



## SPACE SENSORS, PAYLOADS AND EQUIPMENT

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## Our place in Space



**SELEX GALILEO**  
A Finmeccanica Company



## SPACE ACTIVITIES

With a presence in the European Space industry since its dawn in the 1960's, SELEX Galileo leverages its unique expertise in the development and production of qualified optical payloads, RF equipment, photovoltaic assemblies, power conditioning and distribution units and robotic arms. SELEX Galileo has delivered innovative space sensors and sub-systems to international customers including the European Space Agency (ESA), the Italian Space Agency (ASI) and NASA.



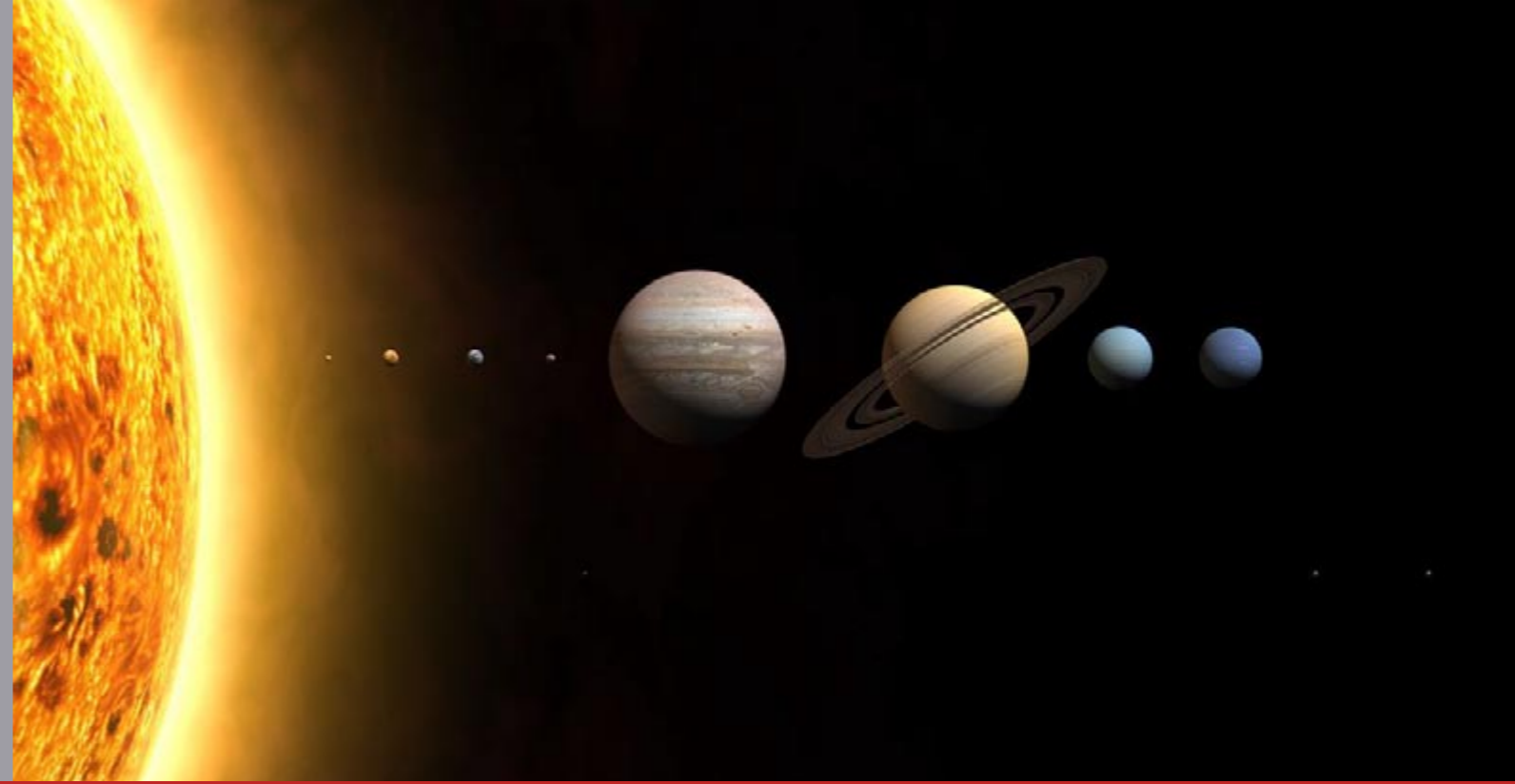
SELEX Galileo, a key player in the European Space industry and part of the Finmeccanica group, provides a wide range of highly reliable solutions for Earth observation, science, planetary exploration, navigation and telecommunication programmes. The first equipment of SELEX Galileo to be deployed in Space dates back to the 1960's. Since then SELEX Galileo has developed and produced qualified space optical assemblies, attitude sensors, RF equipment, photovoltaic assemblies, power conditioning and distribution equipment, robotic arms. Within the Space Line of Business, SELEX Galileo supplies equipment and payloads to the European Space

Agency (ESA), the Italian Space Agency (ASI), NASA and other international customers.

Space operations take place in Firenze, Nerviano, Pomezia, Edinburgh and Southampton where all design, development, manufacturing and testing activities are carried out on within an area totalling 18,000 m<sup>2</sup>. SELEX Galileo also hosts clean rooms and laboratories equipped with appropriate space simulators and facilities for environmental and functional testing. The space headquarters are located in Firenze.

From design to manufacturing and testing of optical payloads, mastering optics, focal plane assembly, electronics and precision mechanics, SELEX Galileo has developed a unique competence in mission payloads with outstanding performance, for a high quality observation of the Earth and of faint space objects.

Starting with the design and assembly of the hyper-spectral instrument GOME for the ESA ERS-2 mission, SELEX Galileo has developed state-of-the-art spectrometers and hyper-spectral cameras for the observation of the Earth, planets and comets. Other scientific payloads for space missions include instruments for planetary in-situ analysis and micro-gravity facilities.



## ELECTRO-OPTICAL PAYLOADS FOR SCIENTIFIC MISSIONS

### Visible InfraRed Thermal Imaging Spectrometer (VIRTIS)

Imaging spectrometer for remote sensing in the visible to mid-infrared bands. Selected by ESA as an orbiter payload for the Venus Express mission and for the Rosetta mission to the comet 67P/Churyumov-Gerasimenko.

A VIRTIS-like product has been developed for the NASA DAWN Discovery mission under an ASI-JPL agreement.

VIRTIS combines a high-resolution VIS and IR imaging in the 0.25 to 5  $\mu\text{m}$  range at moderate spectral resolution (VIRTIS-M channel), developed in-house, and a high resolution spectroscopy in the 2 to 5  $\mu\text{m}$  range (VIRTIS-H channel).

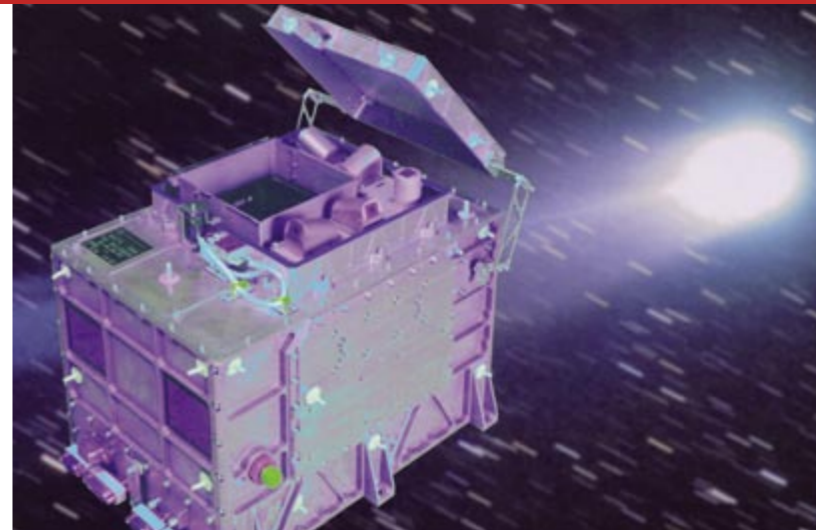
SELEX Galileo led the system engineering, integration and testing of the whole instrument.



### Spectrometer and Imager for MPO Bepi Colombo Integrated Observatory SYSTEM (SIMBIO-SYS)

SIMBIO-SYS for ESA Bepi Colombo mission is an Optical Instrument suite made by three instruments:

- HRIC (High resolution Imaging Channel), a high resolution multi-band camera
- STC (STereo imaging Channel), a stereo and multi-band camera for topography and 3D reconstructions
- VIHI (Visual and Infrared Hyperspectral Imager), an imaging spectrometer for mineralogic mapping.



### Grain Impact Analyser and Dust Accumulator (GIADA)

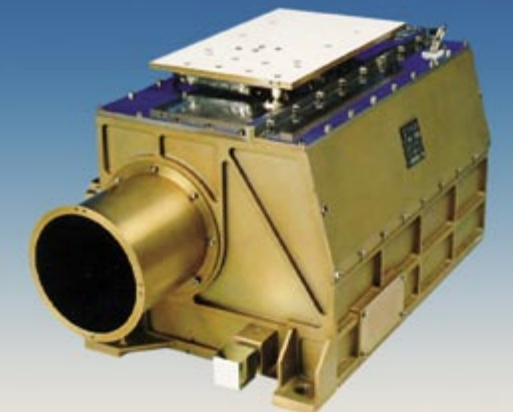
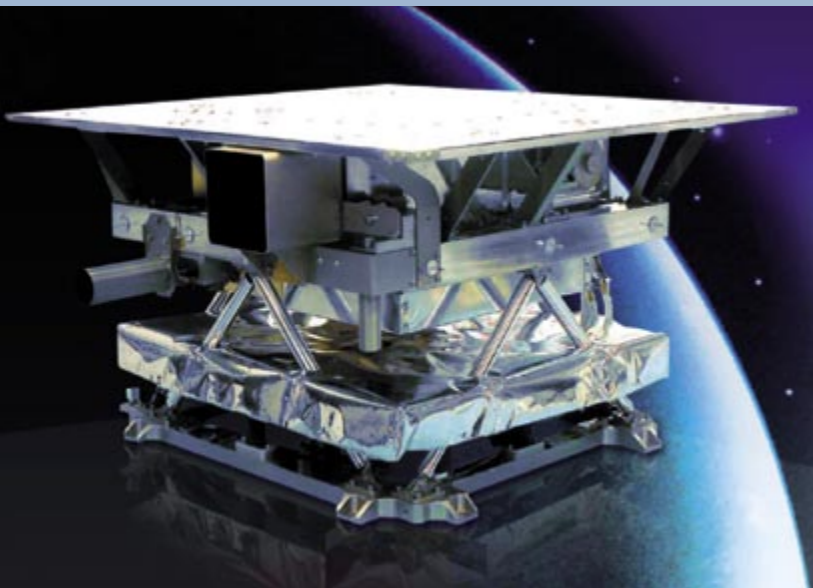
Multi sensor equipment designed to measure the physical properties of the cometary dust (number of particles, their mass and speed) by means of optical systems and piezoelectric transducers (microbalances).

GIADA is part of the Rosetta mission payload to study the comet dust flux evolution and grain dynamic properties.

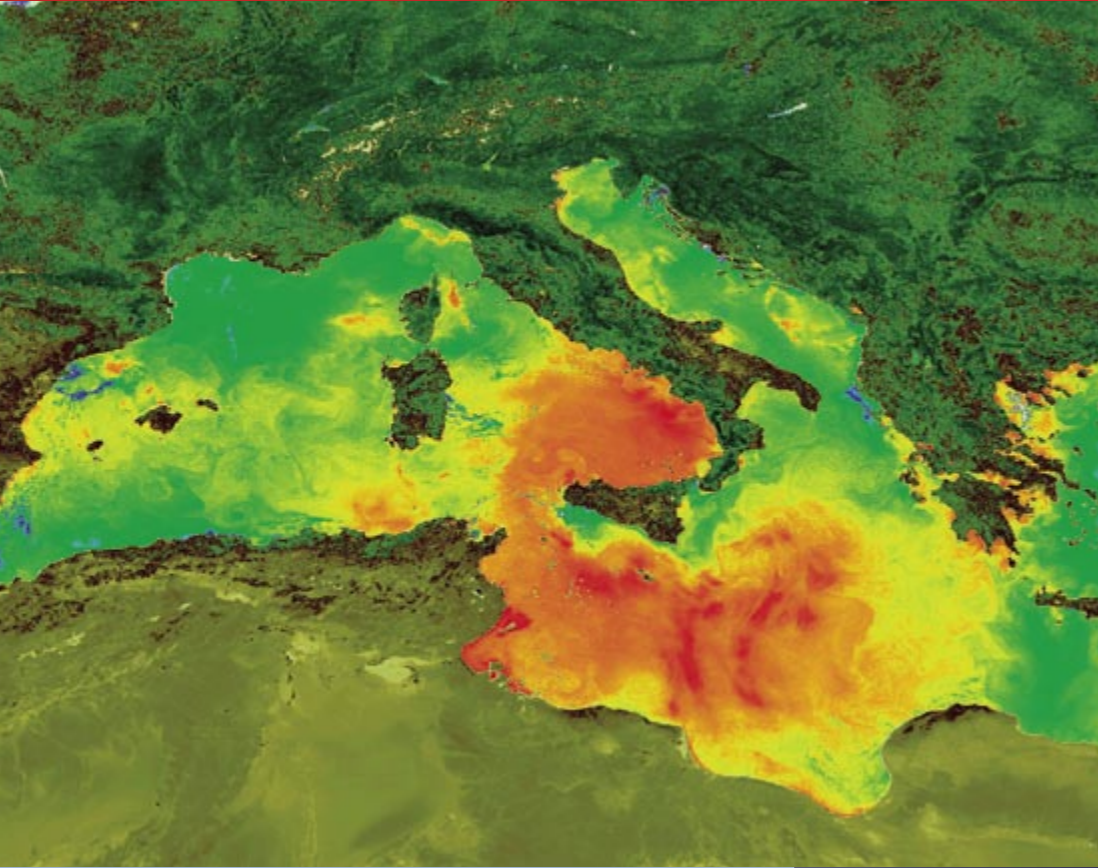
### Visible InfraRed Mapping Spectrometer (VIMS)

Remote sensing instrument developed for ASI as part of the Italian contribution to the NASA Cassini mission.

VIMS is installed on the Cassini Orbiter: its primary scientific objective is to provide two dimensional, multispectral, high resolution images for the detailed study of the composition and structure of Saturn's ring system and atmosphere.

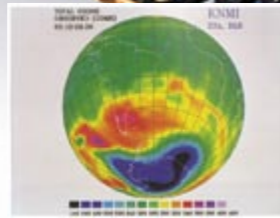
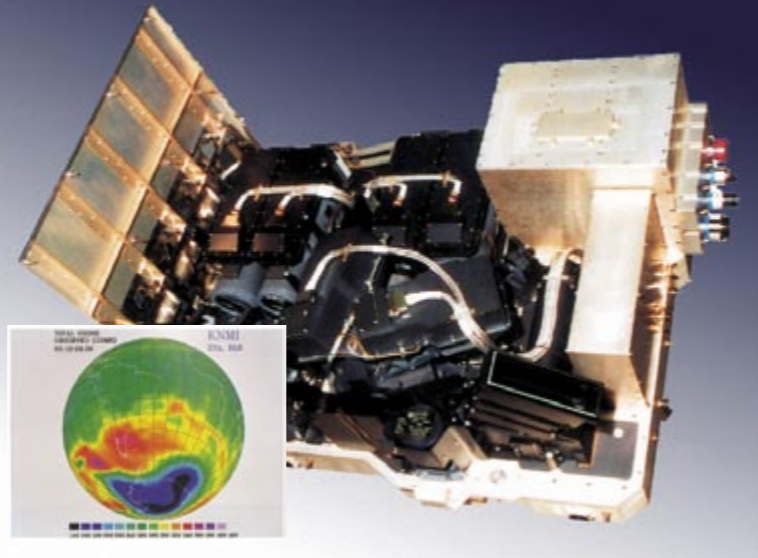


# ELECTRO-OPTICAL PAYLOADS FOR EARTH OBSERVATION MISSIONS



## Sea and Land Surface Temperature Radiometer (SLSTR)

SLSTR for the GMES Sentinel 3 mission is devoted to operational oceanographic and land services. SLSTR is an enhanced Radiometer based on ATSR-family (Along-Track Scanning Radiometer), designed for ocean and land-surface temperature measurement.



## Laser Transmitter Assembly (TXA)

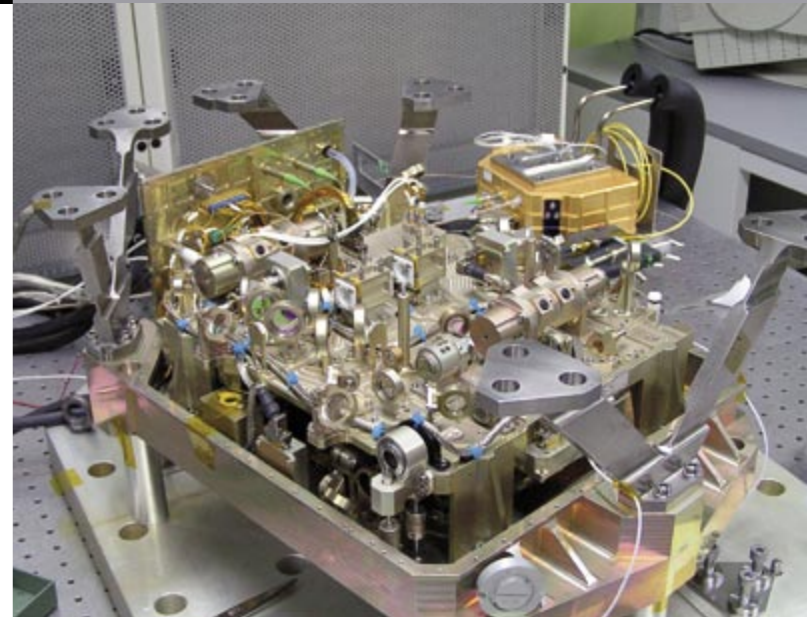
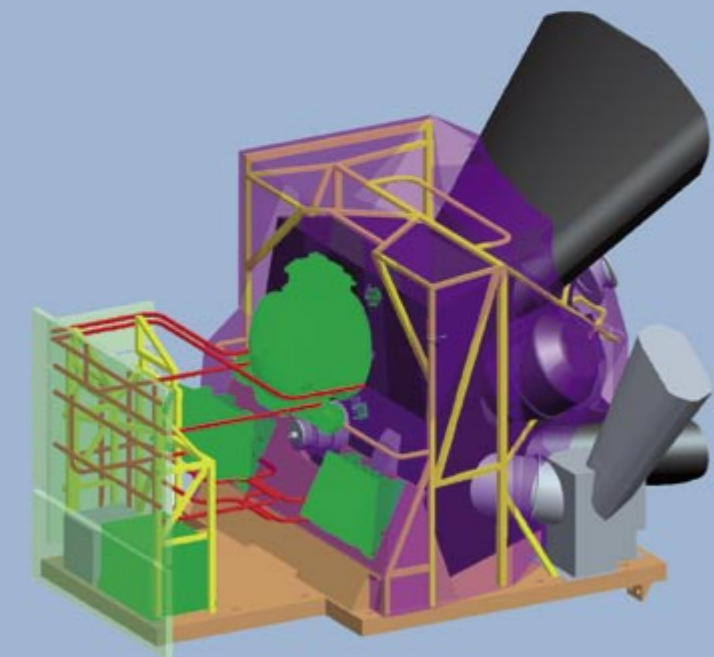
Laser Transmitter Assembly is an all-solid-state laser source for the ESA Earth Explorer ADM/Aeolus mission. It allows 3D wind measurement with global Earth coverage and accuracy > 2m/s. The TXA is the most powerful laser transmitter ever built for space applications, with 120 mJ optical power @ 355 nm. SELEX Galileo is also responsible for the TXA of the ATmospheric backscattered LIDar (ATLID) for the ESA/JAXA Earth-CARE mission; E-CARE will study the interactions between cloud, radiative and aerosol processes.

## Global Ozone Monitoring Experiment (GOME)

Optical spectrometer in the UV band designed to measure daily total ozone column content and vertical ozone profile in the atmosphere, detecting other minor atmospheric components. The data delivered by GOME are assembled in monthly and seasonal maps of ozone distribution, which contribute to the forecast of long term evolution of the atmosphere. GOME will be deployed on all METOP satellites of the Eumetsat Polar System (EPS).

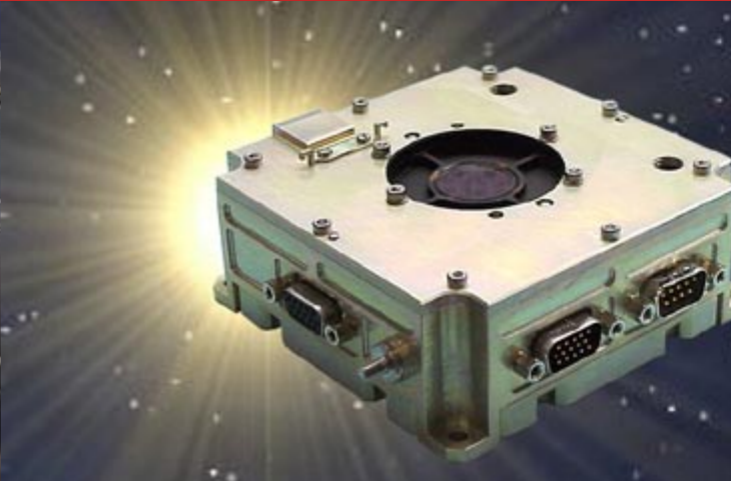
## PRISMA Optical Payload

PRISMA, an Earth Observation mission, has on board an optical payload for environmental monitoring and risk management, under development for the Italian Space Agency (ASI). The optical payload is made by a Hyperspectral camera in the VNIR and SWIR and a Panchromatic VIS camera.



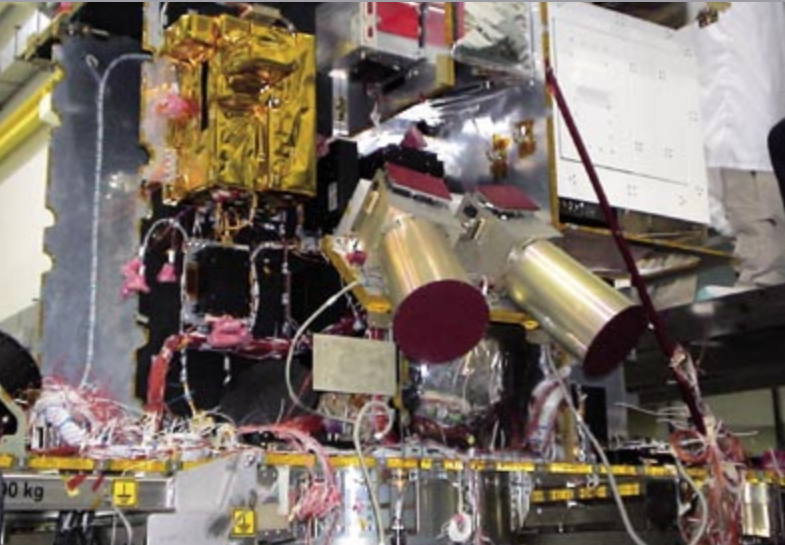
# ATTITUDE CONTROL SENSORS

An extensive experience in optical technology sets SELEX Galileo at the leading edge of space sensor development. With 350 sensors delivered in over 90 space programs for European, Asian and American customers, SELEX Galileo is a world leader in the supply of Earth, Sun, Stars, Autonomous Star Trackers and Navigation Sensors, offering standard and custom configurations.



## Smart Sun Sensor (S3)

Two axes solar sensor with low mass and consumption, based on a radiation hardened APS detector, S3 has been developed and qualified for Earth Observation and GEO Telecommunication spacecraft. The S3 is also suitable for Interplanetary missions (up to 50AU) and for spinning spacecraft (up to 100rpm). With a large dynamic range providing medium/high accuracy, and wide FOV, S3 combines the tasks traditionally performed by both Fine and Coarse Sun sensors. An ITAR free version is also available.



## STAR TRACKERS

SELEX Galileo has developed a family of multipurpose and fully autonomous star trackers to provide attitude data and motion rate of satellite.

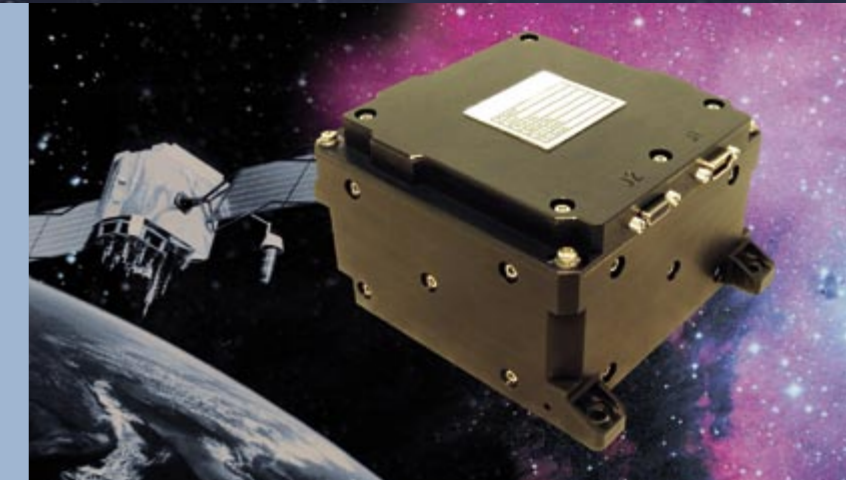
SELEX Galileo Autonomous Star Trackers are based on a radiation hardened design and proprietary algorithms that ensure accurate and robust 3-axes attitude determination in all types of mission.

SELEX Galileo Star Trackers has accumulated an excellent in-flight heritage, demonstrating accuracy exceeding the required performance of few arc seconds as well as high reliability and tracking robustness under severe radiation

## SiREUS

### THE SILICON RATE SENSOR

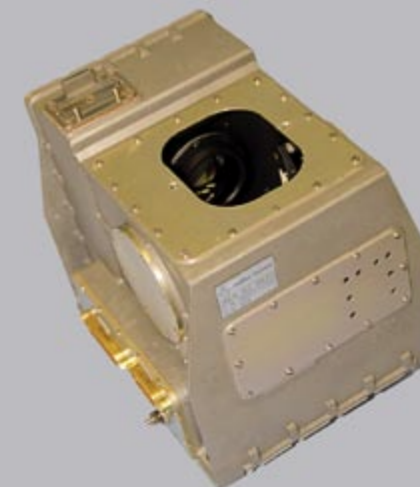
SiREUS meets the Space market need for a Coarse Rate Sensor as a key part of Attitude and Orbital Control Systems. It is robust and radiation hardened to provide a three axis MEMS based gyro solution for use in Geostationary satellites as well as applications in LEO Earth Observation, Scientific and Exploratory space missions. The single box unit contains all the control, processing, power and interface requirements necessary for operation and is usually provided as a flight set of two units.



## A-STR - Autonomous Star Tracker

Medium Field of View CCD based Star tracker leveraging over 20 years of experience in star tracker development. Most recent successes include flying on board STEREO, Phoenix Marslander, PLUTO, Mars Reconnaissance Orbiter, and on spinning spacecrafts such as New Horizon.

More than 30 flight units have been delivered to Customers all over the world. A-STR uses a common design for a broad range of missions delivering an off-the-shelf, readily available product. All A-STR operations are executed under microprocessor control by means of mission dependant SW modules with in-flight reprogramming capability.



## AA-STR - APS Autonomous Star Tracker

New generation, medium FOV star tracker based on a rad-hard Active Pixel Sensor (APS) detector. The AA-STR (ITAR free) highly compact, lightweight and low power delivers an accuracy comparable to that of the CCD based star trackers, beginning a new age for star trackers that will dominate the future satellites AOCSS. The AA-STR design offers exceptional robustness under harsh conditions (launch loads, protons,...).

The AA-STR has been selected as the standard star tracker for the next generation of the European TLC-GEO platform ALPHABUS and the scientific mission Bepi Colombo.

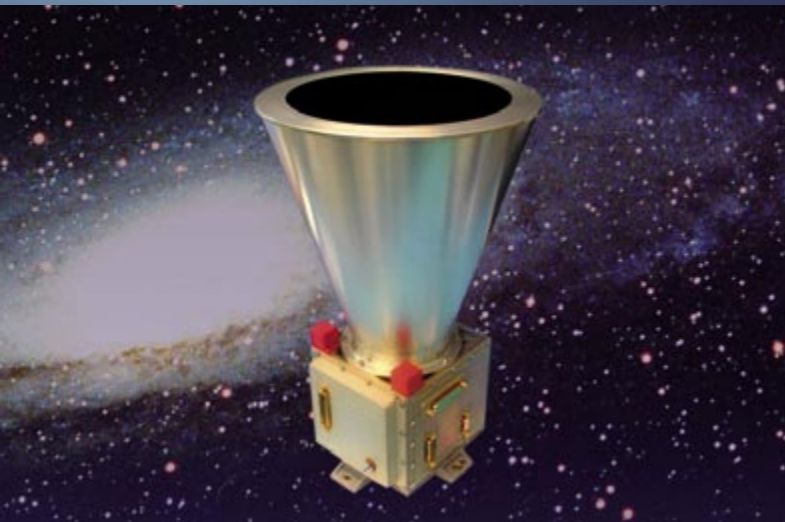
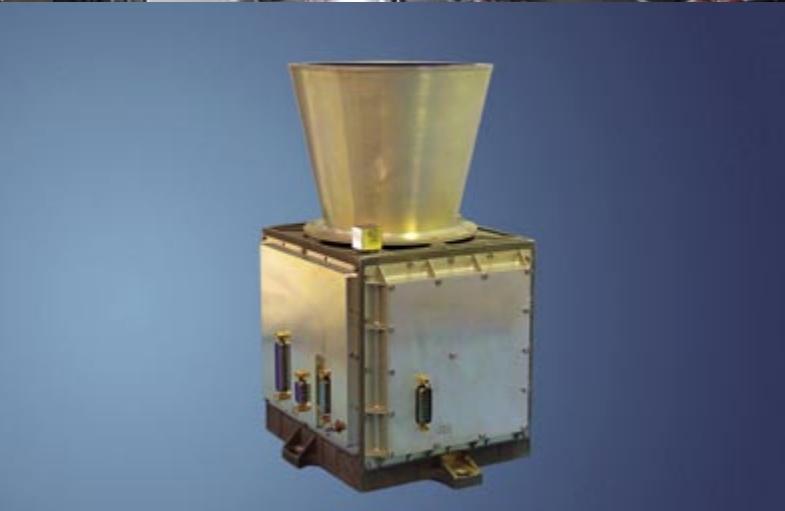
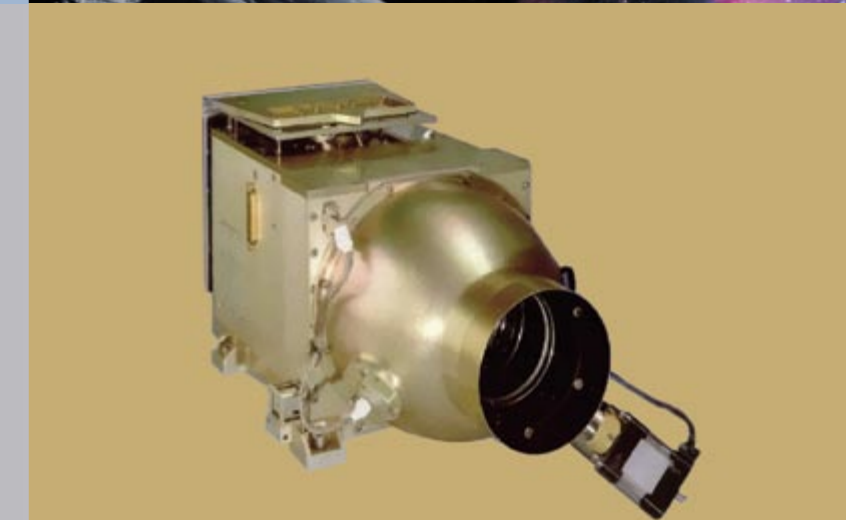
## Infrared Earth Sensor (IRES)

With more than 20 years of flight proven experience, the SELEX Galileo Earth sensors have been deployed in over 40 programmes. IRES is a two axes Earth horizon sensor for attitude control of 3-axes stabilized GEO spacecraft. Operating principle is based on electromechanical modulation of the radiation coming from the Earth horizon in the 14÷16.25  $\mu\text{m}$  band based on bolometers. IRES consists of an optical head and processing electronics in a single housing for the two axes measurement. Full performance Pitch and Roll are computed inside the sensor by means of a dedicated ASIC. An ITAR free and lower cost configuration based on pyroelectric detectors (IRES-N2) is also available with the same interfaces and performances as IRES-NE. IRES-N2 has been selected as the baseline Earth sensor for the Galileo constellation.

## Navigation Cameras

A multipurpose CCD based Navigation Camera is currently guiding the ESA Rosetta Spacecraft toward the comet 67P/ Churyumov-Gerasimenko to support acquisition and tracking of point like sources and extended objects ranging from 2 to 11 magnitude as well as to allow full frame image acquisition.

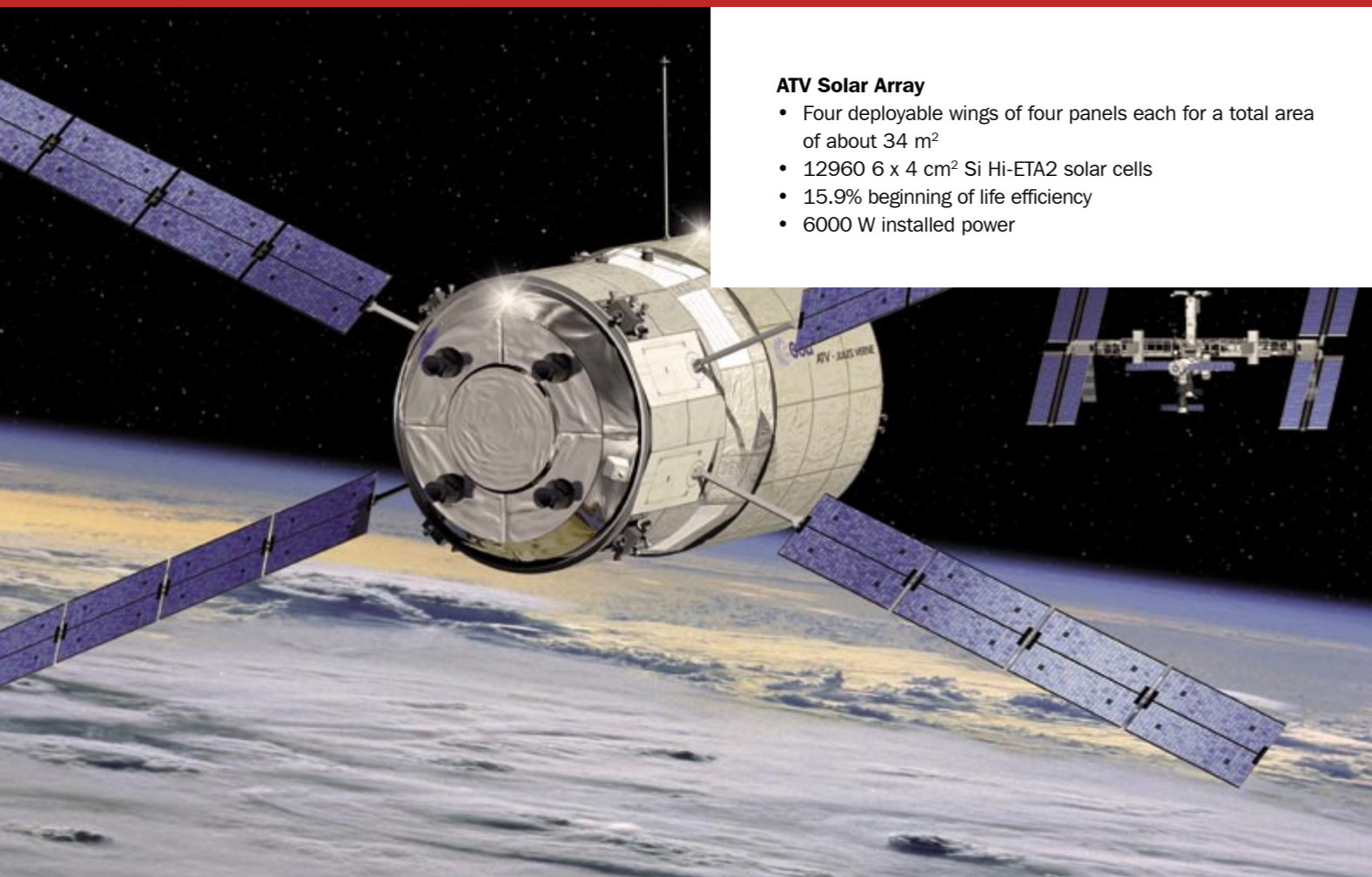
A state-of-the-art, compact and modular navigation camera based on APS technology is now available, and can be tailored to different mission needs, offering significant reductions in mass, power consumption and costs. SELEX Galileo also designed and developed the ERA-CLU cameras (Camera and Lighting Unit) for the European Robotic Arm of the International Space Station. The ERA-CLU is equipped with a laser diode illuminator.





Key player in Photovoltaic Assembly (PVA) design and lay-down, with a proven capability to supply state-of-the-art fixed solar array, SELEX Galileo started its activities with an Italian GaAs solar arrays technology development program funded by the Italian Space Agency. SELEX Galileo has, since, delivered high flexibility and excellent cost/performance ratio Photovoltaic Assembly becoming the reference Company in Europe for small satellites and a leader in large solar array. With solar panels deployed on most of the latest ESA programmes: Rosetta, ATV, PROBA, Herschel and Planck, ADM Aeolus, GIOVE A, Lisa Pathfinder, GAIA and the LEO constellations Cosmo SkyMed and Pleiades, the Company has recently increased its PVA production area to about 600 sqm with an integration capability of 60.000/80.000 solar cells per year.

## PHOTOVOLTAIC POWER GENERATION



### ATV Solar Array

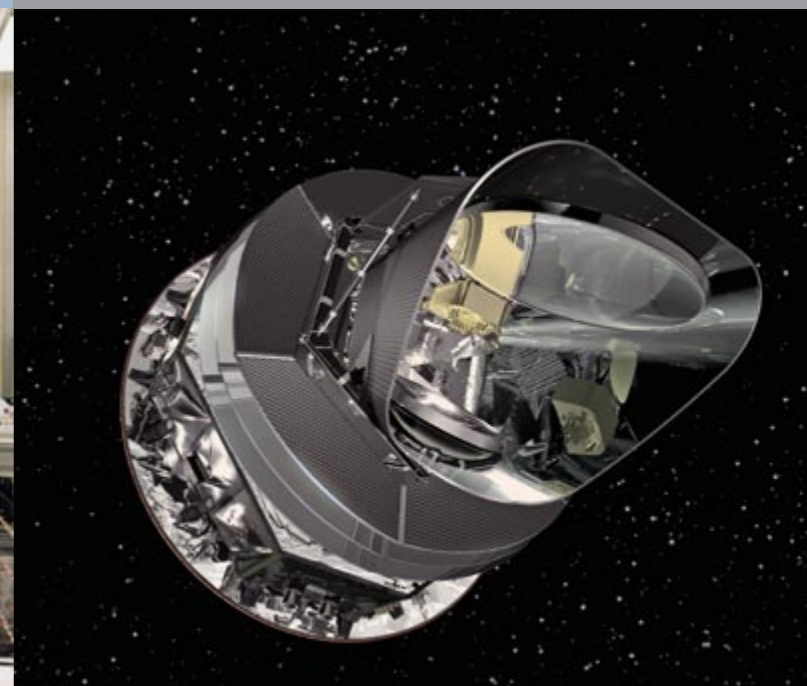
- Four deployable wings of four panels each for a total area of about 34 m<sup>2</sup>
- 12960 6 x 4 cm<sup>2</sup> Si Hi-ETA2 solar cells
- 15.9% beginning of life efficiency
- 6000 W installed power

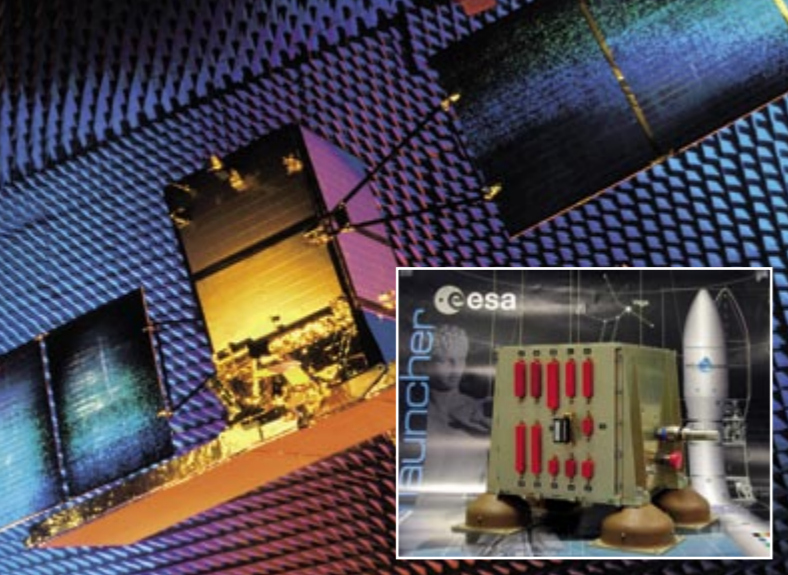
### COSMO/Skymed

- Two deployable wings of four panels each for a total area of 18.3 m<sup>2</sup>
- About 5000 TJ GaAs based solar cells 8 x 4 cm<sup>2</sup>
- 26.8% average efficiency
- 5000 W installed power

### PLANCK Solar Array

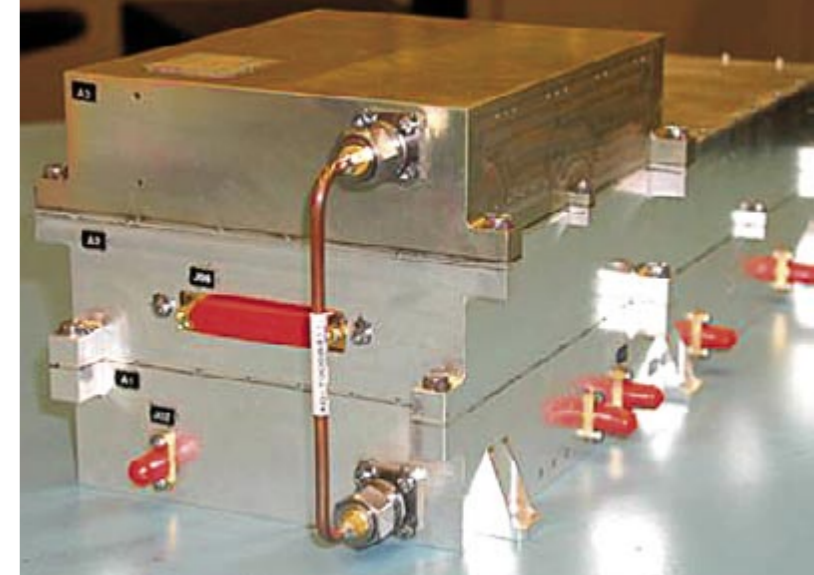
- 5 fixed panels equipped with solar cells, disk-shaped divided in two concentric areas for a total area of about 14,5 m<sup>2</sup>
- About 2700 TJ GaAs based solar cells 84 cm<sup>2</sup>
- 26.7% average efficiency
- 3000 W installed power.





Over 200 units for electrical power regulation and distribution applications have been deployed on space programmes such as Ariane, Giotto, Soho, Cluster, Artemis, METOP, ATV, VEGA, Sicral 1 & 1B, COSMO SkyMed, Lisa Pathfinder (FEPP), GAIA and Sentinel 1. Based on a modular concept of functional blocks and boxes, the electrical Power systems are tailored to Customer requirements.

Leveraging its over 40 years experience in the development and production of radiofrequency equipment, SELEX Galileo has taken part in Mars Reconnaissance Orbiter program and in most of the European space programmes: ERS 1 & 2, Envisat, Cassini, ATV, Cosmo SkyMed, Sicral 1 and 1B, SkyNet 5, GIOVE A and B and Galileo, and has produced over 100 flight units.



## ELECTRICAL POWER

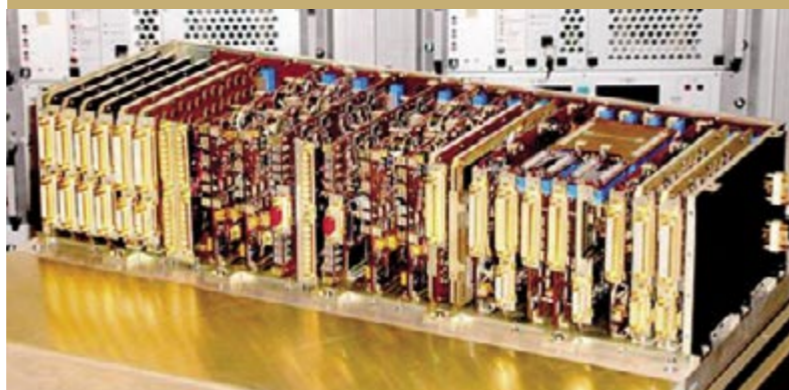
### Available functional blocks

- 28,42 and 50 V Main Bus DC/DC converters (S3R, BDR, BCR) for both sunlight and fully regulated systems
- $\mu$ P based batteries control electronics and EPS I/F management
- 28 to 120 V (up to 13A rated) SSPC's and fuse modules for MB lines protection and distribution
- Pyroelectronics and thermal cable cutters drive modules
- Thermal control heaters supply and command modules

The Power Equipment are designed and manufactured for different applications (GEO, LEO, Deep Space missions), ranging from Watts to KWatts (and from Volts up to Kvolts) with different topologies and power conversion technologies, both for platforms and payloads.

### Electrical Power

- Power Control and Distribution Unit (PCDU)
- Main Regulator Unit (MRU)
- Power Control Unit for FEPP ( Field Emission Electric Propulsion)
- Thermal Control Unit (TCU)
- Pyro Drive Unit (PDU)
- Electronic Power Conditioner (EPC) for TWT (Travelling Wave Tube)



## RF EQUIPMENT



### Chirp up Converters and Transmitters for Radar

#### High Power Amplifiers and Transmitters

- High efficiency and reliability equipment, for CW and pulse operation:

#### Travelling Wave Tube Amplifier (TWT)'s

- Frequency coverage from L through Ku to Ka bands
- Power levels up to 150 W
- High linearity for multicarrier operation

#### Solid State Power Amplifier (SSPA)'s:

- UHF, L, S and X frequency bands
- Power levels up to 100 W
- Gain Control Capability
- High Linearity for multicarrier operation



### Passive Hydrogen MASER (PHM)

PHM is an atomic clock with outstanding stability for averaging times from 1 to 100.000 seconds, to be used in precise positioning, time keeping and other on boards applications. It has been qualified to operate in space environment not less than 12 years MASER "and it has been selected as the reference clock for the Galileo constellation".

### Modulators and Frequency Converters

#### Frequency Generators

#### High stability sources

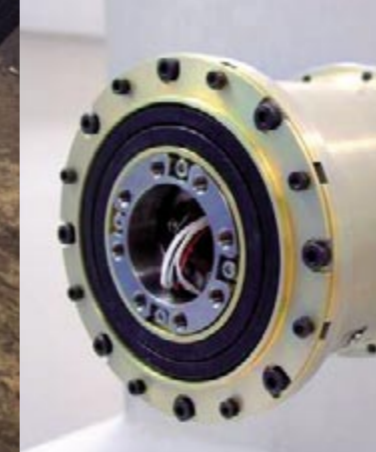
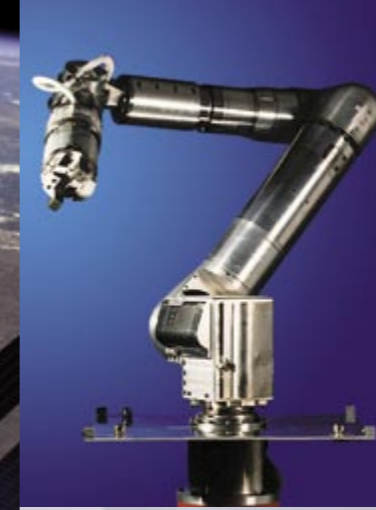
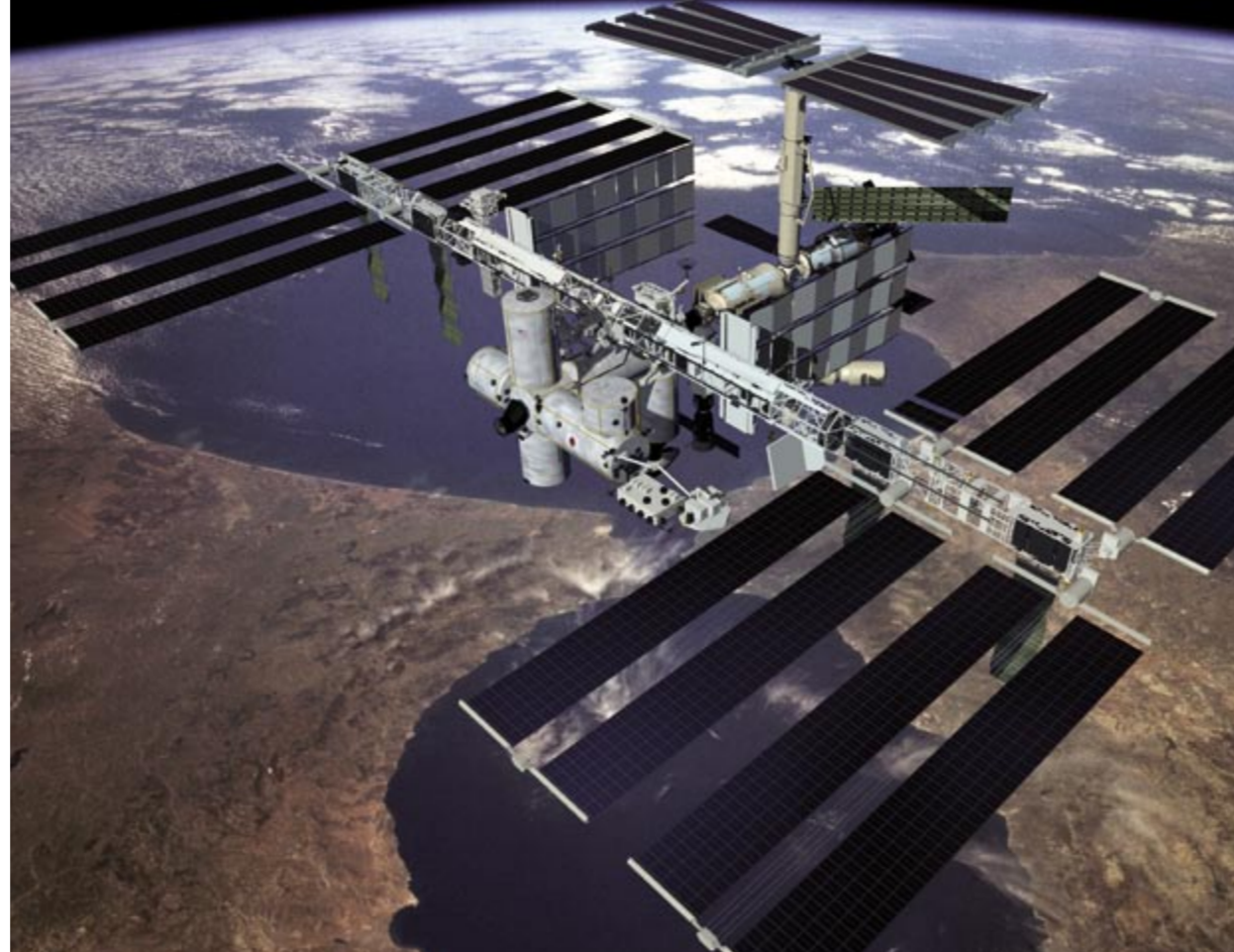
With ultra low phase noise and excellent spectral purity, including crystal oscillator and PLL multiplication functions, using both sampling and digital frequency synthesis

#### Direct Digital Synthesizers (DDS)

#### Clock Generators

With a dedicated robotic laboratory, which includes two industrial robotic arms and various Software and Hardware facilities, SELEX Galileo delivers state-of-the-art motion control software and sampling and manipulation systems.

SELEX Galileo has participated in the most important ESA and ASI programs in the field of A&R: SPIDER, EUROPA, ERA (European Robotic Arm for the International Space Station), and is involved in all the on-going European programs for planetary exploration and space robotics such as Rosetta, ExoMars, Mars Sample Return, Dexarm and Eurobot.



**A&R systems for payload servicing:**

- Manipulators
- Sensorised End Effectors
- Control and Drive Electronics
- High Power Density Actuators

**Sampling and robotic systems for planetary exploration:**

- Drill and Sample Distribution Systems
- Mechanism for Planetary Exploration

**A&R software for hi-rel and distributed systems:**

- robotics arms, drill and sampling systems, autonomous systems.

**Testbed** for in orbit robotic activities simulation at 1g conditions.

**EUROPA**

Conceived for the International Space Station (ISS), EUROPA (External Use of RObotics for Payload Automation) is the ASI robotic technological demonstrator for the ISS.

**AUTOMATION AND ROBOTICS**

**Drill, Sampler and Distribution System for the Rosetta Lander (SD2)**

SD2 drills and collects samples from the comet nucleus at a depth greater than 20 cm and distributes them through its carousel and sample containers to the scientific instrumentation (chromatograph and microscopes). This robotic system has been developed to endure extreme environmental conditions and to meet challenging requirements in terms of low mass and low power consumption.



**Fully integrated drill unit breadboard**

ExoMars mission requires the collection of subsurface samples down to a depth of 2 metres. Once collected, the sample is then distributed to a suite of scientific instruments for rover on board analysis.

SELEX Galileo is in charge for the development, manufacturing and integration of the drill unit, a multi-rod system which allows the achievement of the desired drilling depth by summing up a string composed by one front end drill tool plus three extension rods. The front end drill tool is equipped with a polycrystalline diamond cutting head and incorporates a motor actuated mechanism capable to collect, hold and discharge a sample.

