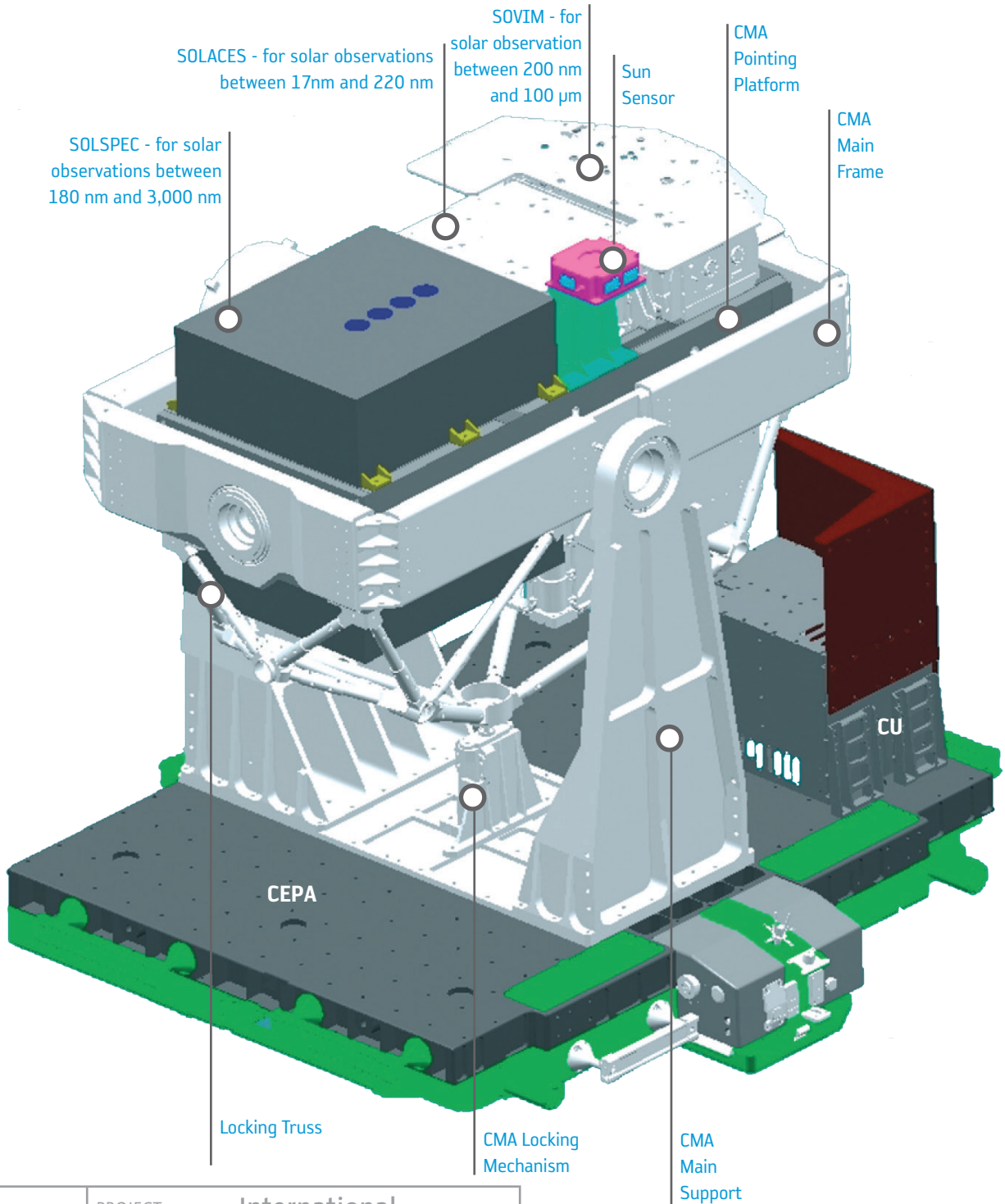
→ SOLAR

Sun monitoring experiment on the external payload facility of Columbus

SOLAR is a payload located on the Columbus External Payload Facility that measures the Sun's spectral irradiance over a wide range with unprecedented accuracy. The payload consists of three complementary science instruments: SOVIM, SOLSPEC and SOLACES, which monitor the solar flux in different wavelengths varying between 17 nm and 100 µm.



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ERASMUS Centre - Directorate of Human Spaceflight and Operations

Facility Description

COLUMBUS EXTERNAL PAYLOAD FACILITY - CEPF

The External Payload Facility consists of two external structures mounted symmetrically on the starboard end-cone of the Columbus Laboratory. The Facility provides a total of four accommodation locations with associated sets of resources for external payloads requiring specific viewing or exposure to the space environment. The accommodation locations are such that one faces towards the Zenith direction (i.e., directly away from the Earth); one towards the Nadir direction (i.e., directly towards the Earth), with the remaining two facing towards the starboard side of the ISS (i.e., per-pendicular to the ISS velocity vector).

The accommodation location facing Zenith is occupied by the Sun monitoring experiment SOLAR.

The SOLAR payload consists of 3 instruments complement-ing each other to allow measurements of the solar spectral irradiance throughout virtually the whole electromagnetic spectrum - from 17 nm to 100 µm - in which 99% of the solar energy is emitted. The instruments are mounted on a Coarse Pointing Device for Sun pointing and are controlled by a Control Unit. The scientific instruments are:

- SOVIM (SOlar Variable & Irradiance Monitor) covers near-UV, visible and thermal regions of the spectrum (200 nm – 100 µm).
- SOLSPEC (SOLar SPECctral Irradiance measurements) covers the 180 nm - 3,000 nm range with high spectral resolution.
- SOLACES (SOLar Auto-Calibrating Extreme UV/UV Spectrophotometers) measures the EUV/UV spectral regime (17 nm – 220 nm) with moderate spectral resolution.

SOVIM and SOLSPEC are the upgraded versions of instruments that have already accomplished several space missions.
SOLACES is a newly developed instrument.
Thanks to the Solar Package consisting of SOVIM, SOLSPEC and SOLACES new topics are investigated as was not possible in the past.

The three instruments are pointed towards the Sun using a multi-purpose, two-degree-of-freedom, Coarse Pointing Device (CPD) that compensates for the ISS orbital motion.

COARSE POINTING DEVICE (CPD)

The Coarse Pointing Device is a multi-purpose system that has the function of keeping the supported instruments pointed to a target (in this case to the Sun), compensating for the orbital motion of the ISS. For the SOLAR payload mission, during each observation orbit, the Coarse Pointing Device keeps the instruments pointed to the Sun during an observation period of about 15 minutes per orbit.
The Coarse Pointing Device provides a movable frame, which can rotate around two axes, thanks to a cardanic type mechanism. The motion is controlled in closed loop, using a Sun sensor located on the moving frame, brushless motors and encoders mounted on each axis. The control loops for the two axes are implemented in the software running on the Control Unit.
The maximum range of the Coarse Pointing Device angular motion is +/- 25° around the axis compensating for the seasonal variation of the ISS orbit inclination, and +/- 40° around the axis compensating for the ISS orbital motion.
The pointing accuracy is +/- 1 degree; the pointing stability is 0.3 deg over 10 seconds.
During launch and re-entry, the Coarse Pointing Device mechanism is locked in both the degrees of freedom by means of an electrically-actuated pin; the pin is retracted only when the payload is on-orbit, in its operational location, such that the pointing function can be operated.
From a structural/mechanical point of view, the Coarse Pointing Device is designed such that it can take all launch and re-entry loads due to the acceleration and vibro-acoustic environment typical of the Space Shuttle, acting on its structures and payload.
For the SOLAR payload it carries about 75 kg of scientific instruments.

THE COMMAND UNIT (CU)

The Control Unit is functionally composed of two sections that perform power conversion, protection and distribution and data handling and communication respectively. The Control Unit supplies electrical power (28 VDC) to the scientific instruments as well as to the Coarse Pointing Device. The Power distribution is based on the following availability of resources:

- 28 VDC Stay-Alive Power, when in Cargo Bay, provided to Coarse Pointing Device through two feeds from the Orbiter.
- 120 VDC Operational Power, on orbit, is drawn all from one of the two feeds at the Columbus External Payload Facility Interface.
- 120 VDC Stay-Alive Power, when on-orbit, is drawn all from the other one of the two feeds at the Columbus External Payload Facility Interface.

The data handling section of the Control Unit includes a microprocessor system, mass memory, Input/Output channels.
The Control Unit interfaces electrically to the Columbus External Payload Facility (CEPF) through the CEPA connectors.
The payload software running on the Control Unit is composed of the following elements:

- Basic software (derived from the Standard Payload Computer - SPLC project)
- Payload Application software

The software supports the Coarse Pointing Device pointing control as well as the management of the Coarse Pointing Device operation and telemetry/tele-command via ISS.

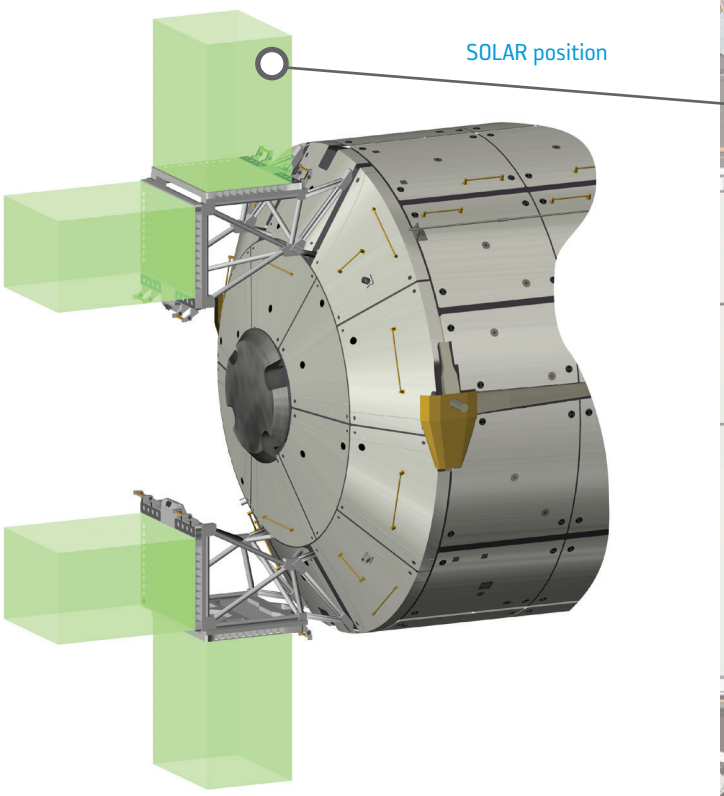
The payload application software is in charge of managing the payload mission. Using the services provided by

the basic software the application software implements the following main functions (in both nominal and contingency phases):

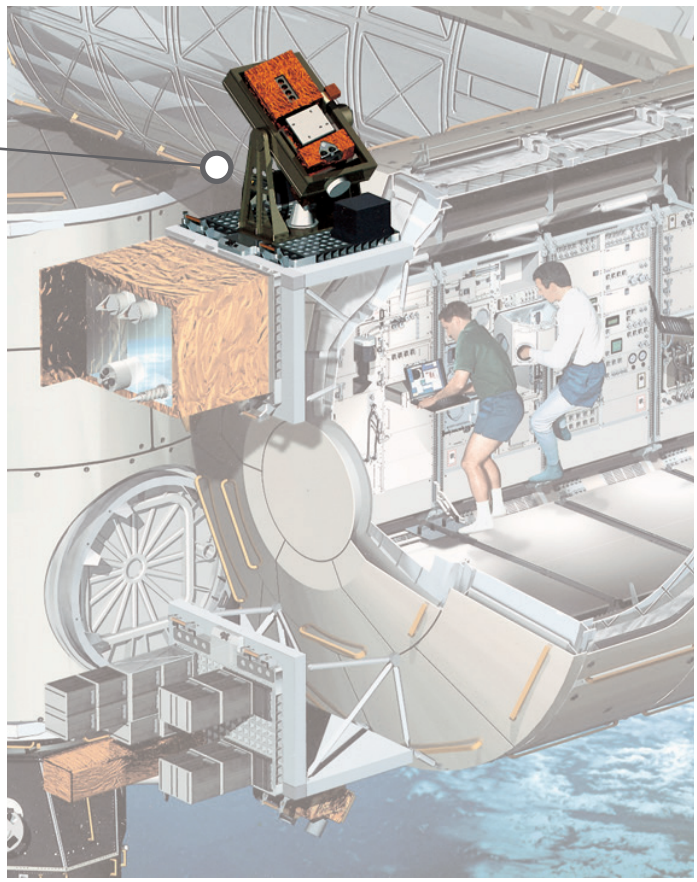
- Management of the payload telemetry/tele-command interface with the Columbus;
- Commanding (on the basis of a pre-defined, modifiable time-table) of all the payload units;
- Monitoring of all the payload units;
- Management of housekeeping and scientific data coming from all the payload units.

BACKGROUND

The SOLAR payload is a Monitoring Observatory that allows to measure with unprecedented accuracy the solar spectral irradiance. Apart from scientific contributions for solar and stellar physics, the knowledge of the solar energy irradiance into the Earth's atmosphere and its variations is of great importance for atmospheric modelling, atmospheric chemistry and climatology.



Columbus External Payload Facility showing the different payload envelopes.

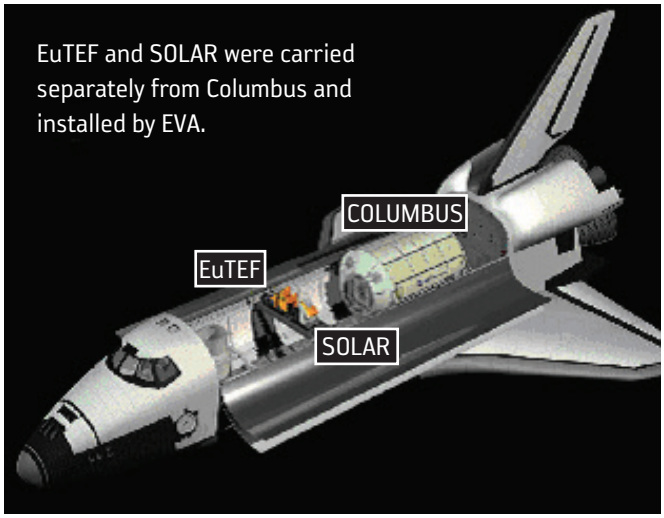


Artist's view of the Columbus External Payload Facility showing SOLAR.

Operations and Utilisation

ACCOMMODATION & TRANSPORT

SOLAR was launched aboard Space Shuttle Atlantis on 7 February 2008, together with EuTEF and the European Columbus Laboratory.



Once the Space Shuttle was docked at the International Space Station, the payload was removed from the Shuttle Carrier by a astronaut during an EVA. The Shuttle and the ISS robotic arms supported to transfer SOLAR to CEPF and to install the payload at the foreseen location on the ISS.

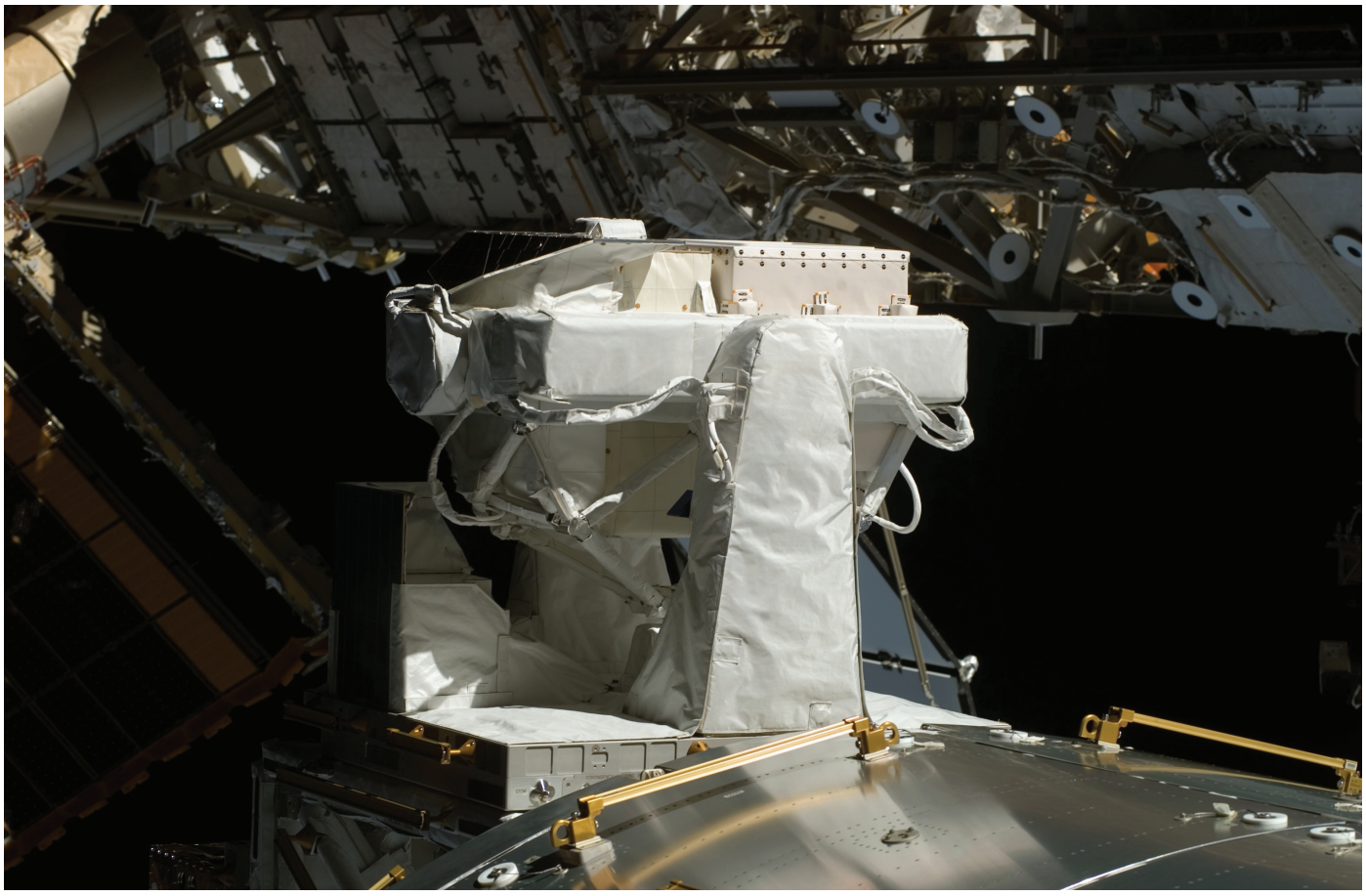
At the operational location, the necessary electrical power and data channels are provided to the payloads through the electrical connectors mounted on the CEPA, mated to the respective counterparts at the ISS via the Flight Releasable Attachment Mechanism.
At the end of the operational life, the payload is brought down to Earth using the procedure mentioned above in reverse order.

OPERATIONAL CONCEPT

Since installation on the International Space Station the SOLAR payload operates continuously for a period of 4 years. The instruments are pointing to the Sun for an observation period of about 15 minutes per usable orbit.
The Data Handling channels provide the possibility to exchange the observation data between SOLAR and Columbus External Payload Facility. From here Columbus Data Management System provides
MIL-STD-1553B data bus and redundant Ethernet for sending the data via the ISS communication means to the ground.

UTILISATION SCENARIO

The Facility Responsible Centre (FRC) for all SOLAR payload systems aspects and related phases of payload operations, i.e. pre-flight activities, in-flight operation and post-flight activities is the Belgian User Support and Operation Centre, the B.USOC, in Brussels.



View of Sun Monitoring on the External Payload Facility of Columbus