PROTOTYPE OF K/S-BAND GROUND STATION ANTENNA

(GSTP REF. G511-0035GS)

indra

Index

INTRODUCTION

LEO/MEO Earth Observation Satellite

TM
2.025-2.120 GHz

TC
2.2-2.3 GHz

25.5-27 GHz
Earth observation data → High rate (> 1Gbps)
Monopulse Autotrack (beamwidth <60 mdeg)

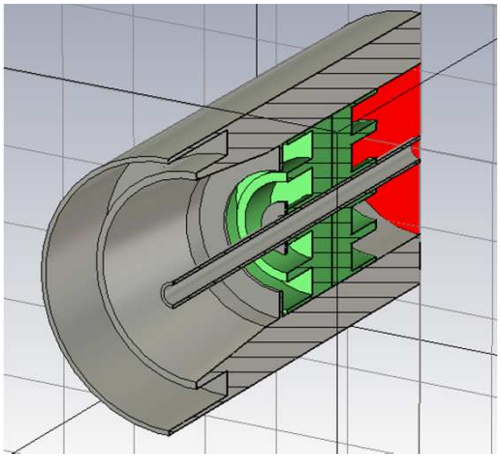
Ground Station

INTRODUCTION

- Prototype of K-Band Ground Station Antenna target requirements
  - K-band, downlink: 25.5 – 27 GHz
  - S-band, uplink: 2.025 – 2.120 GHz
  - S-band, downlink: 2.2 – 2.3 GHz
  - Polarization: RHCP and LHCP in both bands
  - High antenna efficiency > 70%
  - Antenna directivity K-band ≥ 60.5 dBi
  - K-Band G/T ≥ 37.5 dB/K
  - Pointing accuracy: 0.035º (up to100Km/h wind)
  - Low axial ratio (<1 dB in S band / <0.5 dB in K band)
  - Monopulse tracking at K-band capable of tracking linear or circular polarization signals. The feed system has two tracking waveguide ports
  - Tracking accuracy: better than 5% of θ-3dB
  - Reflector illumination compatible with ITU Recommendation S-732
  - Reflector surface panel 0.1mm total reflector <0.25mm RMS

K/S-BAND FEED DESIGN

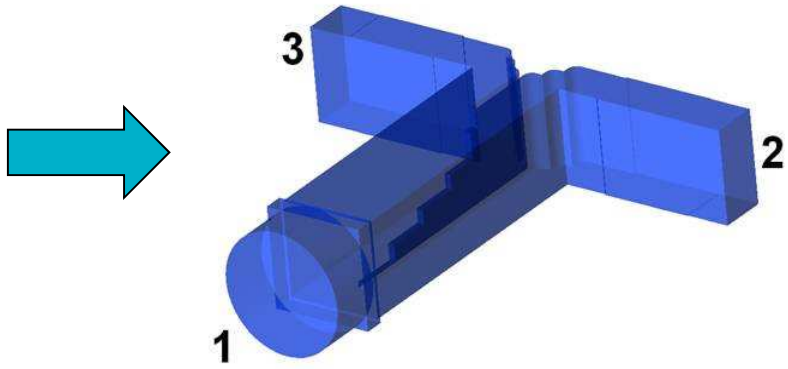
- Dual Band Feed Horn
  - Two horns one inside the other
    - Inner one → high frequency standard open waveguide horn
    - External one → coaxial horn aperture with corrugations



Model simulated with CST to improve tunning and side lobes in both bands

K/S-BAND FEED DESIGN

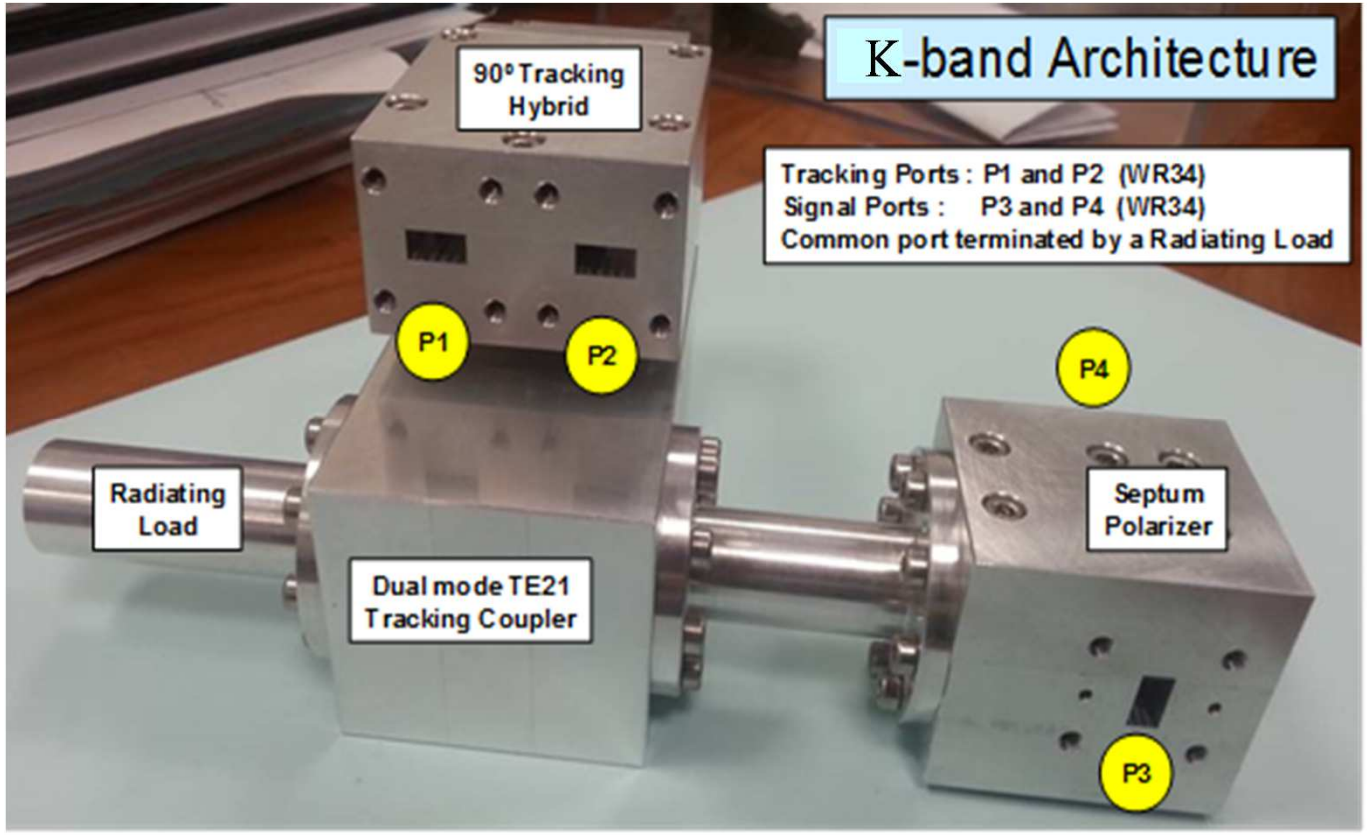
- K-band Section (I)
  - OMT-Septum Polarizer
    - Three step thin septum
    - WR34 for RHCP and LHCP ports



  - Dual TE21 Resonant Tracking Coupler
    - Oversized circular waveguide + under-cutoff waveguide + coupling slots
    - Direction of the slot depends on the higher mode
    - Two resonant structures (to work in both polarizations)
    - Combination of coupled modes → 90º Hybrid coupler
    - 8% bandwidth achieved
    - Size: 160x142x74 mm

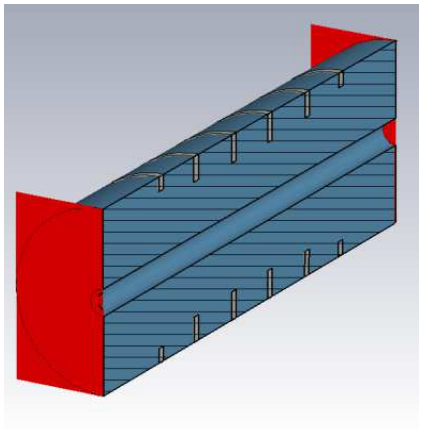
K/S-BAND FEED DESIGN

- K-band Section (II)

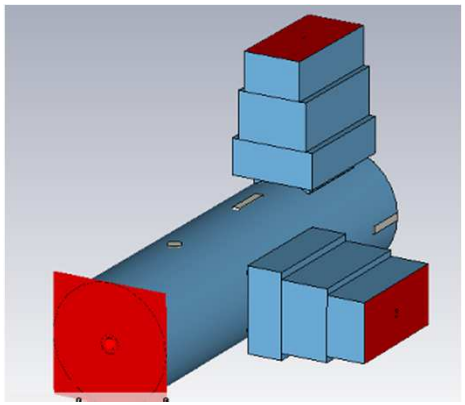


K/S-BAND FEED DESIGN

- S-band Section
  - Corrugated polarizer
    - Convert orthogonal linear polarized signals to circular polarized
  - OMT
    - Separates the two orthogonal linear signals
    - Two slots coupled T-junctions
    - Septum to separate the T-junctions
    - WR340 ports for Tx and Rx (RHCP and LHCP)



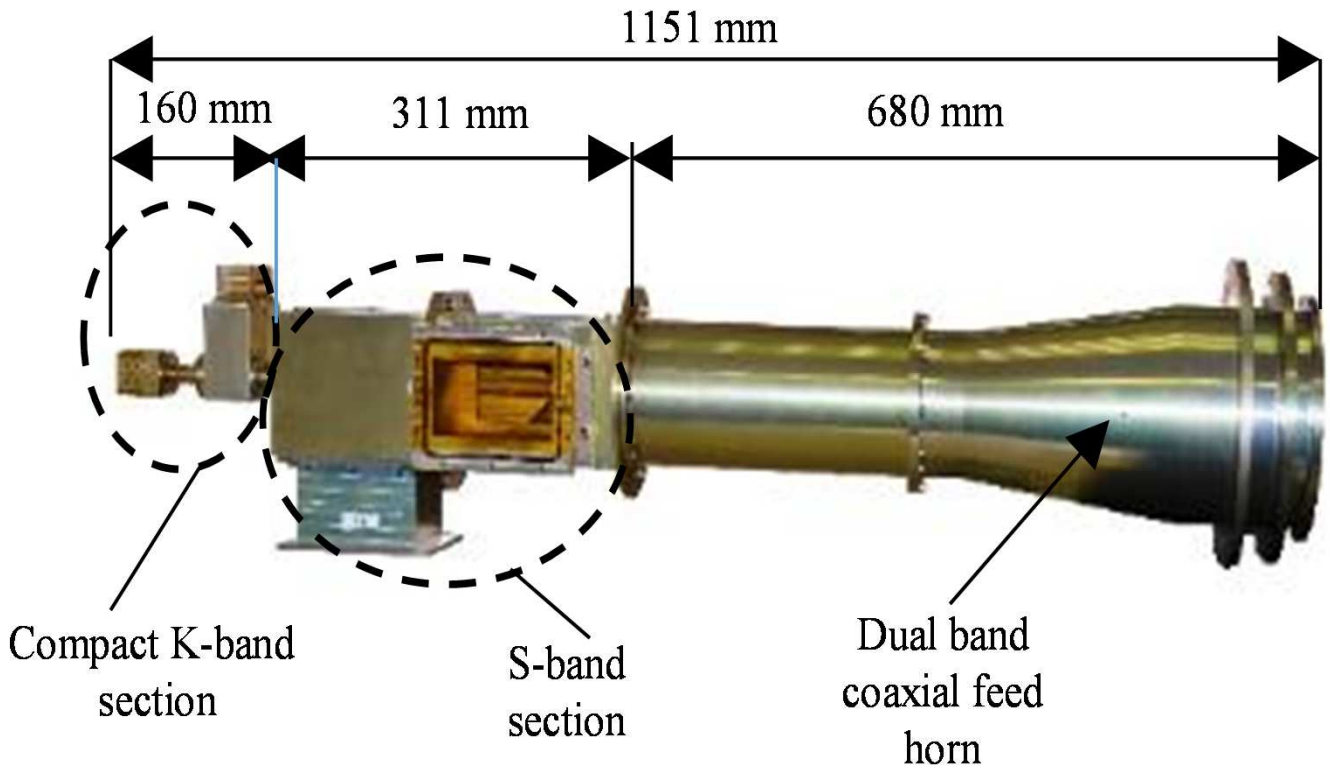
Corrugated polarizer



OMT

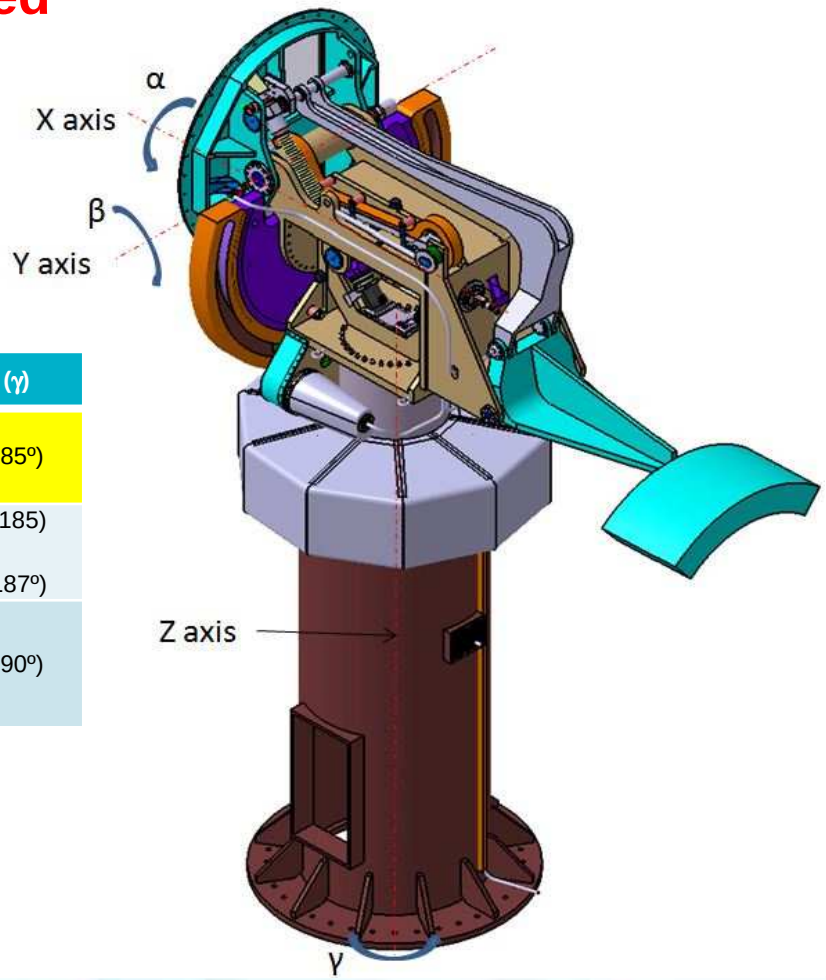
K/S-BAND FEED DESIGN

Manufactured K/S-Band Feed



MECHANICAL DESIGN

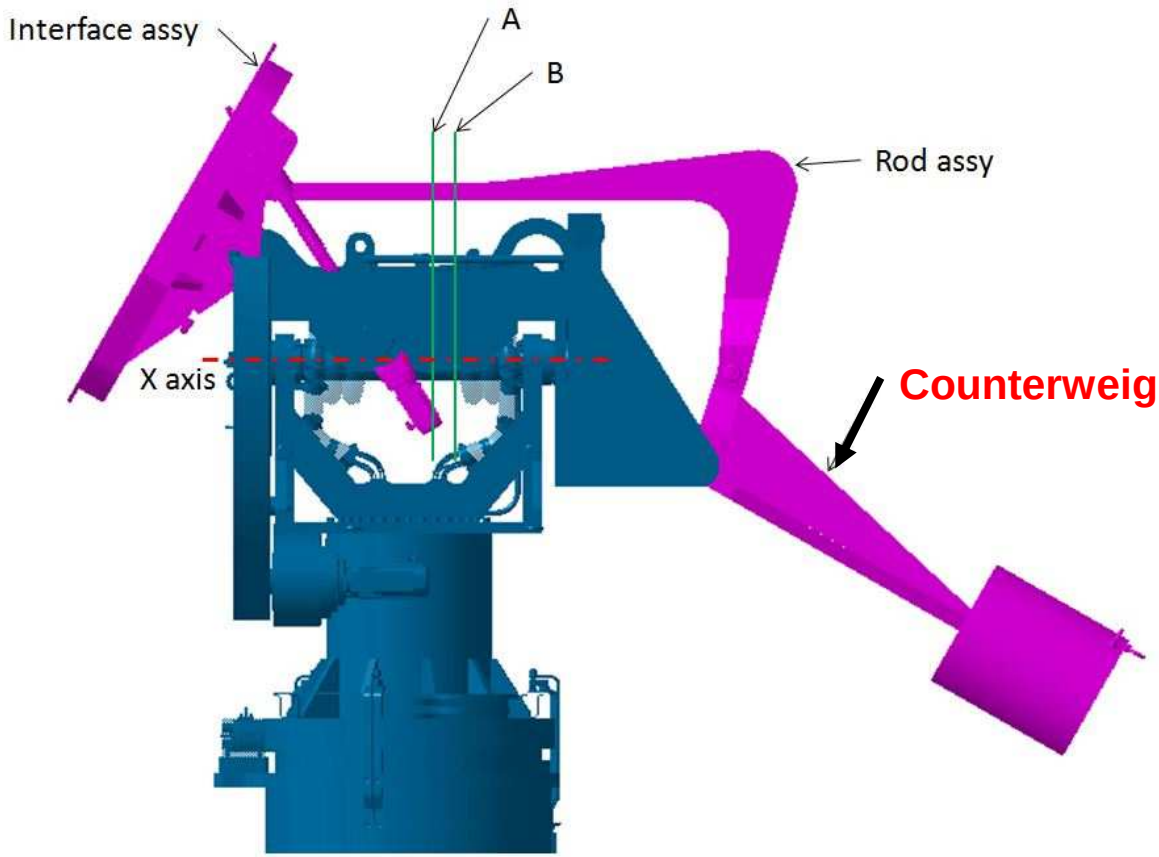
The Positioner mechanical concept based on a 2-axes tracking system (X and Y) with a third axis (Z) to place strategically the X-Y gimbal, minimizing the axes speed



Type of range	Y axis (β)	X axis (α)	Z axis (γ)
Operative range (before electric alarm goes off)	(-5º, 90º)	(-90º, 90º)	(-185º,185º)
Mechanical range (before shock absorbers act)	(-7º, 92º) (-8.5º, 93.5º)	(-92º, 92º) (-93.5º, 93.5º)	(-185º, -185) (-187º, 187º)
Mechanical range (after shock absorbers have been used)	(-10º, 95º)	(-95º, 95º)	(-190º,190º)

MECHANICAL DESIGN

Y axis movement

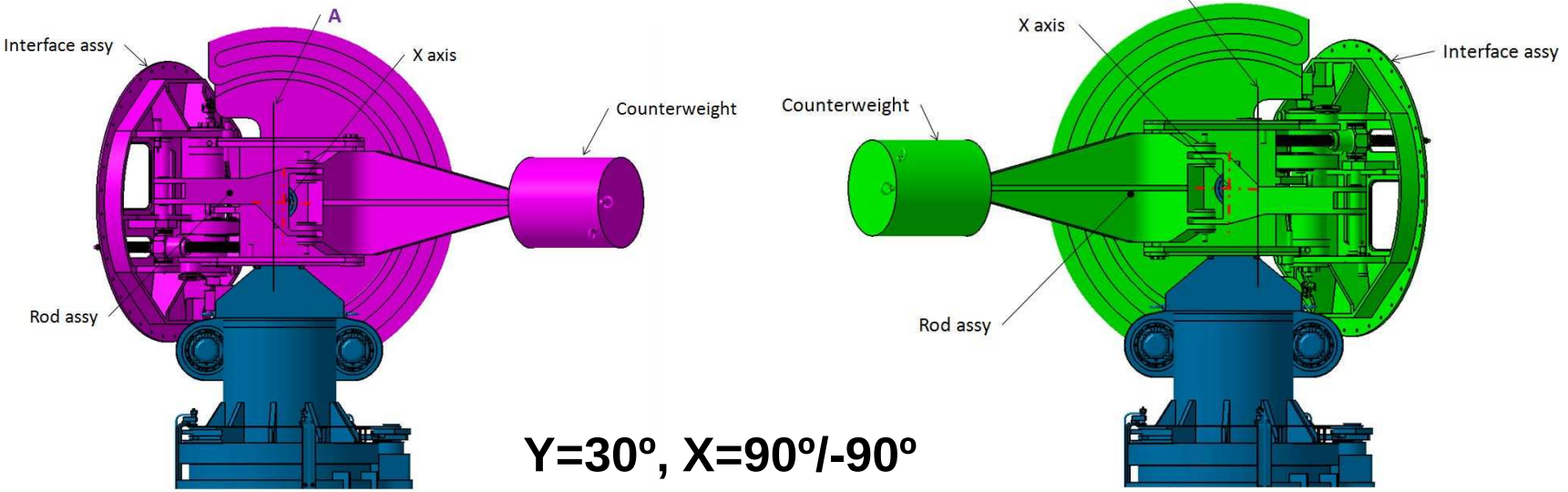


Counterweight → reduces the torque of the cinematic chain

Thanks to the counterweight, during Y axis rotations (from 95º to -10º) pink colour system COG is between green lines A and B, and as close as possible to X axis.
The change up/down is: Y90=79.2 mm, Y0=96.8 mm.

MECHANICAL DESIGN

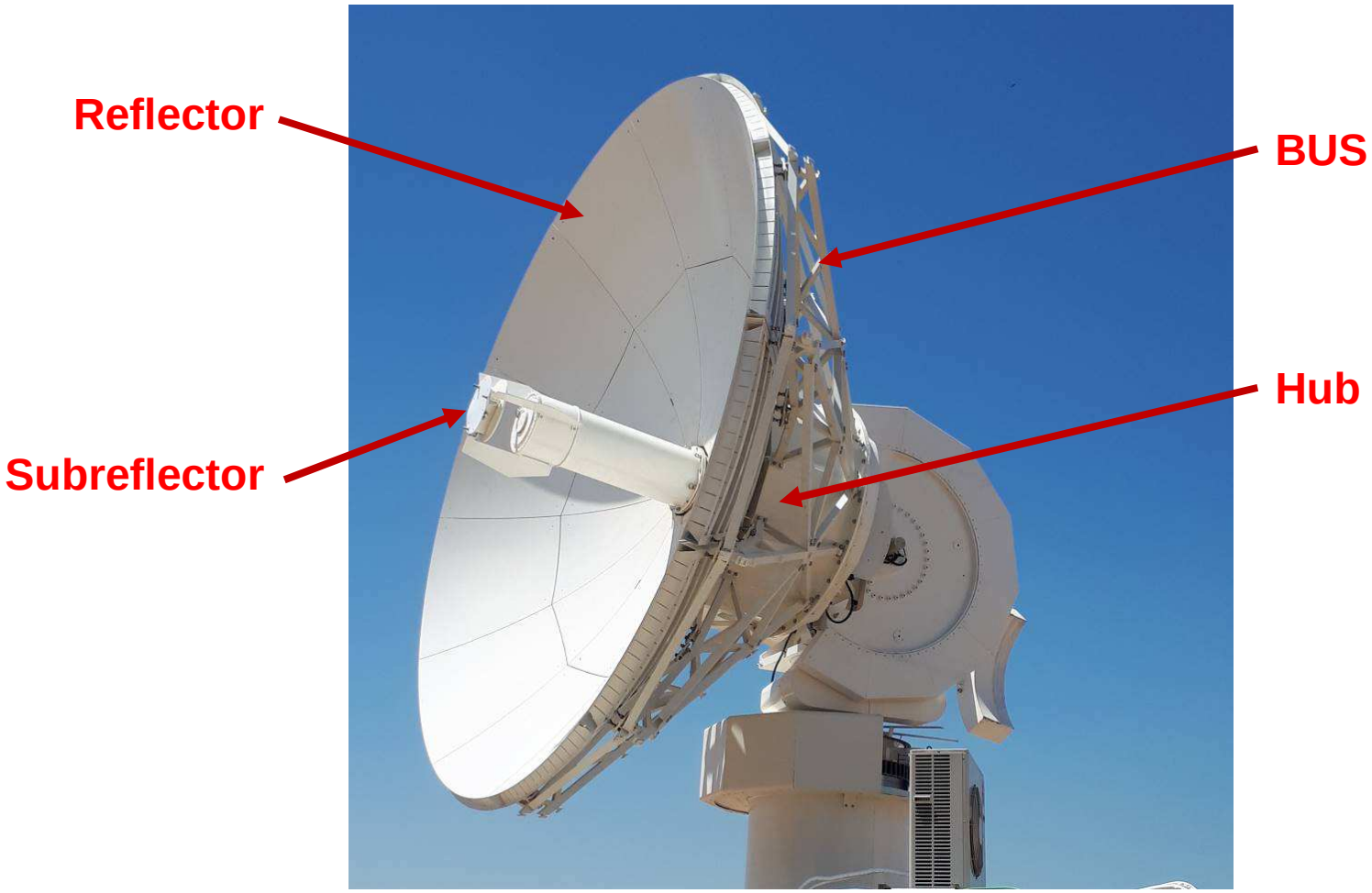
X and Y axes combined motion



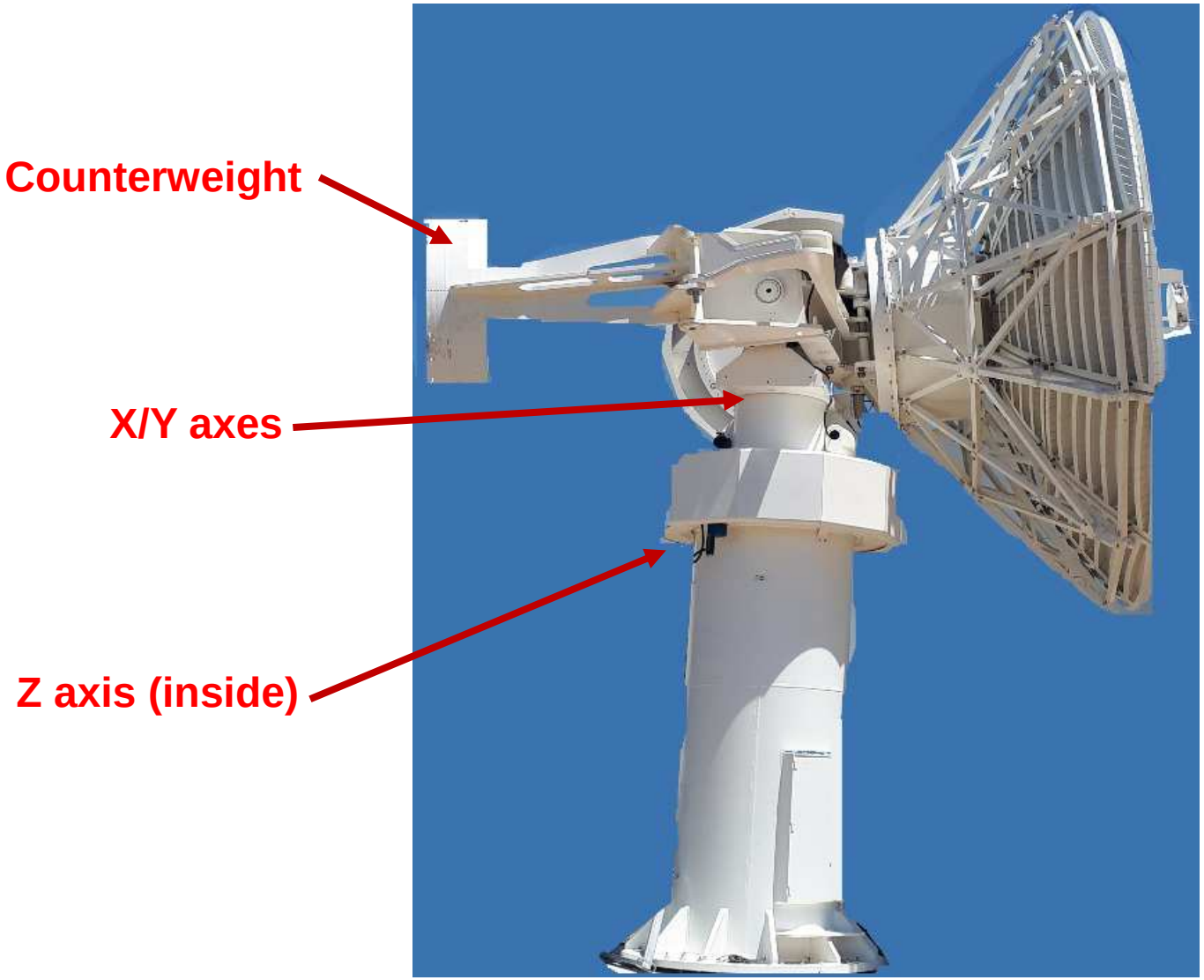
Y=30º, X=90º/-90º

For combined motion of X and Y axes, the aim of the Counterweight is to equilibrate the system during this combined rotation. In this case the CoG is between green lines A and B, and as close as possible to X axis

MECHANICAL DESIGN



MECHANICAL DESIGN



MECHANICAL DESIGN

- The antenna HUB has a considerable size allowing to host K-Band components including down-converters as close as possible to the LNAs.

MECHANICAL DESIGN

SERVO Subsystem main features:

- Controls the antenna motion, limiting the acceleration and velocity of each axis.

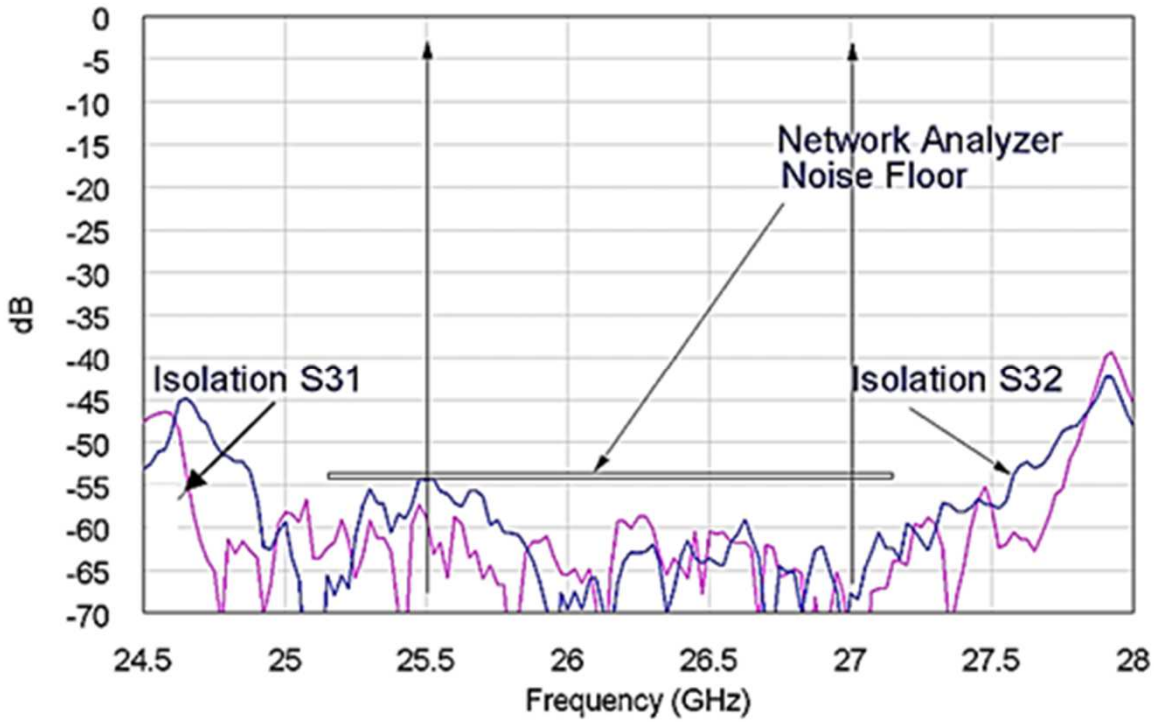
- Guarantees the safety of the motion, by means of several travel limits, emergency pushbuttons and interlocks distributed along the Positioner structure and Servo Drive Cabinet.

- Implements several tracking strategies: Program Track and Autotrack (feedback of error signals received from the Tracking Receiver)

- Interfaces with the Monitoring and Control System in order to accept motion commands and returns the servo system status.

TEST RESULTS

- K-band (I)
  - Feed Isolation
    - P3-P4 Isolation > 28 dB
    - P3-P1 Isolation > 55 dB → **Negligible Crosstalk, ideal for monopulse tracking**

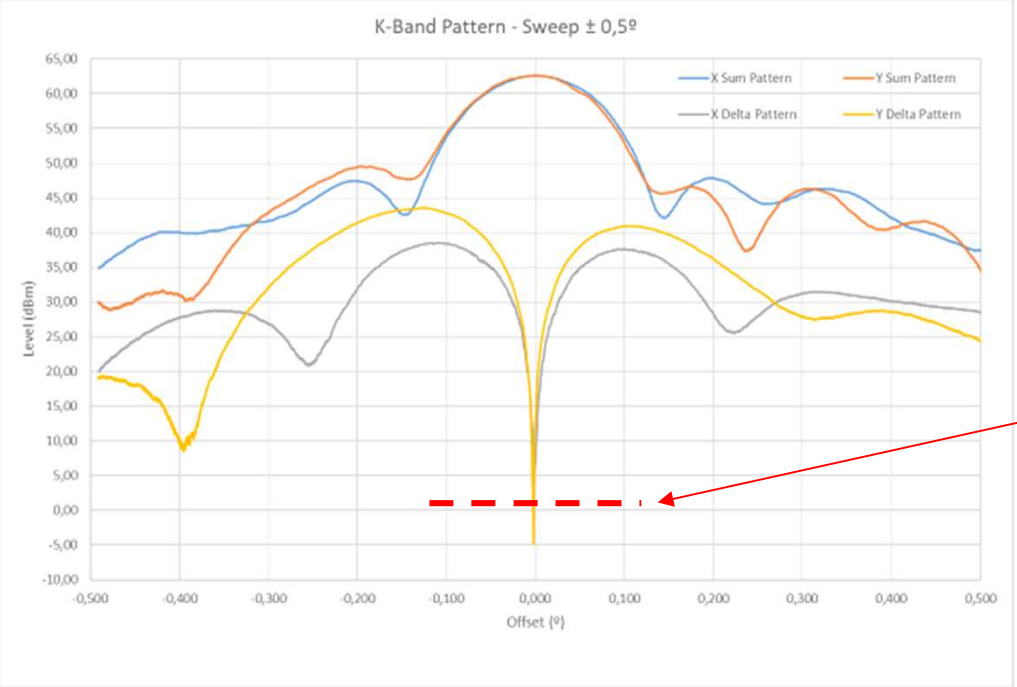


TEST RESULTS

- K-band (II)
  - Feed Insertion Losses
    - Better than -0.18 dB
  - Feed Return Losses
    - S33, S44 < 20 dB
    - S11, S22 < 20 dB
  - Antenna Directivity and G/T
    - Antenna directivity ≥ 63.1 dBi
    - G/T ≥ 36.1 dB/K (with nominal configuration, derived from measurements)
  - Axial Ratio
    - < 0.55 dB (Feed including radome window)
    - Outdoor measurement not valid due to the calibration tower
  - Pointing Accuracy
    - Sigma 6.7 mdeg
    - Adjusted with Sun and GEO satellites in several iterations

TEST RESULTS

- K-band (III)
  - Sum and Delta Radiation Patterns
    - Side lobes > 15 dB
    - 3 dB Beamwidth: 0.116º@25.5 GHz and 0.113º@27 GHz
    - Null depth higher than 45 dB → **ideal for monopulse tracking**

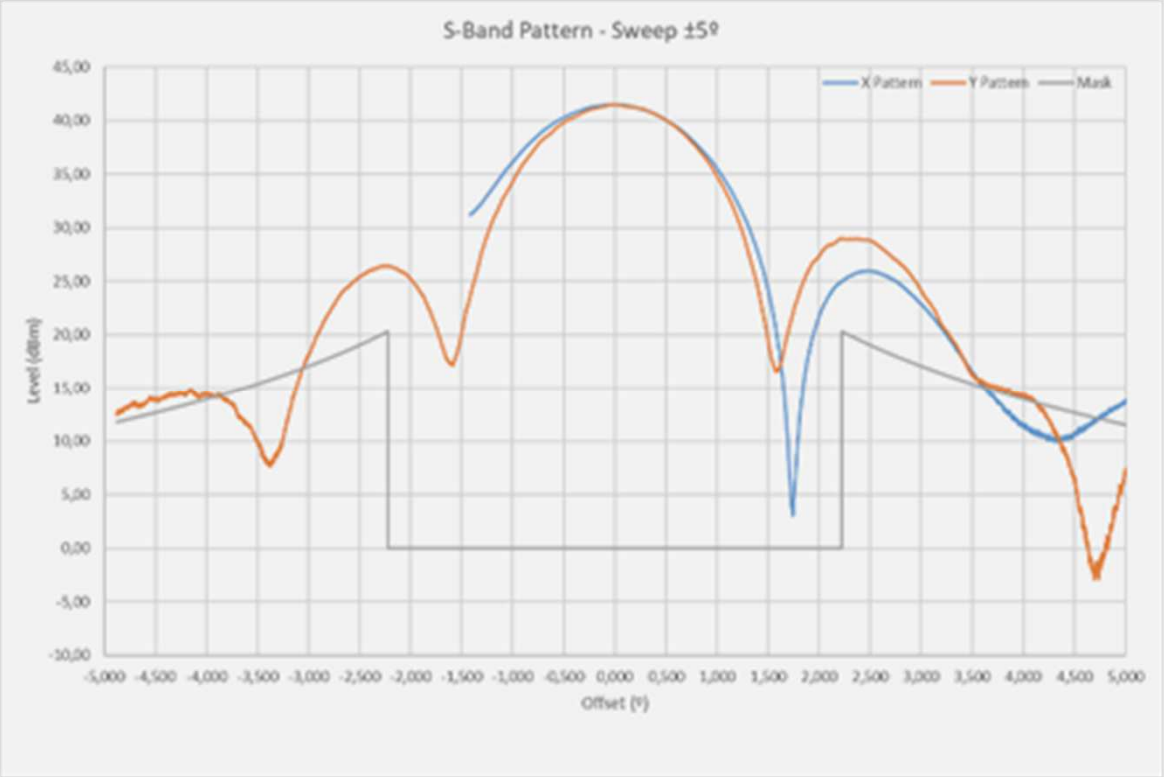


TEST RESULTS

- S-band (I)
  - Feed Isolation
    - Signal ports > 20 dB
  - Feed Return Losses
    - Better than -20 dB
  - Feed Axial Ratio
    - < 1 dB
  - Antenna Directivity and G/T
    - Antenna directivity ≥ 41.9 dBi
    - G/T ≥ 18.3 dB/K (theoretical with nominal configurations, derived from measurements), ≥ 20.4 dB/K (theoretical reception only)

MEASUREMENTS

- S-band (II)
  - Radiation Patterns
    - Side lobes > 15 dB
    - 3 dB Beamwidth: 1.4º@2250 MH



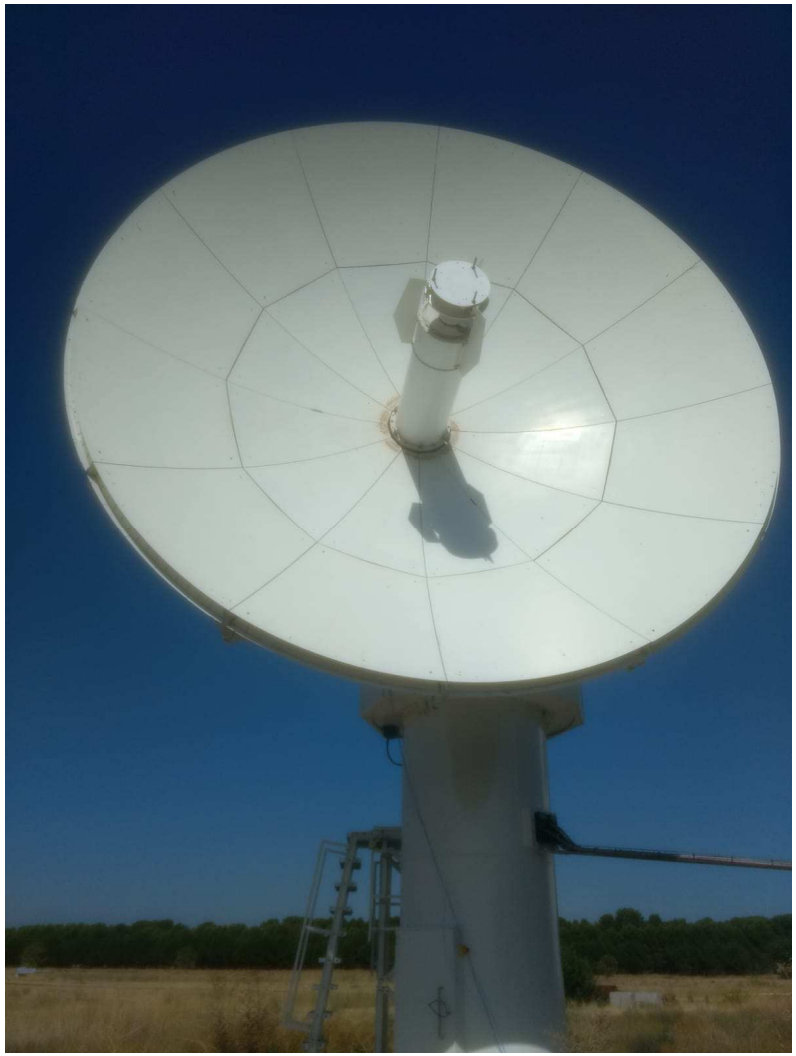
CONCLUSIONS

- Project innovations in different knowledge domains
  - Innovative dual S/K Band feed solution coaxial feeder where inner horn provides K-band and outer horn provides S-band. Including monopulse autotrack.
  - Antenna reflector. Innovative manufacturing process for the antenna reflector with vacuum forming and bonded panels (to be executed within Spanish industry)
  - X/Y/Z Innovative positioner solution. High precision mechanical design able to work in K-band frequency and keep pointing accuracy with such narrow beamwidth.
  - Design to cost. Design to cost efficient ratio, developing a solution

CONCLUSIONS

- Main achievements:
  - Novel compact simultaneous K/S-band feed for next generation of Earth Observation ground stations
  - Positioner X/Y/Z, minimizing the axes speed in LEO/MEO applications.
  - Excellent K-Band radioelectrical performances (0.118 deg at 3 dB beamwidth; antenna directivity ≥ 63.1 dBi)
  - G/T ≥ 32 dB/K (measured with limited LNA performances, and no down-converter gain)
  - Reflector surface accuracy < 0.085 mm RMS
  - 2 channel monopulse with a Tracking null depth ≥ 40 dB

CONCLUSIONS

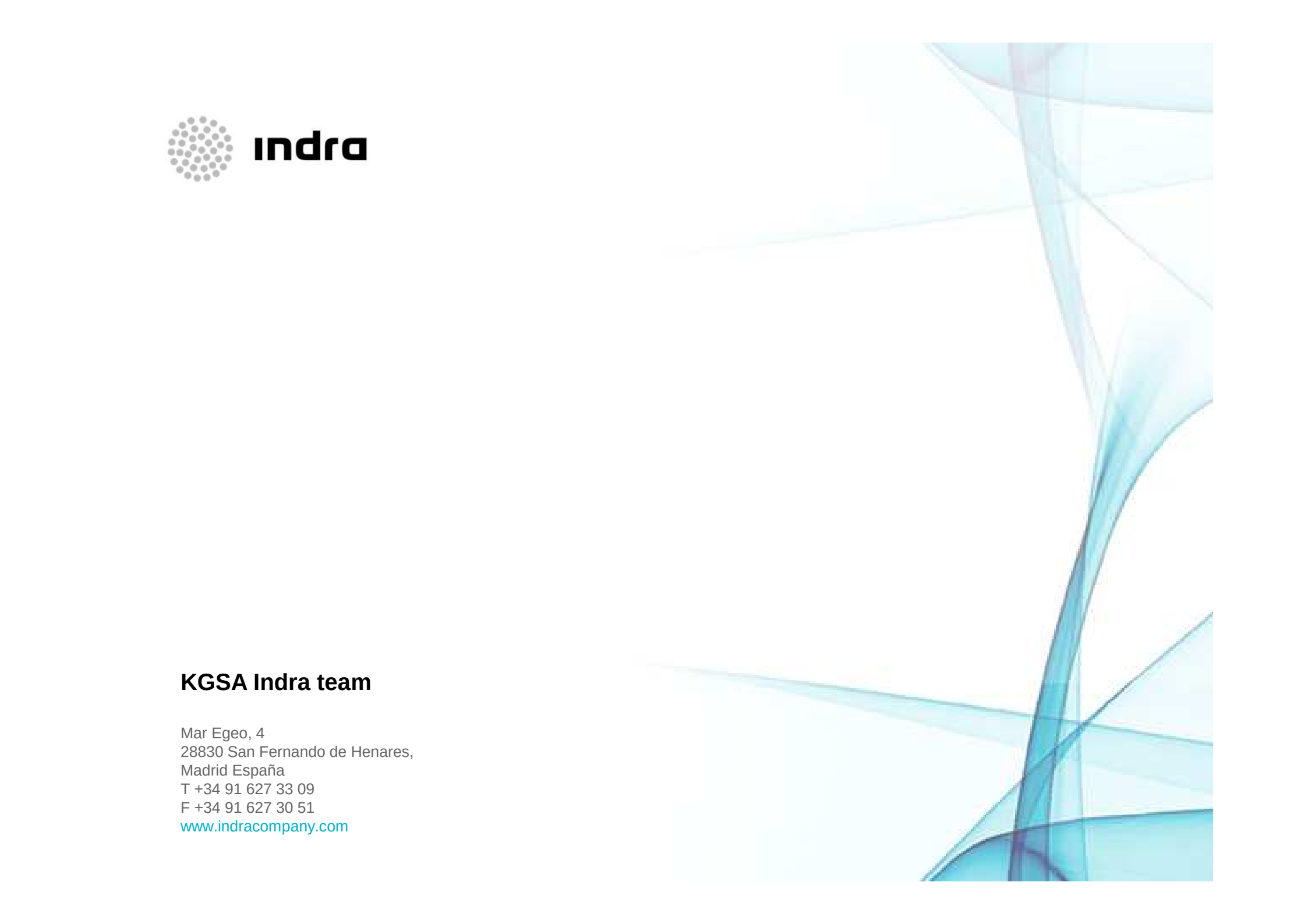


6 meter K/S-band tracking antenna for LEO/MEO applications

K-Band receive and monopulse Tracking chains

S-Band transmit and receive chains for Telemetry and Telecommand

X/Y/Z Positioner (no limitation for high elevation satellite passes and minimum axes velocity)



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