SENER
Aeroespacial

SENER Aeroespacial - **Antennas for Space Missions**

María Angeles González

Leading innovation through technological differentiation

With the strength of a global leader, SENER Group looks to the future by leveraging innovation and reinventing excellence, adapting it to new demands.

Our passion for technological challenge drives us to systematically consider how to offer a differential value in the realization of projects through new and better technologies.

SENER
2020 Facts and figures

Founded in 1956, SENER ranks as the largest privately owned engineering company in Spain.

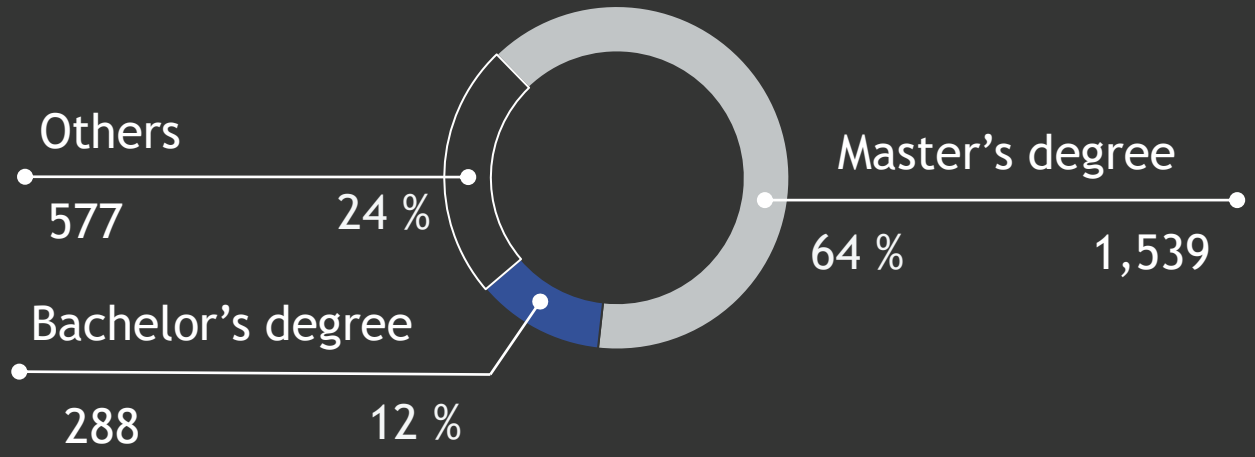
DISTINCTIVE VALUES
- Innovation
- Quality
- Independence

Turnover (M€)
417

Non Spanish sales
82%

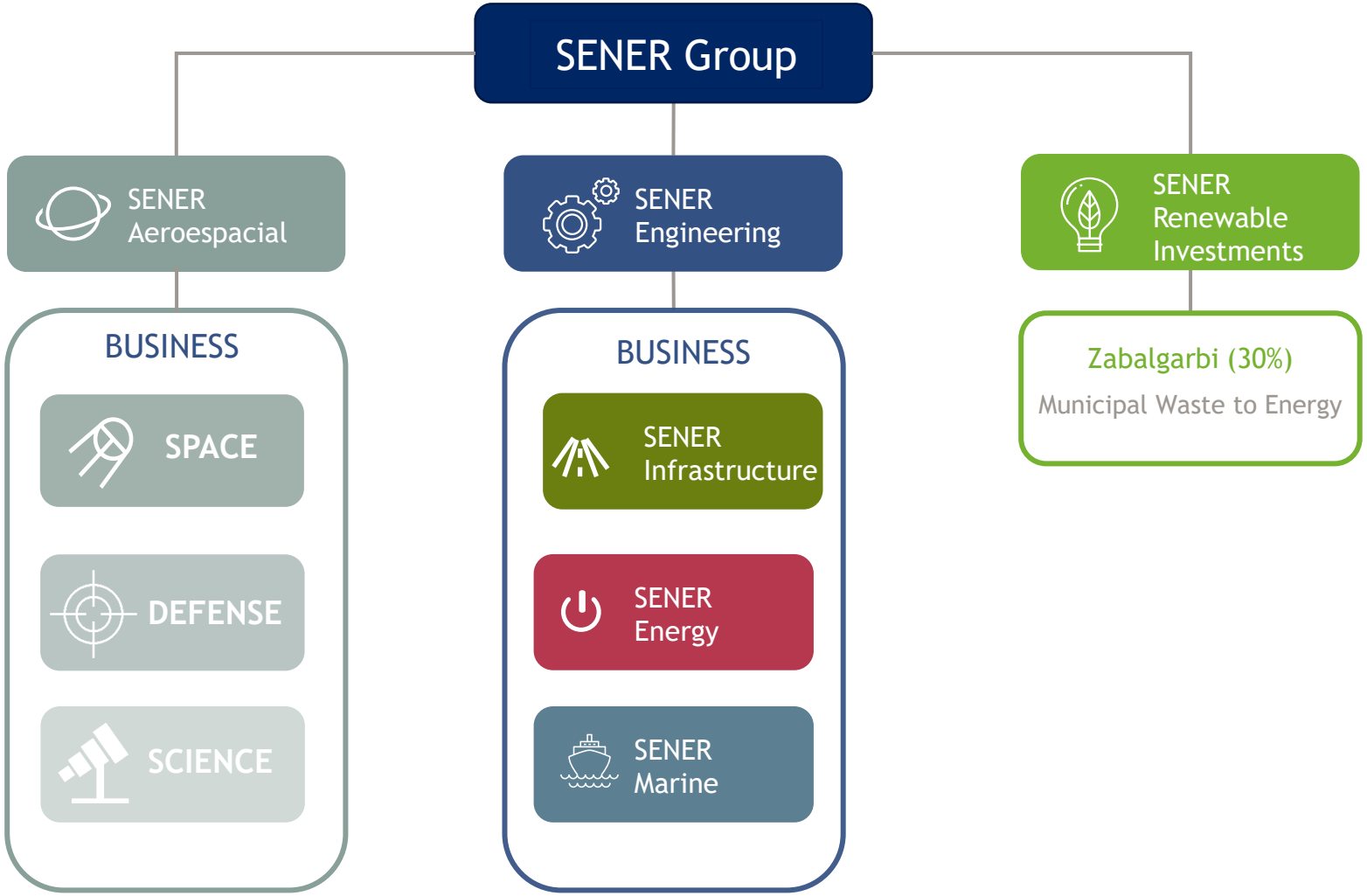
Workforce
2,404

PERCENTAGE OF GRADUATES IN ENGINEERING (2020)



SENER Group
Organization chart

SENER is a privately owned engineering and technology group.



SENER AEROESPACIAL

Leading innovation.
In SENER we create innovative Aerospace solutions.

SPACE | DEFENSE | SCIENCE

SENER Aeroespacial

Resulting figures

Turnover (M€)	Order intake (M€)	Workforce	R&D investment
90.4	171	684	11%

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Markets

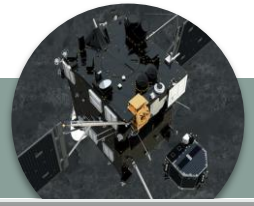
SPACE

SCIENCE

DEFENSE

SENER Aeroespacial

Activities per sector



SPACE

- Mechanical ground support equipment (MGSE)
- Rotary actuators
- Mechanisms for platforms & Payloads

DEFENSE

- Fin control and actuation systems (CAS)
- Stabilization systems

SCIENCE

- Ground telescopes mechanical systems
- Mechanisms for RIs

POSTION, NAVIGATION & TIME SYSTEMS (PNT)

- Attitude control
- Guidance, navigation and control
- Test equipments
- Hybrid navigation equipment

- Autonomous Navigation

RF & COMMUNICATION SYSTEMS

- Antennae pointing sub-systems
- RF active, passive and antenna products

- Communications intelligence (COMINT)
- Data Link Systems

- Waveguides and cavities for accelerators and other research institutes

SENER Aeroespacial

Offices & locations

Las Arenas-Vizcaya
7,969 m²
SEM Electromechanical Systems

Tres Cantos-Madrid
13,659 m²
ASA Avionics & Advanced Systems
SEM Electromechanical Systems

Arganda del Rey-Madrid
COM Communications. Antennas and RF Passives
TCOM (SENER RYMSA)

Cerdanyola del Vallès-Barcelona
5,700 m²
SEM Electromechanical Systems.
COM Communications. RF Actives

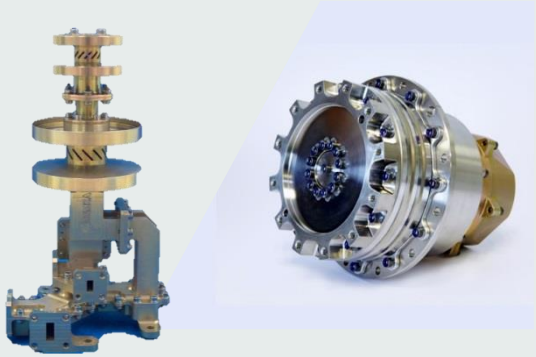
Brussels
75 m²
Belgium
EU and NATO Programmes

Warsaw
457 m²
POL
SENER Polska

SENER Aeroespacial
Space Heritage

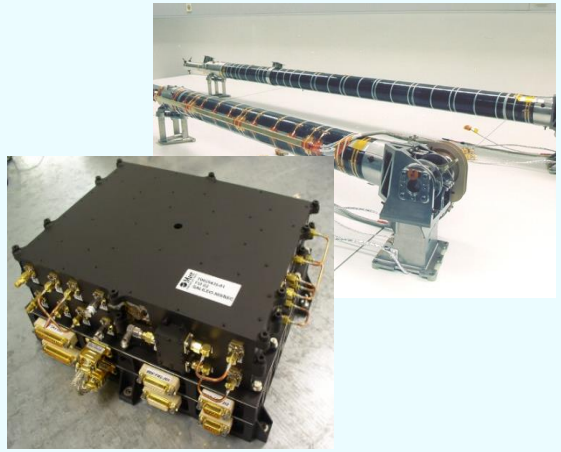
SENER Aeroespacial Space Heritage

10,000 + Hardware Units



For 1400+ Telecom Satellites

Present in 100+ Scientific & EO Satellites



Providing 1200+ Eq. & Subsystems

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Customer map

ThalesAlenia Space
289 sats. 2138 units

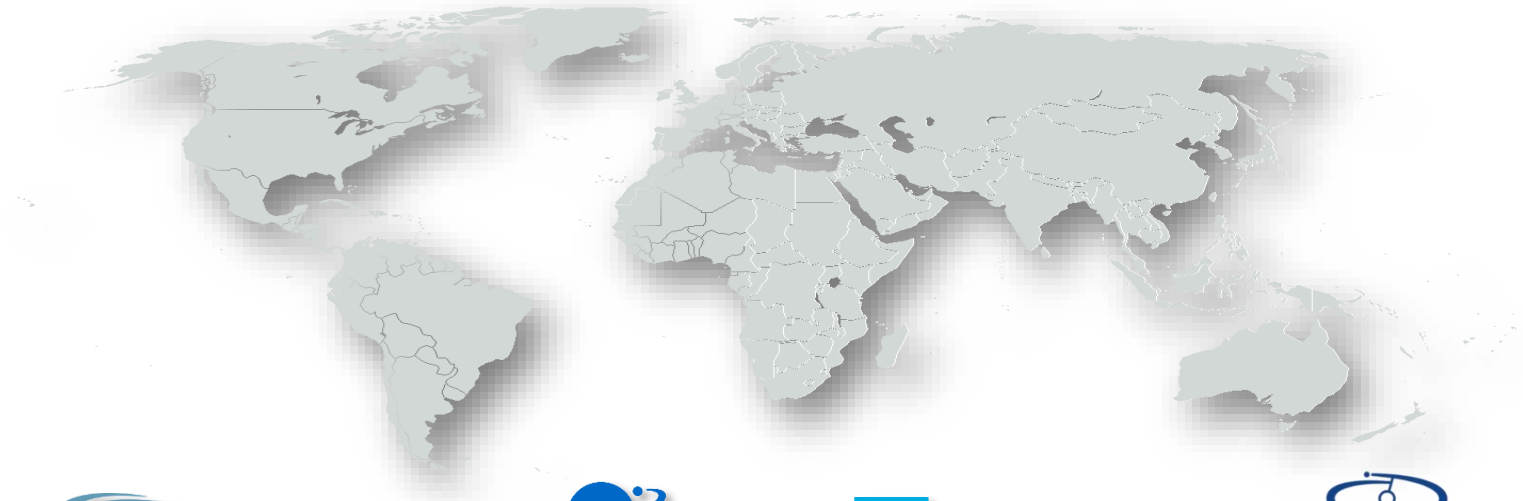
AIRBUS DEFENCE & SPACE
143 sats. 1782 units

SSL
78 sats. 2934 units

NORTHROP GRUMMAN
47 sats. 727 units

OHB
37 sats. 74 units

SURREY SATELLITE TECHNOLOGY LTD
35 sats. 75 units



AVIO ADVANCED VISION INTO ORBIT
26 launchers 56 units

LOCKHEED MARTIN
22 sats. 78 units

MDA
7 sats. 118 units

TESAT SPACECOM
4 sats. 7 units

BOEING
3 sats. 14 units

MITSUBISHI ELECTRIC
3 sats. 13 units

OHB LUXSPACE
3 sats. 13 units

ariane GROUP
2 launchers 7 units

Ball Aerospace & Technologies Corp.
2 sats. 3 units

RESHETNEV COMPANY
1 sats. 10 units

esa
R&D developments

Supplier of 7952 units of hardware for 622 satellites and 28 launchers
6855 units delivered / 5815 units successfully launched

\+ OneWeb Satellites
704 sats. 2816 units

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SPACE

- Electro-mechanical systems
- Navigation systems
- Communication systems
- Opto-mechanical systems

SPACE

- Electro-mechanical systems
- Navigation systems
- Communication systems
  - Antennas
  - Passive equipment
  - Active equipment
  - Baseband modulators
  - Software Defined Radio (SDR)
  - Electromechanical pointing
- Opto-mechanical systems

What is a satellite?

"Repeater" in space or a privileged "observer"

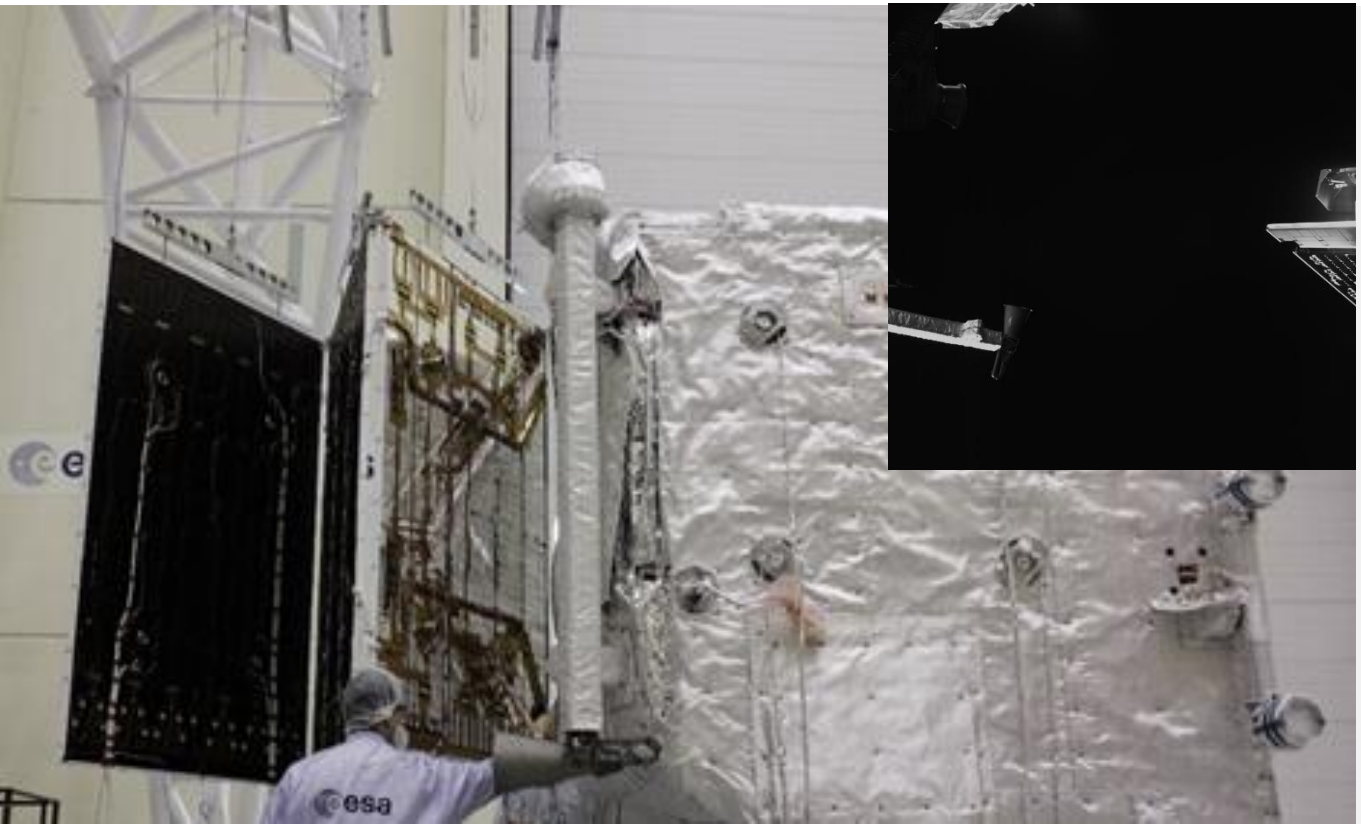
Antennas for space missions
Classification

Huge variety of antenna types for space missions (satellites and vehicles)

- **Applications:**
  - Scientific
  - Military
  - Commercial
- **Orbits:**
  - LEO (200km)
  - MEO (1,000km)
  - GEO (36,000km)
  - Polar orbit and Sun-synchronous orbit (SSO)
  - Transfer orbits and geostationary transfer orbit (GTO)
  - Lagrange points (L-points)
- **Missions**
  - Telecommunications
  - Scientific
  - Earth Observation
  - Human Exploration
  - Navigation
- **Purpose**
  - Telemetry and Telecommand (TTC)
  - Telecommunication Services
    - RF Instrument
- **Gain**
  - High Gain
  - Medium Gain
  - Low Gain
  - Shaped Pattern
- **Frequency ….**

Scientific missions

MGAMA & HGA-APA antenna for Bepi Colombo satellite

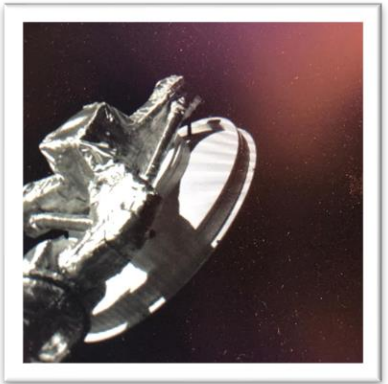


SENER's responsibilities entail the design, manufacturing, integration, and test of the low – gain antenna (LGA) medium-gain antenna (MGAMA) and high-gain antenna pointing mechanism (HGA-APA) of the mercury planetary orbiter (MPO) communications system.

Both antenna and mechanism are crucial to guarantee satellite-Earth communications and also to support the Radio-Science experiment aboard the spacecraft.

https://www.youtube.com/watch?v=VtJOQFykV_U

Scientific missions
SOLar Orbiter antenna sub-system

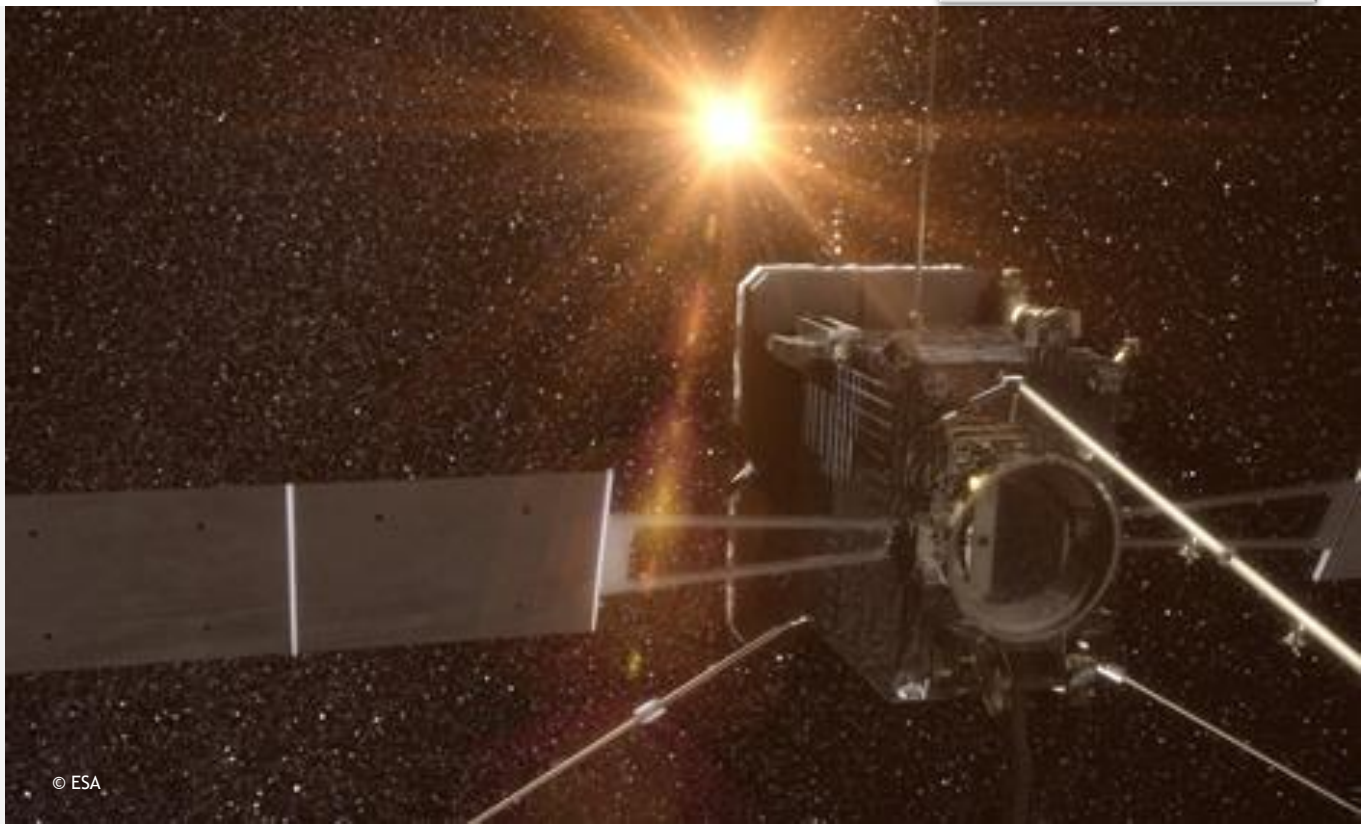


SENER designs, manufactures, integrates, tests, and delivers the complete antenna sub-system of the SOLar Orbiter satellite.

The sub-system is comprised of the following elements:

- High-gain antenna (HGAMA),
- Medium-gain antenna (MGAMA), and
- Low-gain antenna (LGAs).

All capable of operating under extreme thermal conditions due to the nature of the mission.



https://www.youtube.com/watch?v=3y1_Hq59MeM

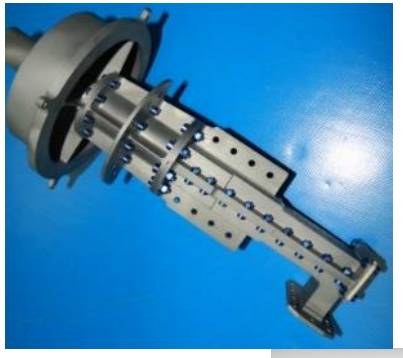
Scientific missions

SOLar Orbiter antenna sub-system

Complete X-band TT&C antenna S/S

- **Titanium based antennas**
- Stringent thermal environment with gradients higher than 500 ºC. Simulation software to predict RF performance in temp. Silver plating over titanium qualification needed.

LGA

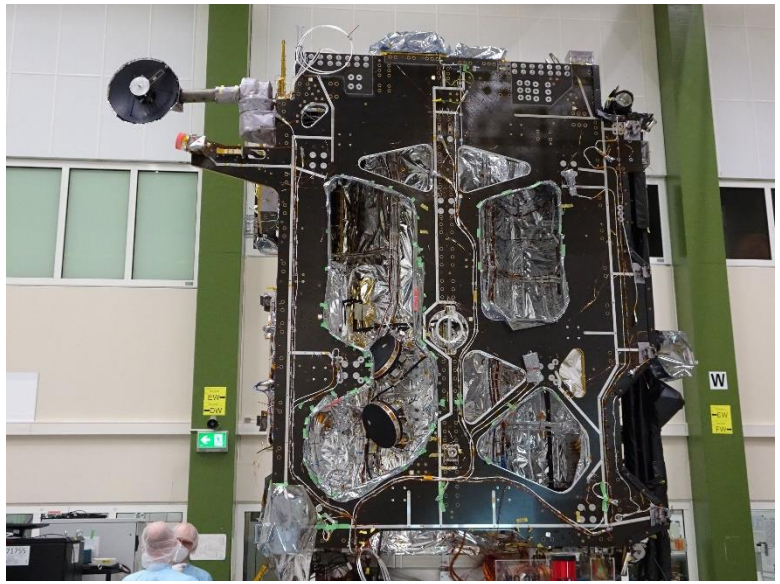


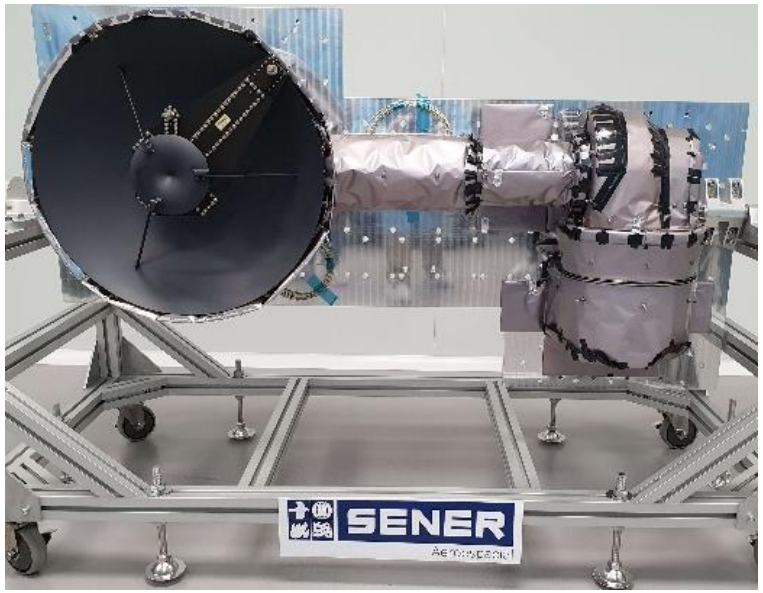
MGAMA

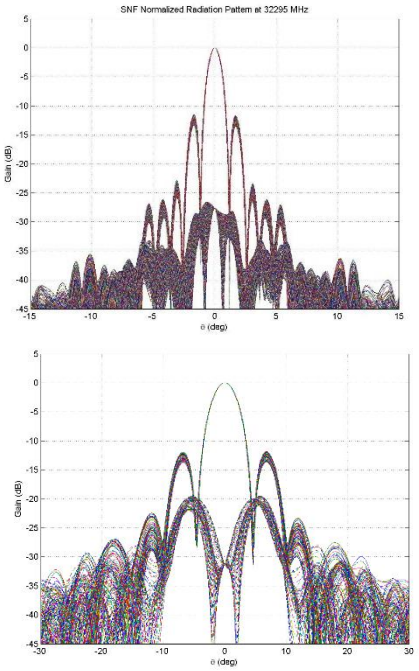
HGAMA

Scientific Missions
JUICE X/Ka MGAMA

- **X/Ka Band Medium Gain antenna**
  - Antenna reflector assembly (ARA), dual band feed, two rotary joints, boom, waveguides, hold down and release mechanisms (HDRM), antenna pointing mechanism (APM) and antenna pointing mechanism electronics (APME)
  - Steerable in two axes with pointing enhanced performances
  - Novel and compact X/Ka dual band feed
  - Optimized size/performance ratio
  - Gain 31.1 dBi @ X-band and 43.2 dBi @ Ka-band





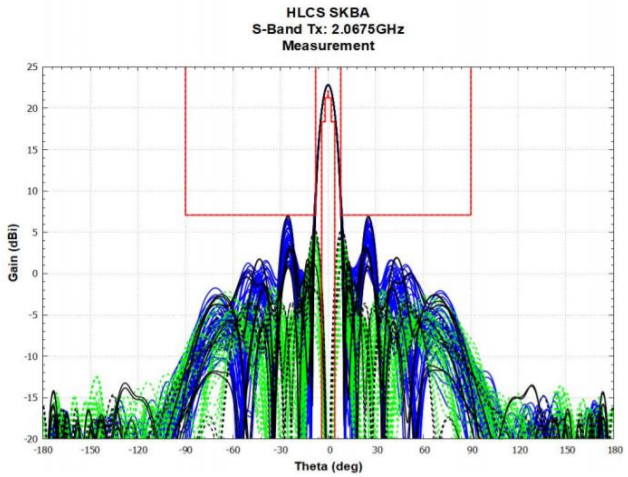


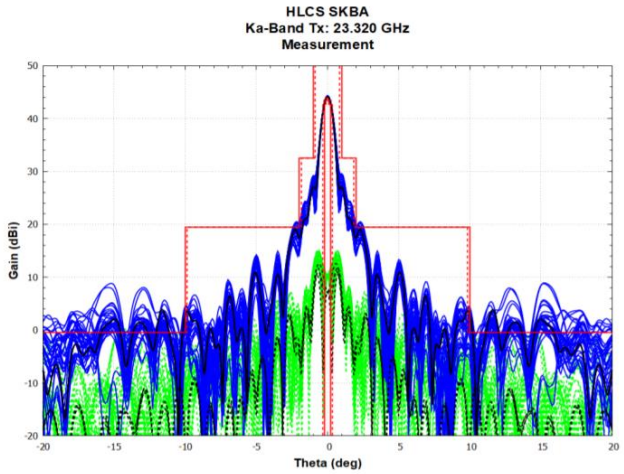
Human Exploration missions

HALO - Lunar Deep Space Gateway

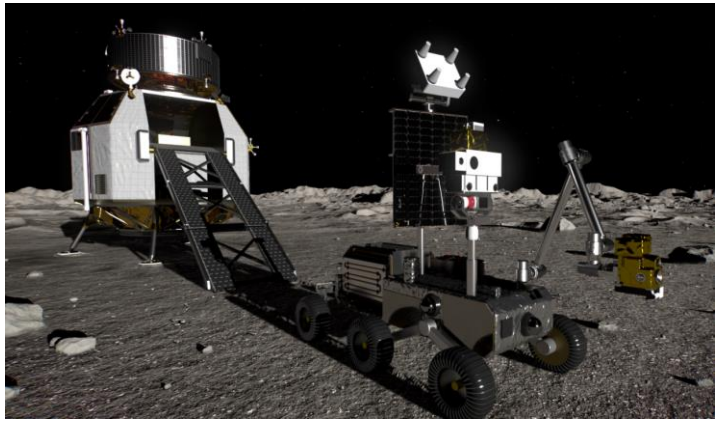
Dual S/K band reflector antenna

- Cassegrain 1250mm aluminum reflector with dual S/K-Band feed.
- Elevation pointing mechanism [0º 180º] and azimuth pointing mechanism [-90º +90º] . S and Ka band signals go through coaxial and waveguide rotary joints, respectively.
- Structural boom: Which provides proper structural support to the antenna and hosts the RF harness formed by WR-34 waveguides and an S-band coaxial cable.
- Deployment actuator. This actuator provides 90º [0º +90º] pointing capability.
- Hold Down Release Mechanisms (HDRM).
- EM model successfully validated.



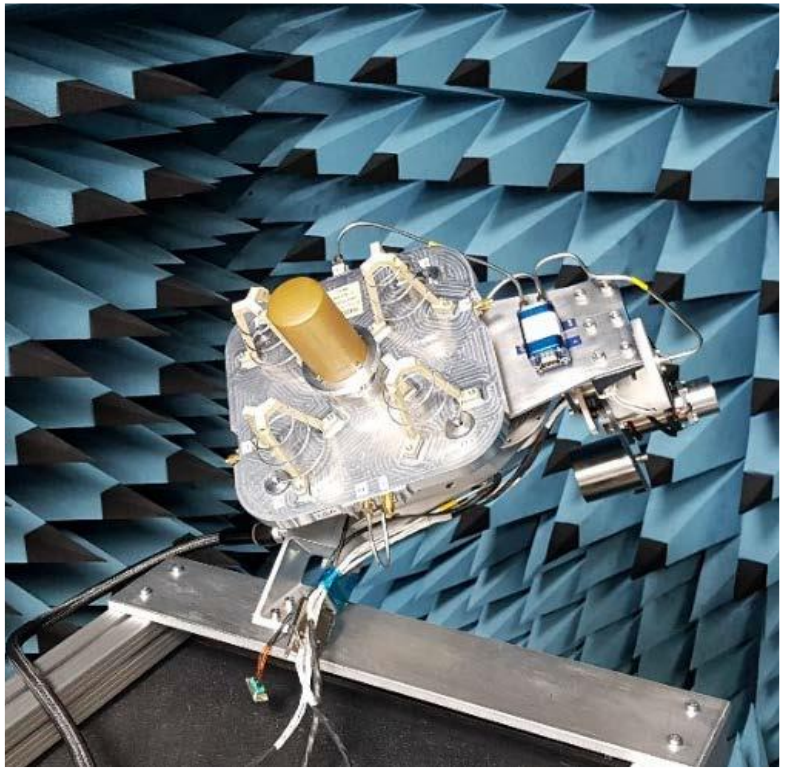


Human Exploration Missions
Antennas for Lunar Rovers and Landers



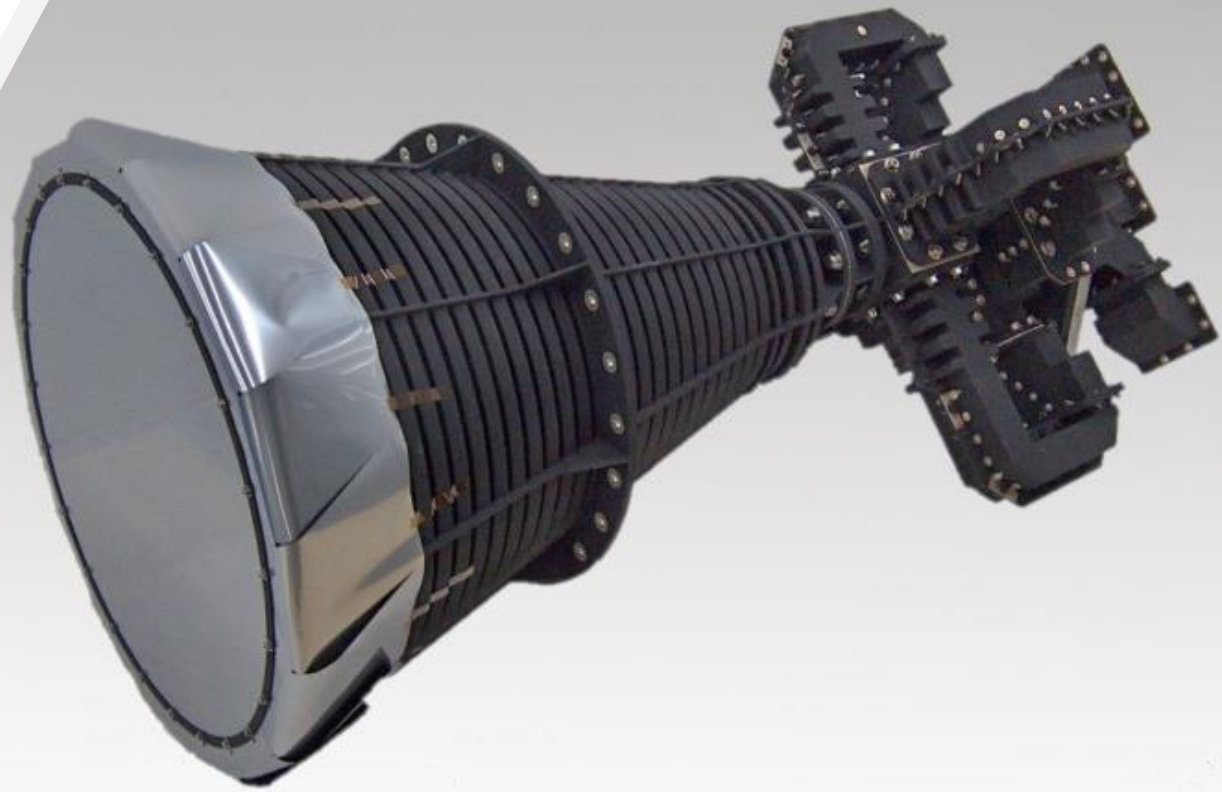
S-band dual gain (LGA/MGA)

- Antenna for Lunar Ascent/desdenct module.
- Dual-axis mechanically steerable
- Two different modes of operation:
  - Medium gain beam: Array of monofilar helices,
  - Low gain beam: Quadrifilar helix located at the center of the array.
- Gain selectable through an electromechanical coaxial switch
- Breadboard model has been manufactured



Antennas

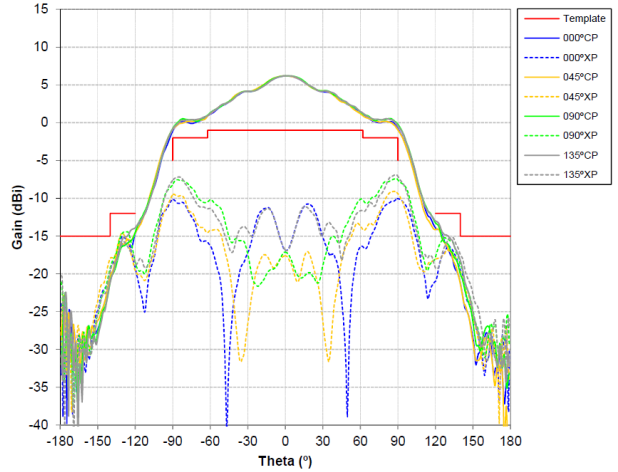
- TT&C
  - Low Gain
  - Medium Gain
  - High Gain
- Payload Data downlink
- Global coverage
- Shaped beam
- Feed Horn assemblies
- Custom designs

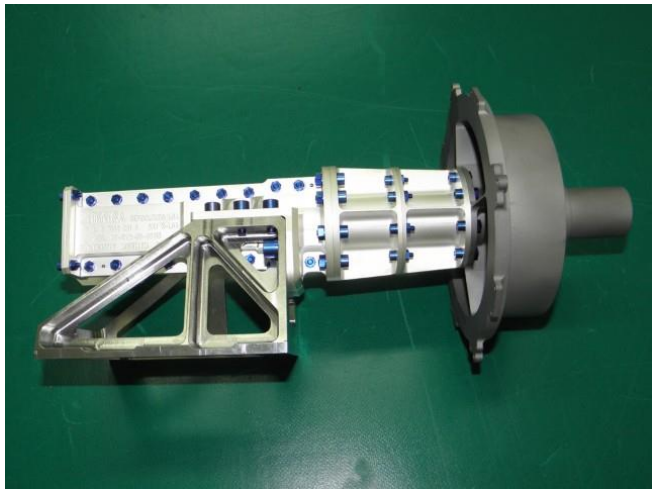


Antennas

TT&C Antennas (hemis and wide coverage)

- Very extensive presence in the TTC subsystems of the main platforms of GEO telecom satellites all over the world
- On board Low Earth and Medium Earth Orbit constellation of satellites
  Globalstar-2, O3B, Iridium NEXT, OneWeb
- Used in X Band for TTC subsystems in scientific missions
  Herschel, Planck, Rocsat, BepiColombo, Lisat Pathfinder, Gaia, Exomars, Solar Orbiter
- Customizable in all aspects
  Hemispherical or wide angle pattern; wide band performance; different mechanical attachment options; any type of interfaces; test caps supplied when required

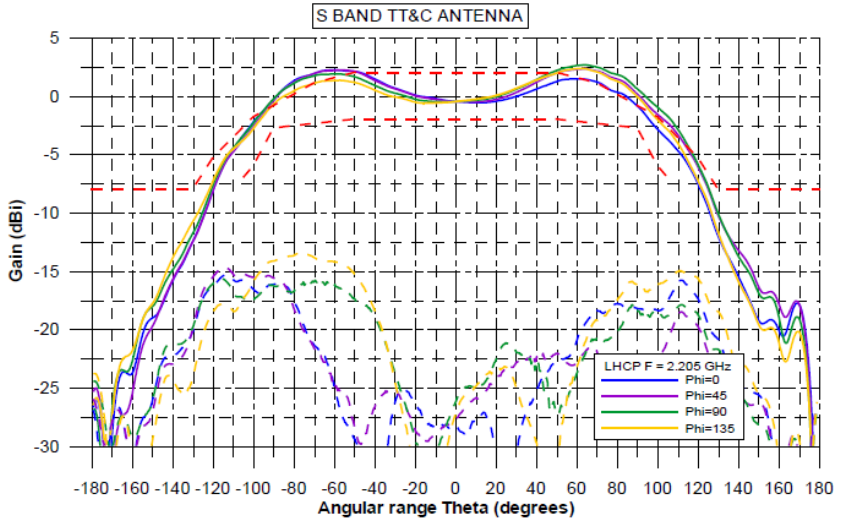


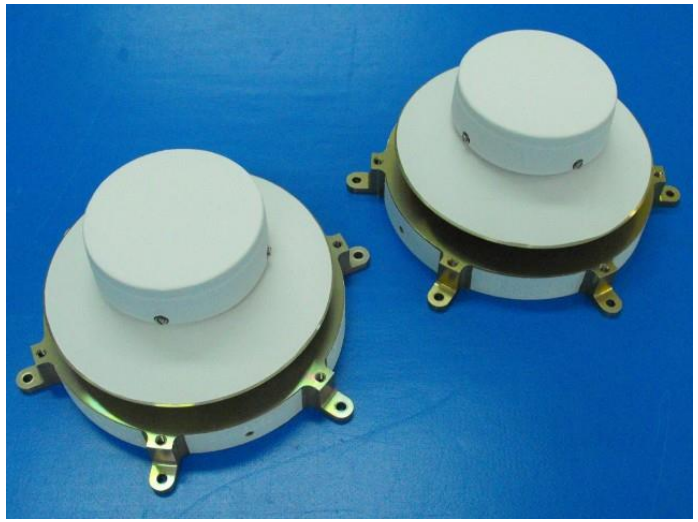


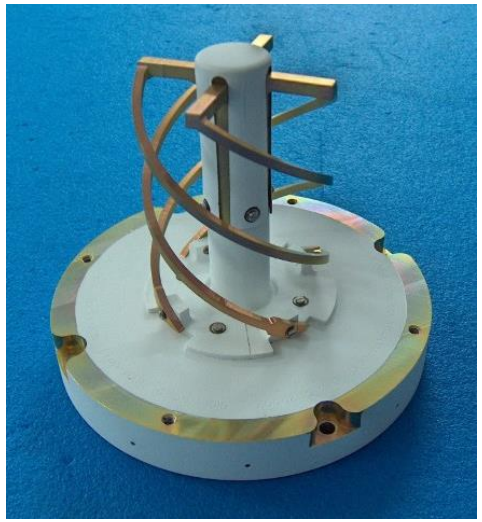
Antennas
Helix and patch antennas

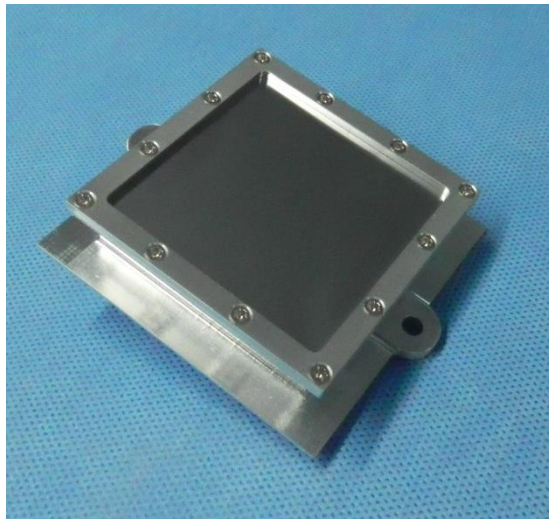
- Typically used for GPS applications or TTC subsystems due to its wide angle coverage:

  Low Earth Orbit (LEO) Satellites
  Geostationary Communication Satellites
  ATV Supply Vehicle for International Space Station
  Europe's global navigation satellite system: Galileo (IOV and FOC Phases)
  Exomars Descend Module
  VEGA ESA's series of small launchers
  Intermediate eXperimental Vehicle, IXV



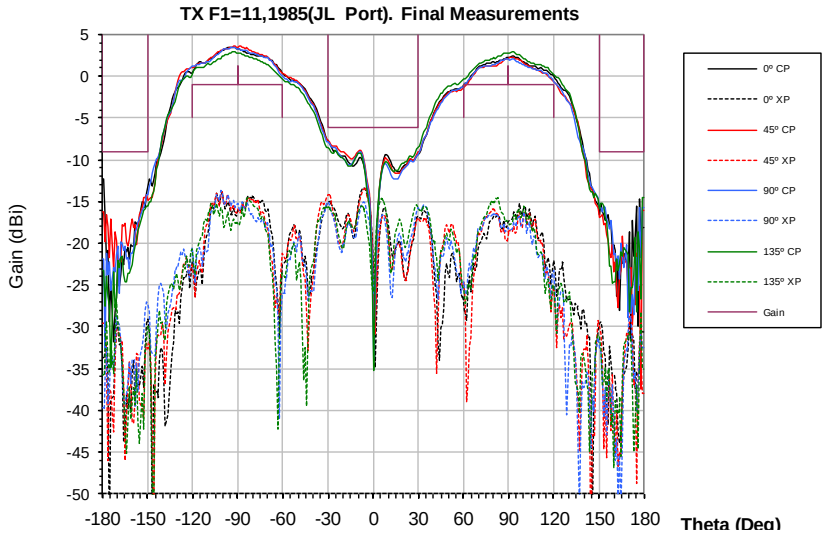


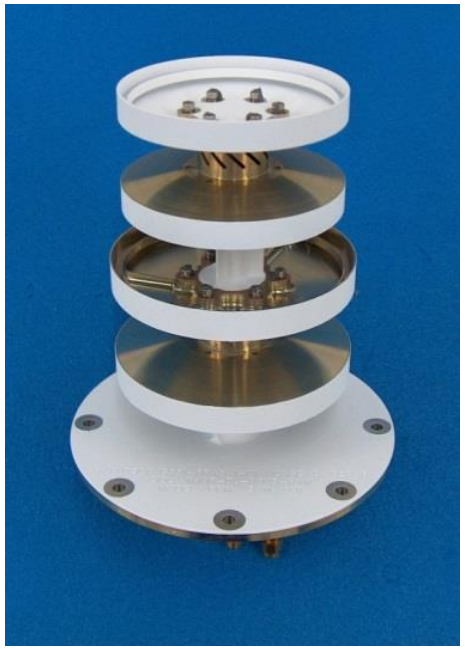




Antennas
TT&C Antennas (toroidal)

- Widely present in the TTC subsystems of US satellite platforms
- Different design options are available
  - Dual band (transmit / receive) operation in a single antenna
  - Wide band designs with either circular or linear polarization
  - Toroidal or semi-toroidal patterns
  - Designs available in all bands from S Band to Ka Band

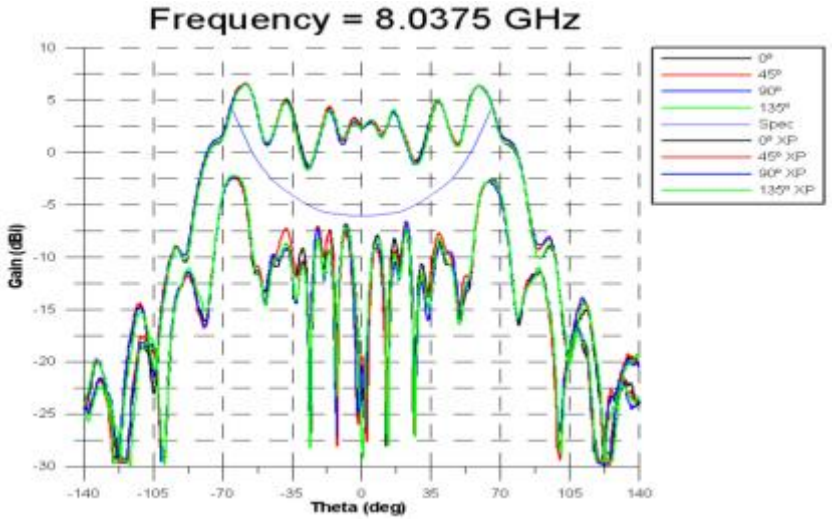


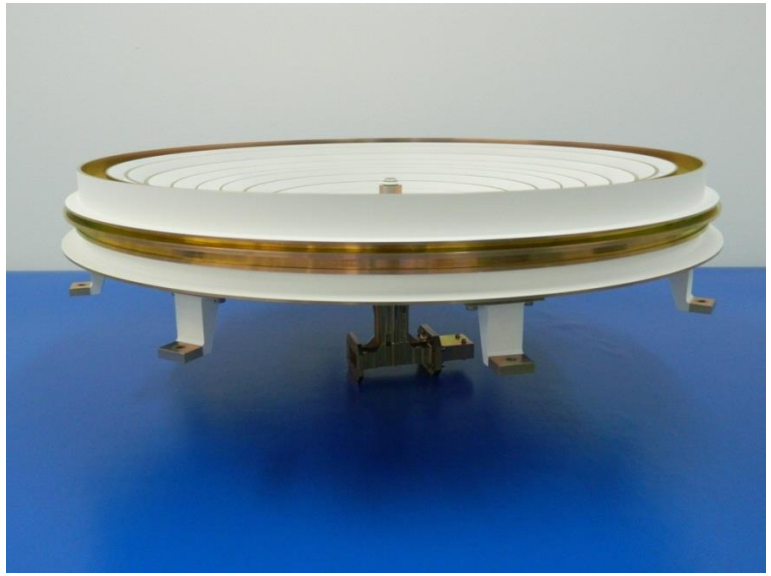


Antennas

X Band isoflux antennas

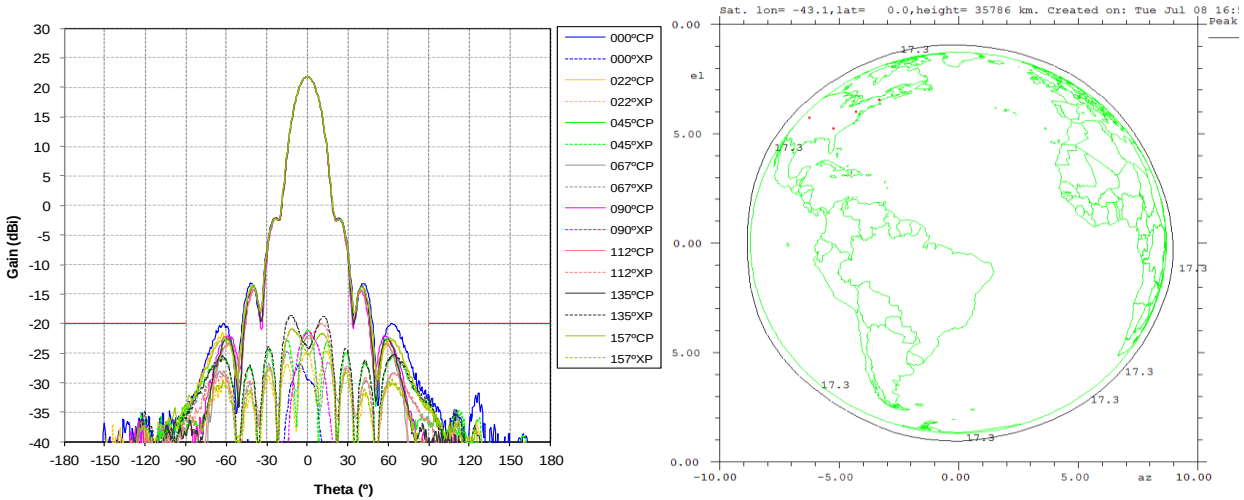
- Used for data downlink from Low Earth Orbit (LEO) satellites in Earth Observation missions
- Isoflux Gain Pattern with gain figure up to 6.75 dBi at 63º from boresight
- Qualified design on board wide amount of Earth Observation missions
- Support structure is customizable for the mission requirement

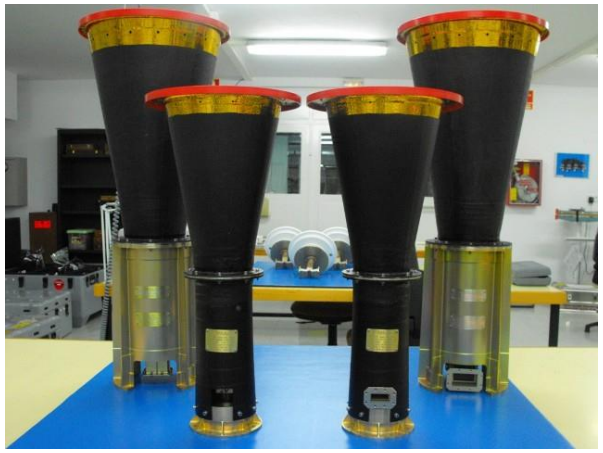


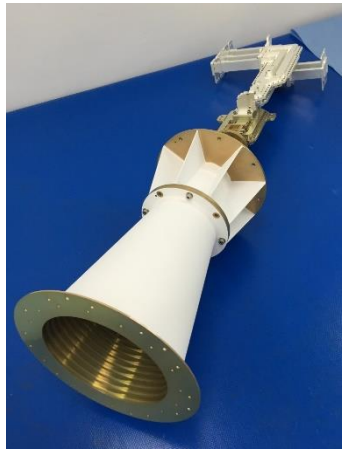


Antennas
Conical horn antennas

- Transmit and Receive Horn Antennas in all bands
  - L Band, S Band, C Band, X Band, Ku Band, K Band, Ka Band
- Custom Feed Network
  - Linear / Circular Polarization (OMT, Septum polarizer, …)
  - Custom designed filters, diplexers or triplexers
  - Test Couplers
  - Waveguide/Coaxial Interfaces/Internal waveguide loads
- Mechanical design for mass optimization
  - Intermediate flange, lateral bracket or vertical support
  - Implementation of desired pointing angle
  - CFRP combined with Aluminium Alloy when convenient

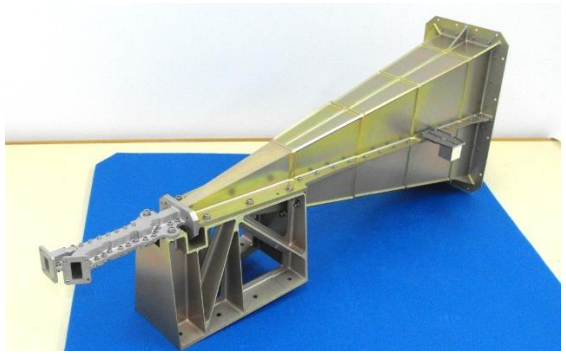


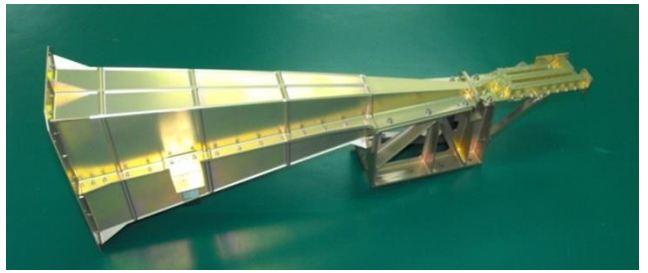


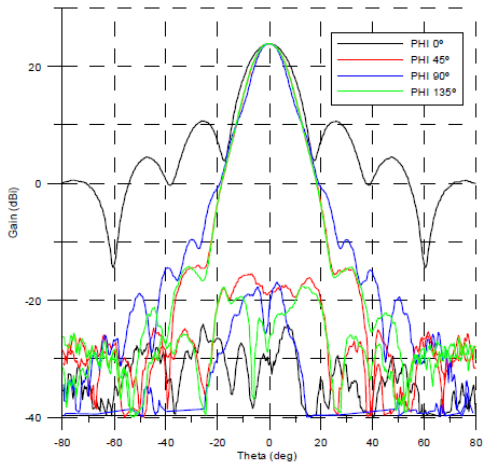


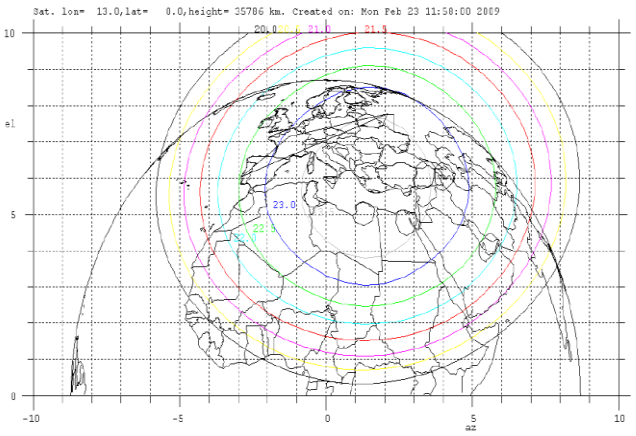
Antennas
Pyramidal horn antennas

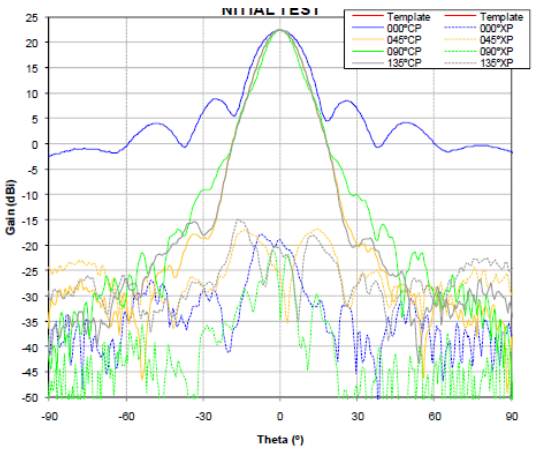
- Typically used in Ku Band and Ka Band TTC subsystems for On-Station TCR, providing shaped coverage with minimum gain values assured for particular Earth regions
- The Feed Network may include Diplexers or Triplexers for band discrimination (Transmit, Receive, Beacon) or Ortho-Mode Transducers for polarization discrimination
- Support Bracket design is specific to the mission requirements and desired pointing angle

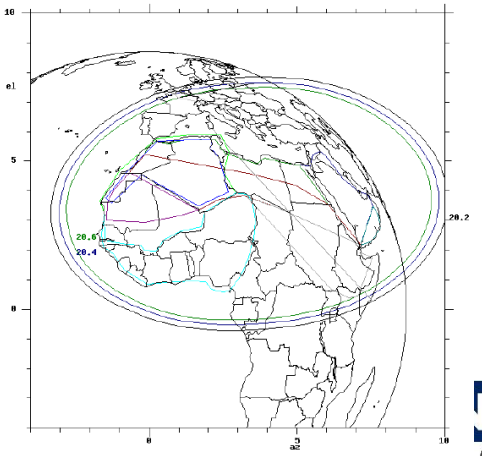








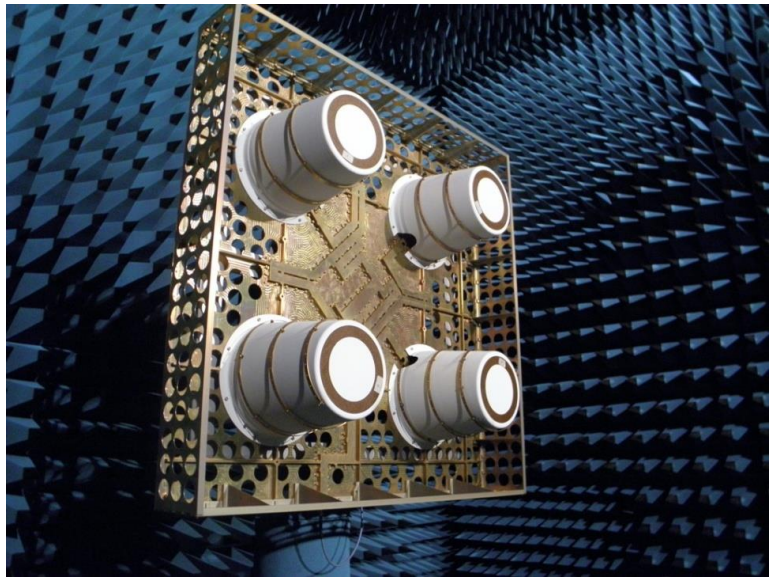


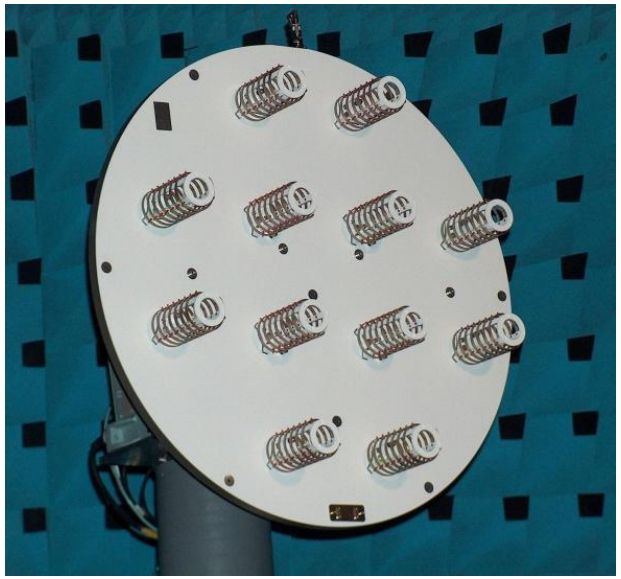


Aeroespacial

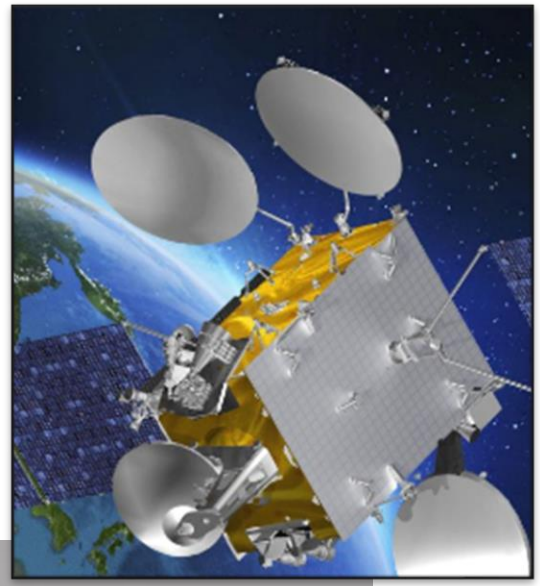
Antennas
Array antennas

- Global coverage in low bands (UHF, L and S Bands), where conical horns become too big
- Gain pattern performance can be optimized in response to particular requirements
- Standard Gain performance is G > 17 dBi or G > 13 dBi for EoC $|\theta| < 9^{\circ}$
- Low Axial Ratio within EoC (AR < 1 dB)
- Novel concept of compact C-band feed cluster for multibeam reflectors

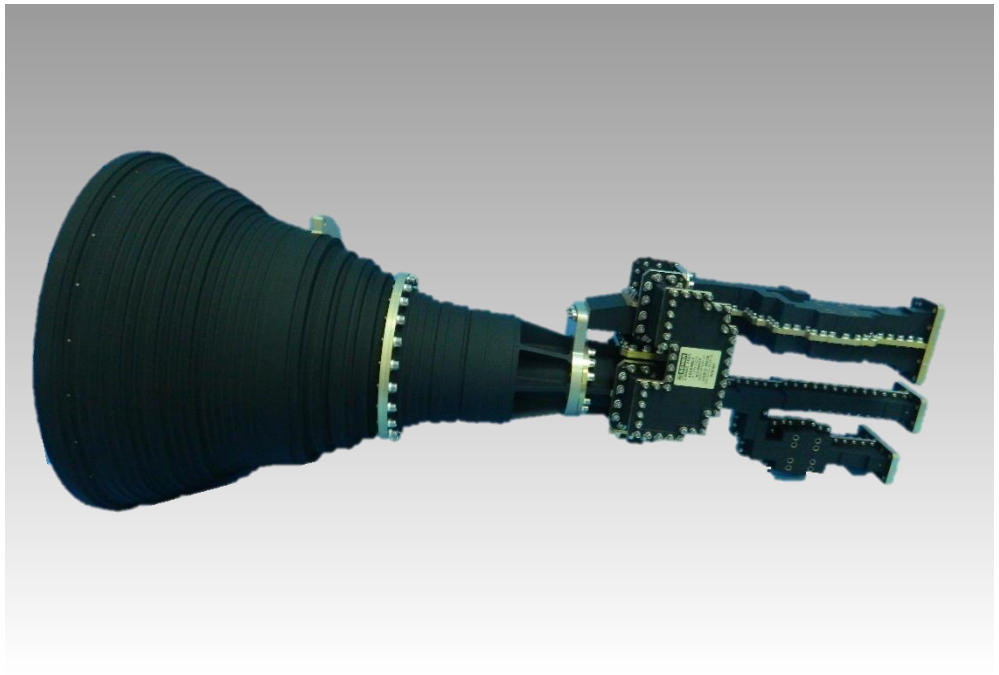




Antennas
C band feed horn assemblies



- Lightweight machined corrugated feed horn antenna
  RF internal profile may be furnished by the Customer or optimized to meet specific requirements
- Wide Dual Band Operation Compact 4-Port Linear or Circular Polarization Ortho-mode Transducer
- Thermo-mechanical design of the complete assembly and support brackets designed in response to specific mission requirements



Antennas
Ku band feed horn assemblies

- Lightweight machined corrugated feed horn antenna

  RF internal profile may be furnished by the Customer or optimized to meet specific requirements

- Very compact wide band asymmetrical LP OMT covering both Ku-Band TX and RX bands (11 to 14.5 GHz)
- Wide band symmetrical LP OMT also available, covering both Ku-Band Fixed Satellite Service (FSS) and Broadcasting Satellite Service (BSS) TX and RX bands (10.7 to 18.1 GHz)
- Thermo-mechanical design of the complete assembly and support brackets designed in response to specific mission requirements

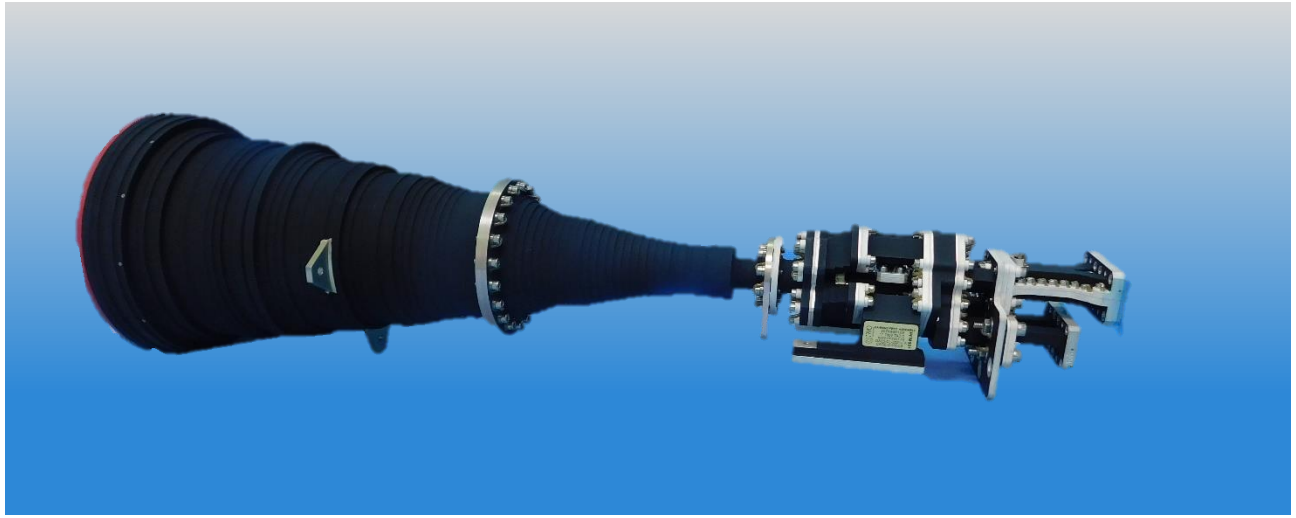
SES-14

Antennas
Ka band feed horn assemblies

- Lightweight machined corrugated feed horn antenna

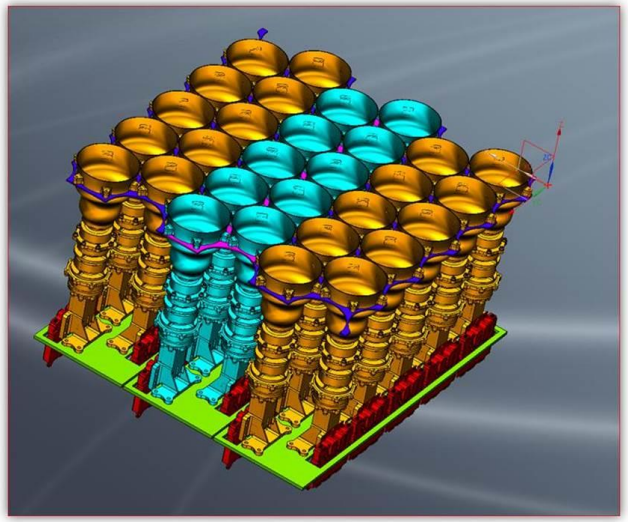
  RF internal profile may be furnished by the Customer or optimized to meet specific requirements
- Compact 4 Port CP OMT covering Transmit (17.7 to 20.7 GHz) and Receive (27 to 30 GHz) bands specifically designed for gateway beams in multibeam / feed cluster applications.
- Compact 2 Port CP OMT (<90g) covering 1GHz bandwidth suitable for user beams in for next generation satellites in multibeam / feed cluster applications.
- Thermo-mechanical design of the complete assembly and support brackets designed in response to specific mission requirements

HISPASAT 1F



Antennas
Direct Radiating Arrays

- Feed horn assemblies for X-band phased arrays, designed for a cluster assembly
- Transmit radiation chains include dual SSPAs
- Receive radiation chains include LNA

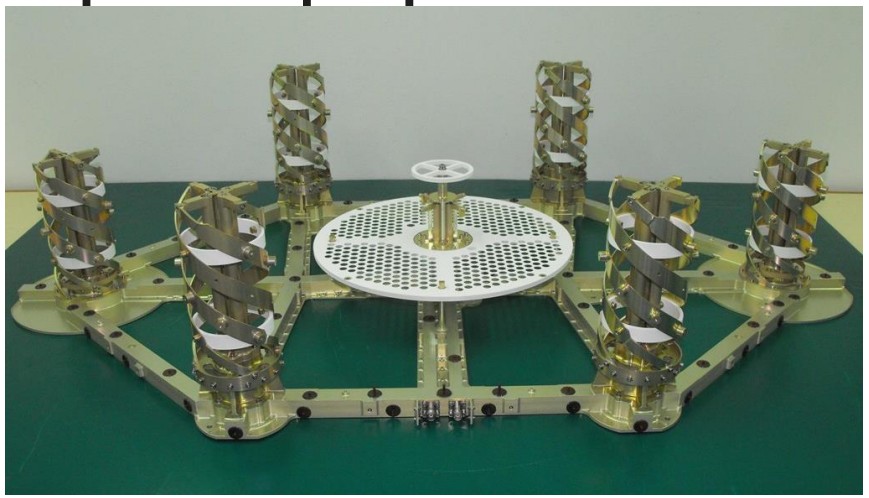


Parameter	Value
Frequency band	7.9-8.4 GHz
Gain	>39.5dB
Input power	-49dBm
OIP3	>14.5 dBm
Input Return Loss	15
Output Return Loss	18
Noise figure (25°C)	<1.5dB
Mass	<71 g
Size	81x 67.8 x 18 mm

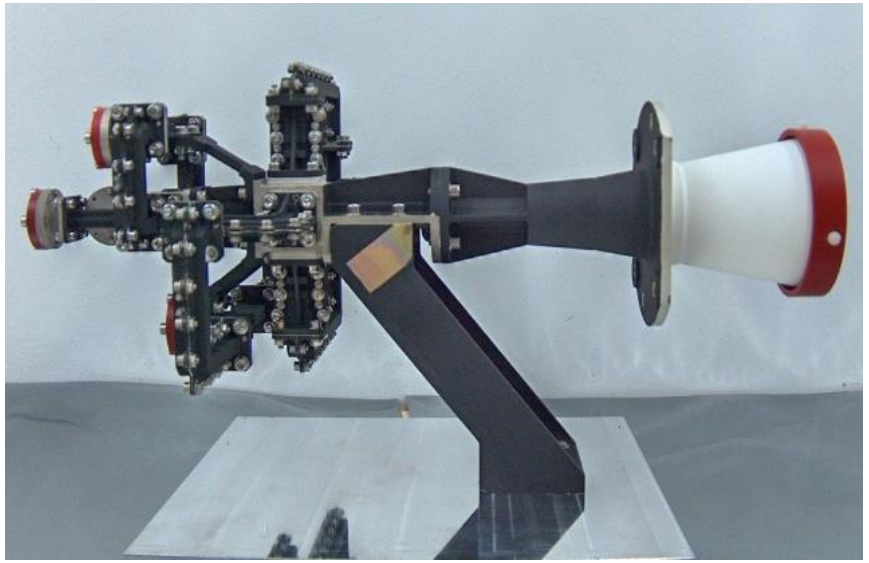
Parameter	Value
Frequency band	7.25-7.75 GHz
Gain	>49dB
Output power	>39.4dBm
PAE	>36% SCS
Output Return Loss	18
Noise figure (25°C)	<14dB
Mass	<111 g
Size	81x 81 x 16 mm

Antennas

Specific purpose antennas



- Dual Antenna for Search & Rescue payload on board all satellites in Galileo constellation
- Receive mission through UHF Band Array Antenna with helix unitary elements; transmit mission through L Band Short Back Fire Antenna



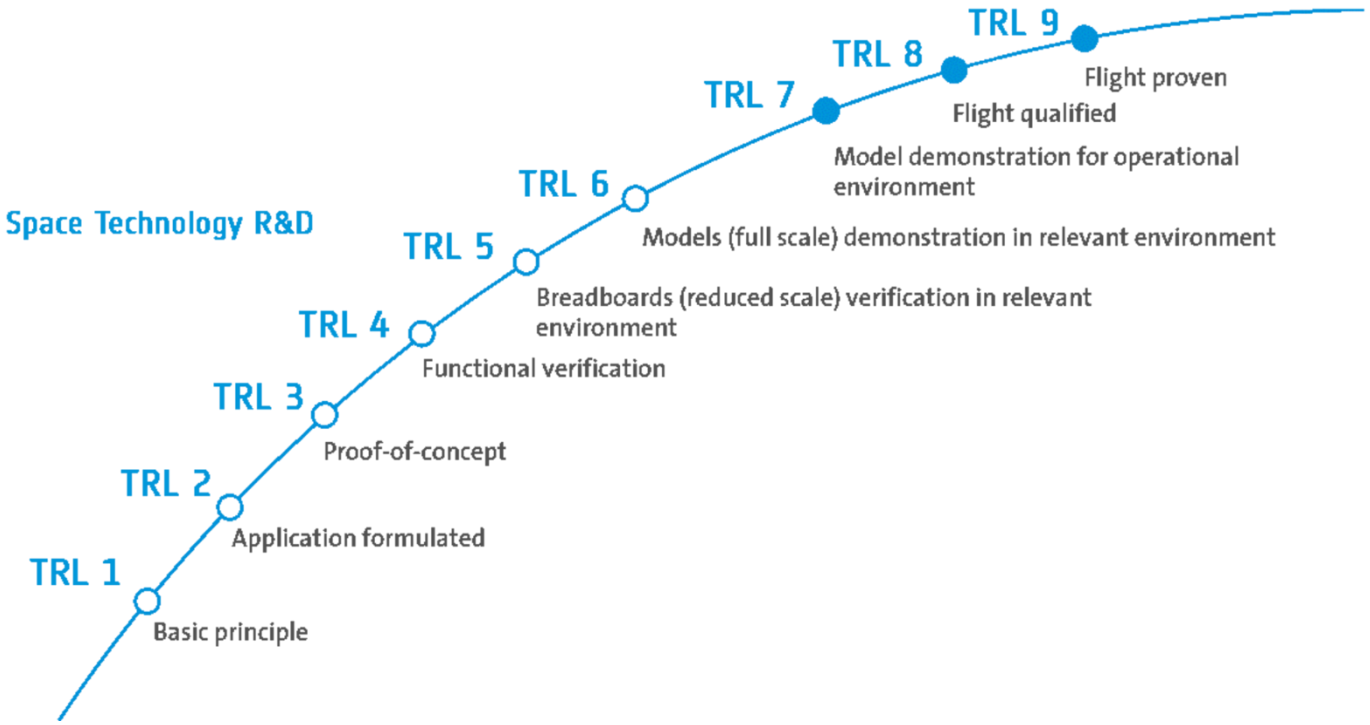
- K/Ka Feed Horn for MADRAS payload on board MEGHATROPIQUES Earth Observation mission (CNES / ISRO joint satellite).
- Three LP OMTs operating at 36, 24 & 18 GHz

Antennas Development

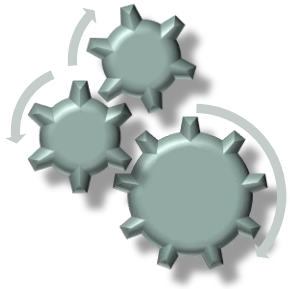
- TRL
- Design and analysis
- Machining
- WG manufacturing
- Assembly and integration
- RF and environmental testing

Space Antennas Development
Technology Readiness Level (TRL)

- Scale used to measure the progress or maturity level of a technology.
- The scale ranges from 1 to 9, where TRL 1 is the lowest and TRL 9 is the highest.
- TRL 1: scientific research is beginning and those results are being translated into future research and development,
- TRL 9: the technology has already been proven to work during a flight mission in space.



Space Antennas Development
Product flow



PROPOSAL PHASE

Engineering Support

Elaboration of **Preliminary Designs**

Response Customer's requirements during proposal phase

PROGRAM PHASE

Wide heritage
Low Non Recurring Effort

Custom designs
Optimized assemblies including Passive/Active equipment and Antennas

Specialty in **power handling and custom MMIC** design

Design-to-cost approach
Highly integrated supply chain

Fluid communication with Customer:
Design shaped to requirements

Mass production capacity

Full **control of schedule** thanks to in-house machine shop, MHIC production capabilities, surface treatment and test facilities

Space Antennas Development
Design and analysis

- Engineering capabilities in all areas

  RF, Electronics, Radiation, Software, Thermal, Mechanical, Product Assurance, Purchasing, CAD, Management, Testing, Commercial…

- Solid experience in Power Handling and custom MMIC design
- Advanced software tools (including commercial applications and proprietary SW)

  RF & Electronics: ADS, CHAMP, CST, FEST3D, GRASP, HFSS, MICIAN, MOMENTUM, SPARK3D, etc.

  Thermo-Mechanical: I-deas, FEMAP, NX NASTRAN, TMG

  CAD: SIEMENS NX exportable to IGES, STEP, Solid-Edge, CATIA, etc.

RF DESIGN & ANALYSIS

- RF Team organized by product type for better knowledge-sharing and R&D
- Custom MMIC design capabilities
- Dedicated expert group for High Power Handling

MECHANICAL DESIGN & ANALYSIS

- Modal analysis
- Strength design: quasi-static, sine, random and shock
- Fatigue analysis
- Condensed mechanical models
- Thermo-elastic analysis
- Venting analysis

THERMAL DESIGN & ANALYSIS

- Detailed and reduced FEMs
- Steady state (on-orbit) and transient cases (on-orbit & launch): temperature maps and heat fluxes
- Thermo-elastic models

CAD / CAM

- CAD Models directly accessible from CAM Office
- CAD Office with wide experience within the Company owning working experience in CAM and machining

Space Antennas Development
Machining & surface treatment

- Machine workshop for high precision & mass production machining

  11 CNCs (3- & 5-axis), 2 Wire & 3 Mould EDM Centers, 3 Turning Lathes, drilling, cutting, sanding machines…

- Automatic line of galvanic baths:

  Including ESA-qualified standards for high conductivity plating applied by electro-chemical or chemical deposition.

- Space qualified black & white painting facilities

Space Antennas Development
Assembly and integration

- Clean areas for assembly and integration

  600 m^2 (6,400 ft^2) Class 100.000 for Antennas & Passive Units

  500 m^2 (5,300 ft^2) Class 100.000 ESD-protected for Active Equipment & Subsystems

  Specific room enclosed for MHIC (100 m^2 Class 10.000)

  Each of the above includes one Class 100 laminar flow hood

- Semiautomatic assembly of STM components

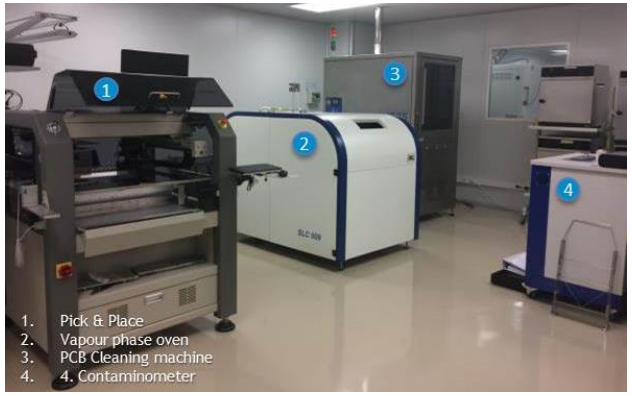
  From CAD to PCB soldering paste dispensing for active equipment

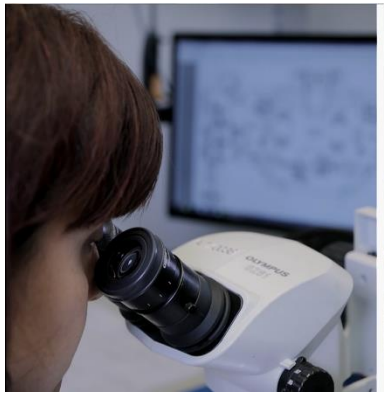
  Ovens for vapor phase soldering, curing and bake-out

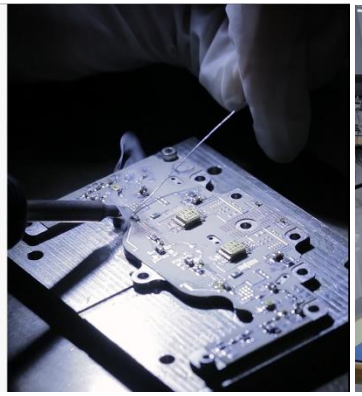
  PCB cleaning machine and contaminometer

- Manual soldering benches

  ESA qualified instructors and technicians for Assembly, Rework and Inspection







Space Antennas Development
Electrical and environmental testing

- RF performance, Antenna Pattern and Power testing
  - Microwave test laboratory for measurement up to 70 GHz
  - Two (2) Anechoic chambers, One (1) Semi-anechoic chamber
  - Two (2) EMC Chambers + Conducted EMC testing facilities
  - Power test benches from L to Ka Band for CW power handling, corona, multipaction and/or PIM
  - Electron seeding source for multipaction tests
- Environmental testing
  - Vibration test shaker
  - Four (4) Thermal vacuum chambers
  - Six (6) Climatic chambers for thermal cycling, burn-in and life testing

SENER
Aeroespacial

THANK YOU

www.aeroespacial.sener/en

www.linkedin.com/company/sener

www.youtube.com/user/senerengineering