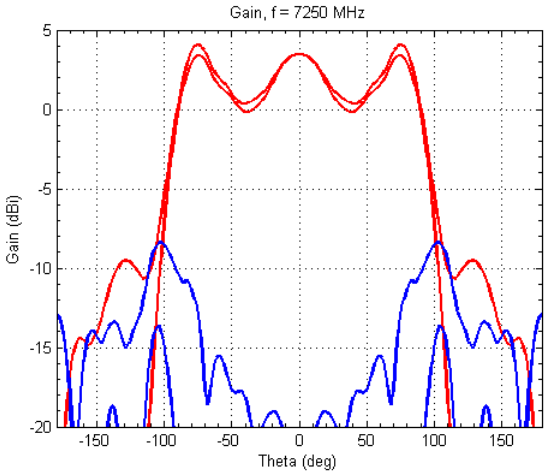
- Hemispherical coverage antenna - EOC angle of 90°
- Dual band design for 7.19-7.25 GHz (TC/RX band) and 8.025- 8.400 GHz (TM/TX Band)
- Strip-line fed helix antenna (low power variant) selected as baseline with a waveguide fed antenna (high power variant) as option
- Using the strip-line feed network provides a more compact polarizer than a conventional waveguide type of polarizer

X-Band TT&C Antenna

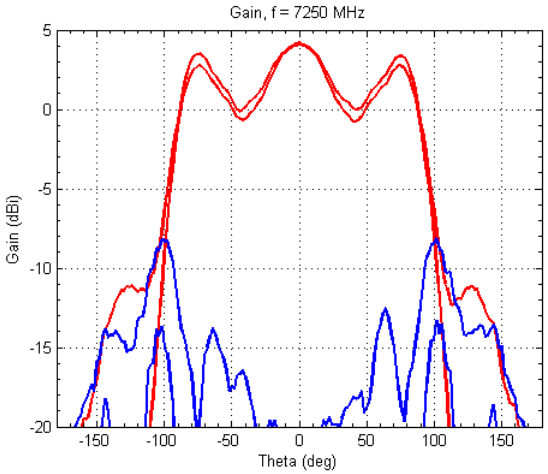
- Analyzed vs measured performance 7.250 GHz (TC/RX band) WG feed
- Software used: HFSS

Gain

Analyzed

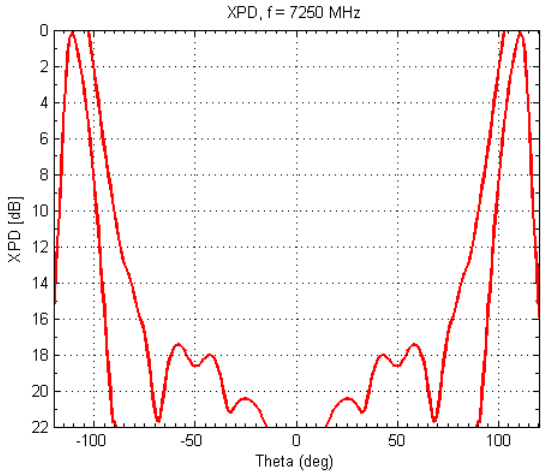


Measured

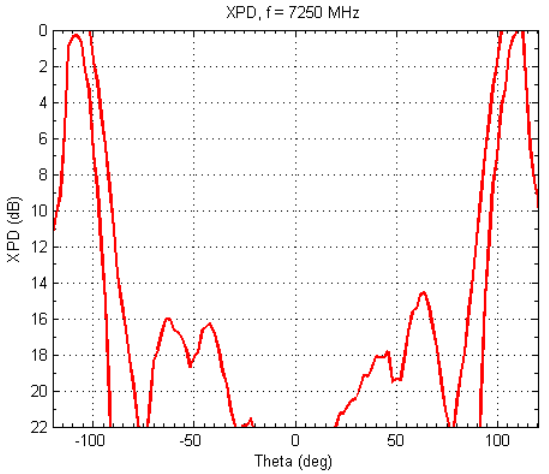


Cross polarisation

Analyzed



Measured



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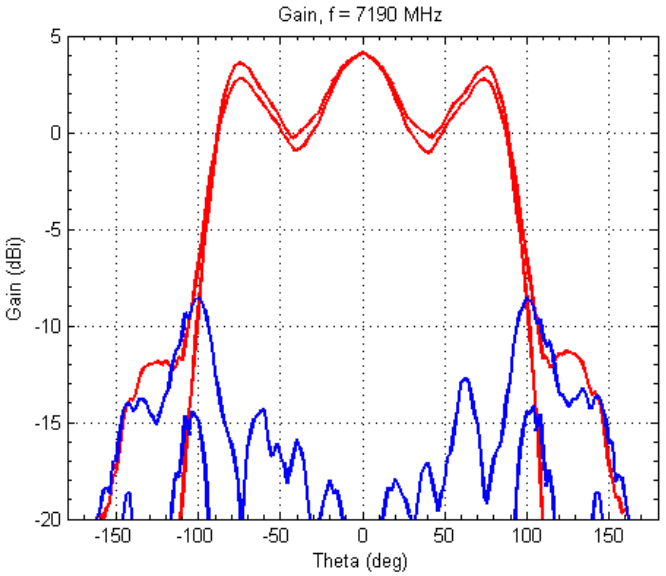
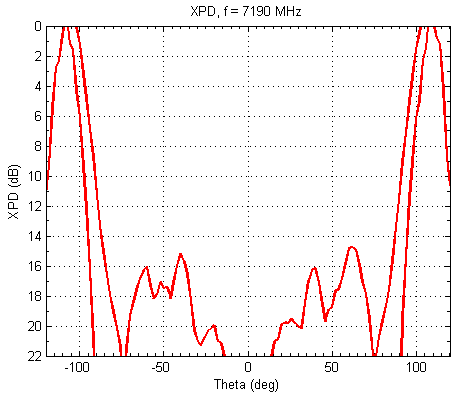
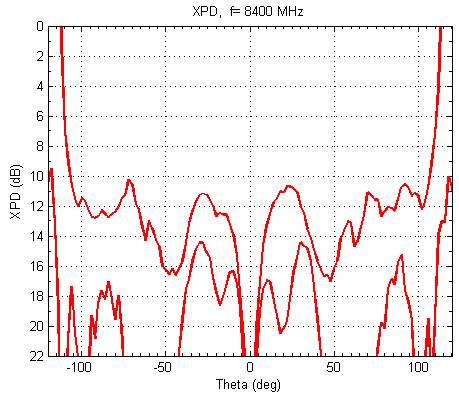
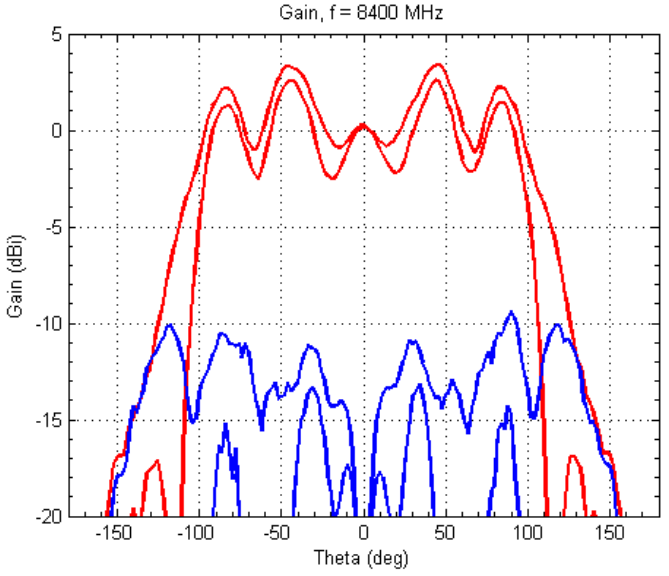
X-Band TT&C Antenna

- Measured performance with WG feed









TC/RX: 7.190 GHz

TM/TX: 8.400 GHz

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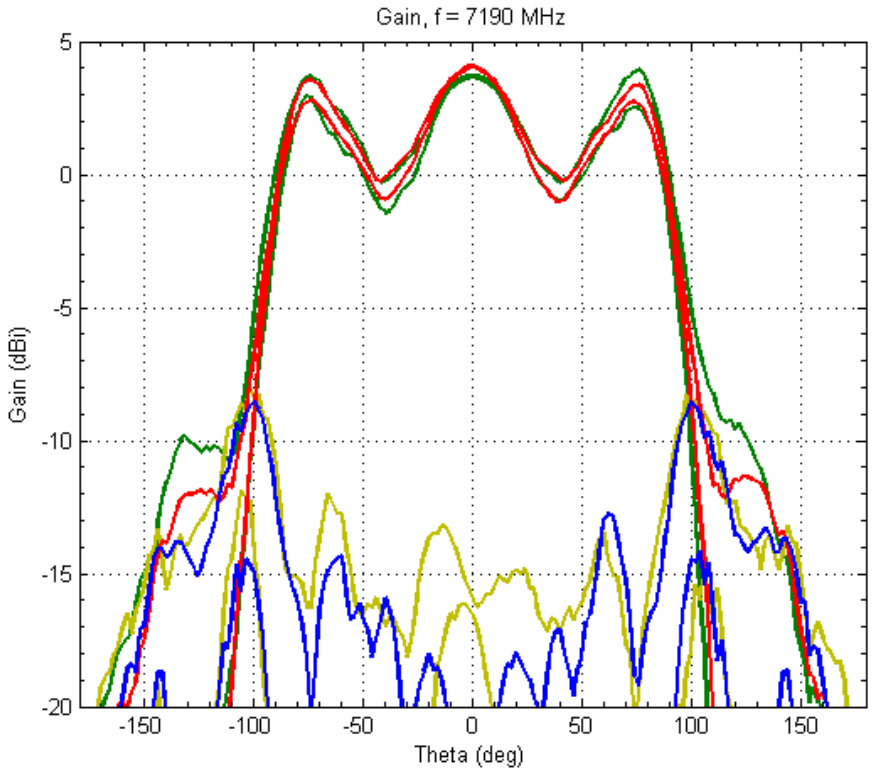
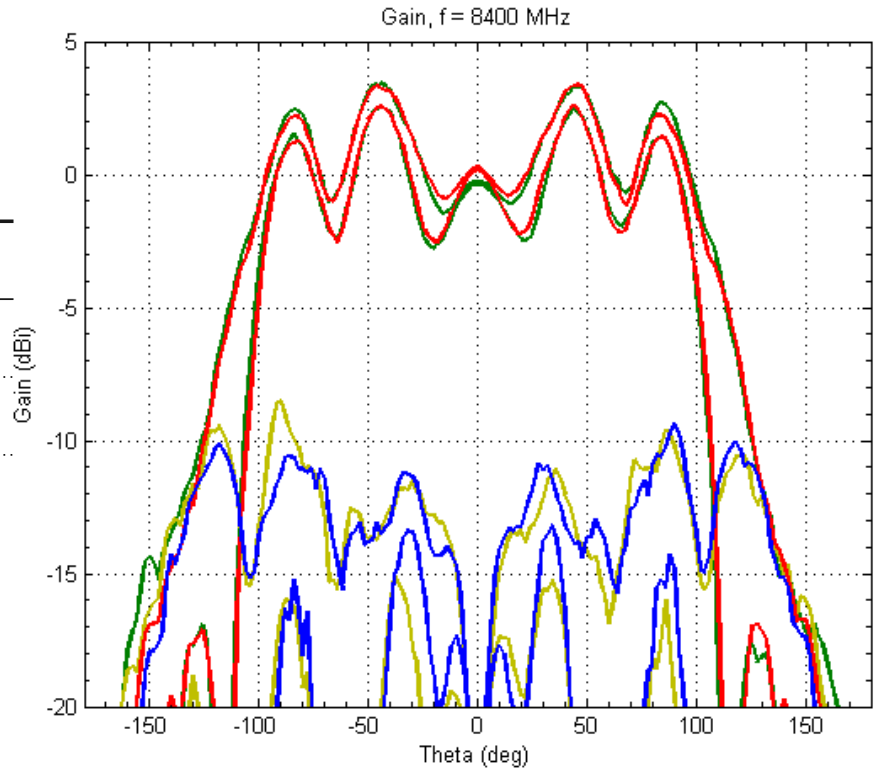
X-Band TT&C Antenna

- Measured performance for WG feed and SMA feed compared



	Co-polar	Cross-polar
WG feed	Red	Blue
SMA feed	Green	Light green



TC/RX: 7.190 GHz

TM/TX: 8.400 GHz

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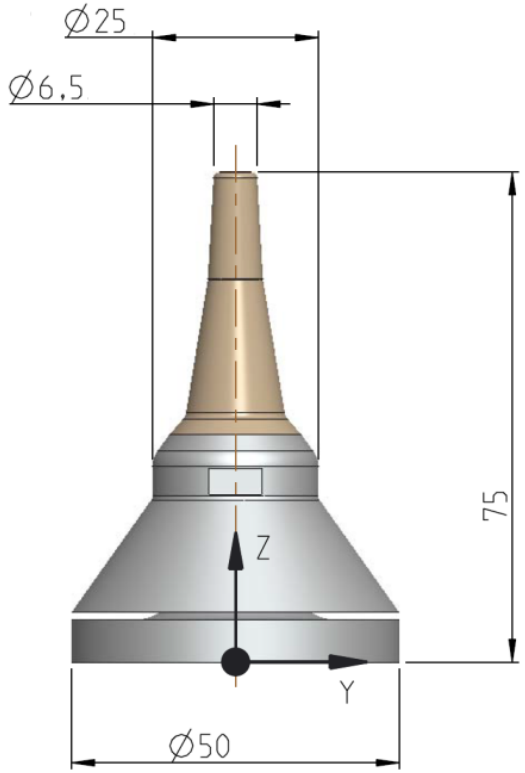
K-/Ka-Band Beacon/DDL Antenna

- Objective: Design and test a compact K-/Ka-band beacon/DDL iso-flux antenna for 26 GHz
  - Size
  - Mass
- Helix technology chosen
- Two manufacturing methods for the helix
  - Conventional machining
  - ADM (3d printing)

K-/Ka-Band Beacon/DDL Antenna - design

- The antenna main parts:
  - Radome assembly
    - Helix radiator inside
  - Septum polarizer assembly
- WG I/F (WR34)



Total mass: 130 g

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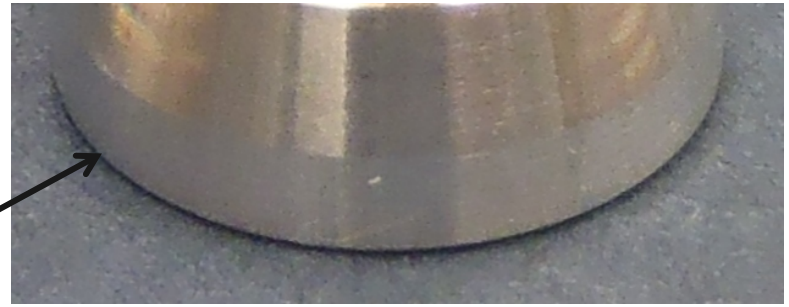
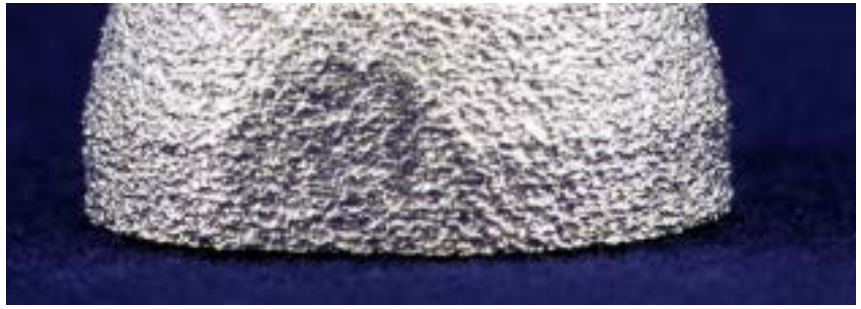
K-/Ka-Band Beacon/DDL Antenna

- Two helix radiators manufactured
  - Conventional machining
  - ADM technology (3d printing)
- Challenges due to size
- Helix radiators ø13.5 mm at the base, ø1.8 mm at the top.
  - Total height: 44 mm



Conventionally machined helix base



ADM technology (3d printed) helix base

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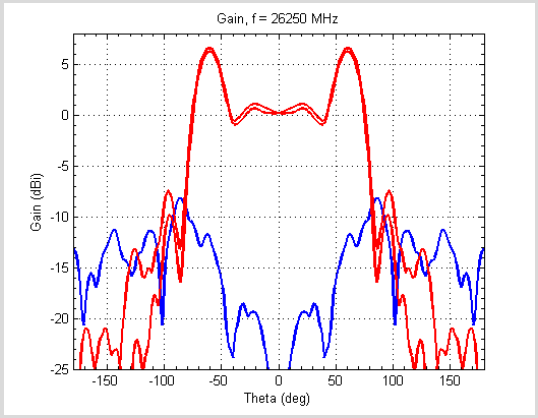
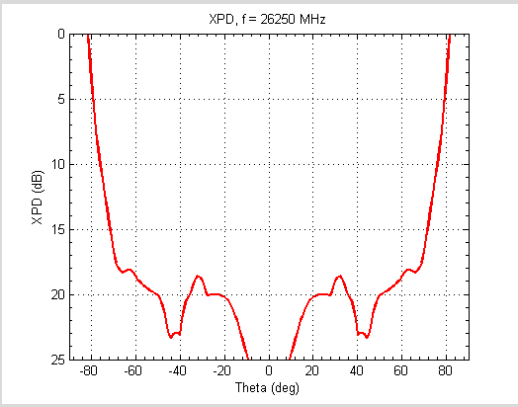
K-/Ka-Band Beacon/DDL Antenna – Performance

Gain

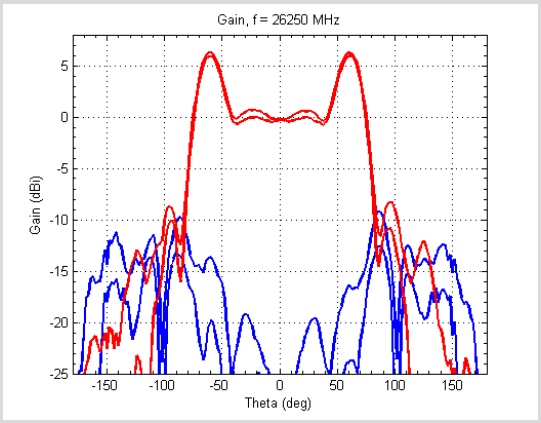
Cross polarisation

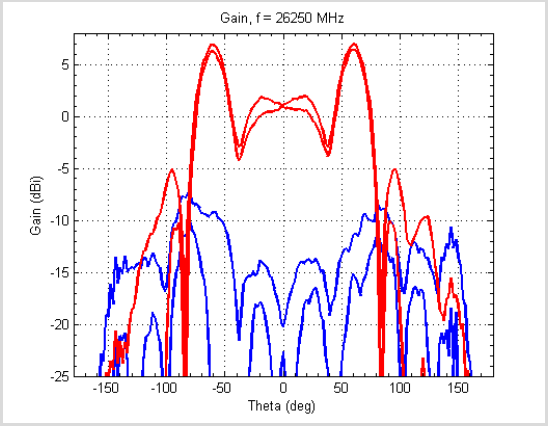
Analyzed

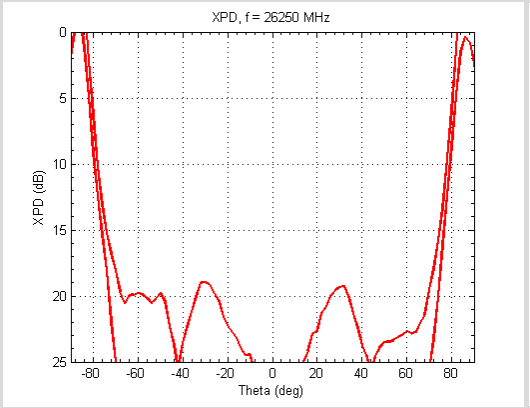


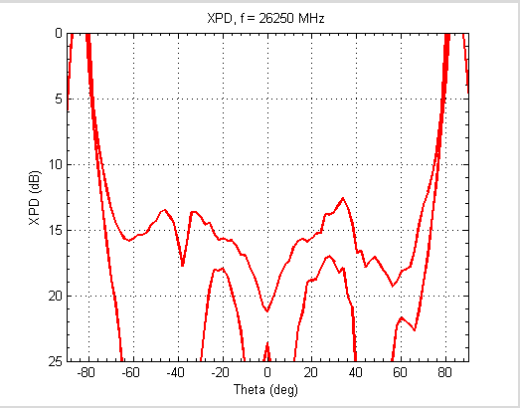


Measured









Machined helix

3d printed helix

Machined helix

3d printed helix

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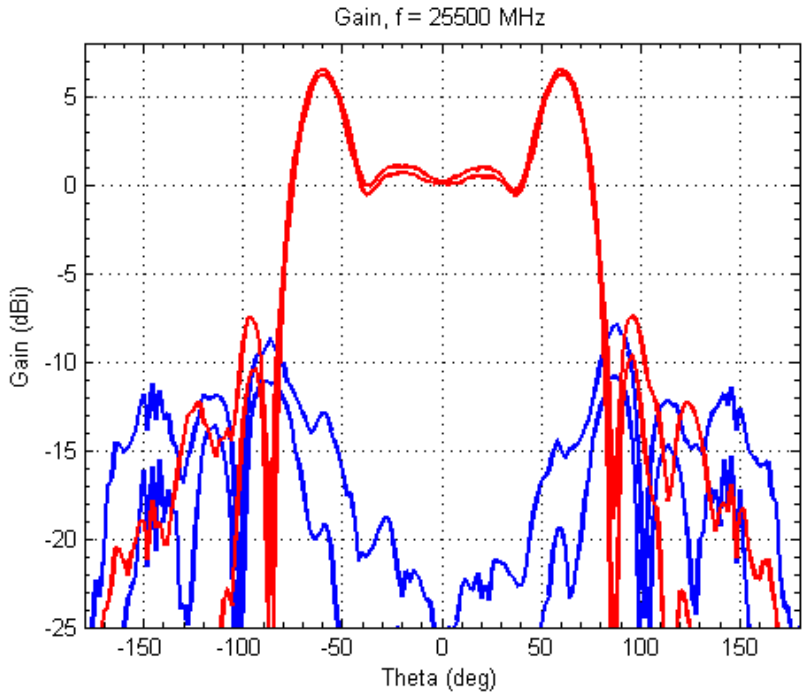
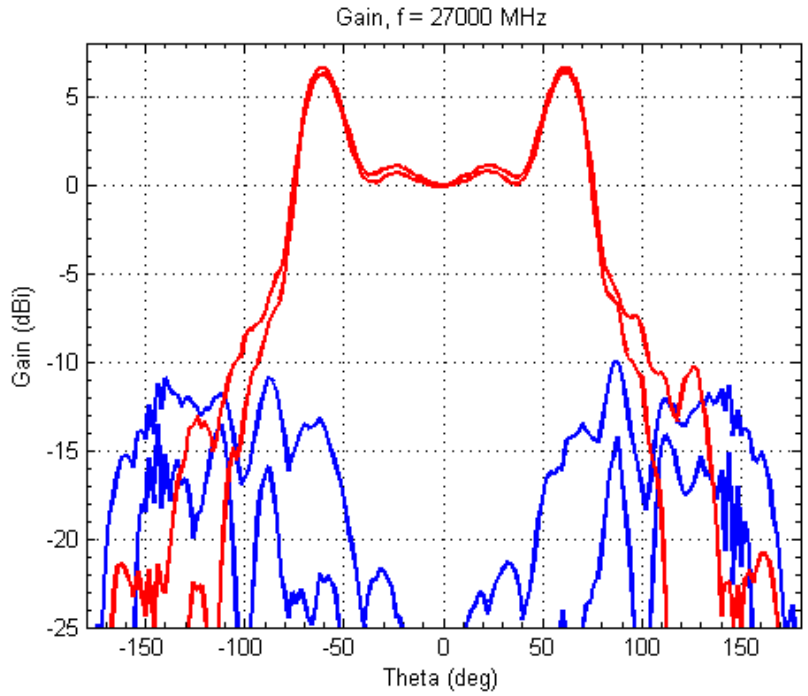
K-/Ka-Band Beacon/DDL Antenna

- Measured performance 25.50 GHz and 27.00 GHz on machined helix antenna
- Covers the full DDL frequency band





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K-/Ka-Band Beacon/DDL Antenna

- Although the size of the K-/Ka Band helixes was demanding, both manufacturing methods were successful
  - The antenna with the machined helix showed full compliance to the requirements
  - The antenna with the 3d printed helix did not fully reach the requirements - however it showed surprisingly good RF performance despite its rough appearance
- Average loss over the frequency band is about 0.5 dB for both the machined and the 3d printed antenna with surface treatment
- Low level vibration test performed – good correlation to analysis

Conclusion

- New and exciting developments
  - Compact, dual band X-band TT&C antenna
  - K-/Ka-band Beacon/DDL iso-flux helix antenna
- To our knowledge it is the first K-/Ka-Band helix antenna, able to be used in space, ever made.
- The use of the 3d printed technique resulted in a promising outcome, but further work must be done to understand the reasons for the antenna gain and XPD behavior.
- Future work for X-band TT&C antenna
  - EQM
- Future work for K-/Ka-band Beacon/DDL iso-flux helix antenna
  - EQM for machined helix
  - Qualifications of materials and processes for 3d printed helix