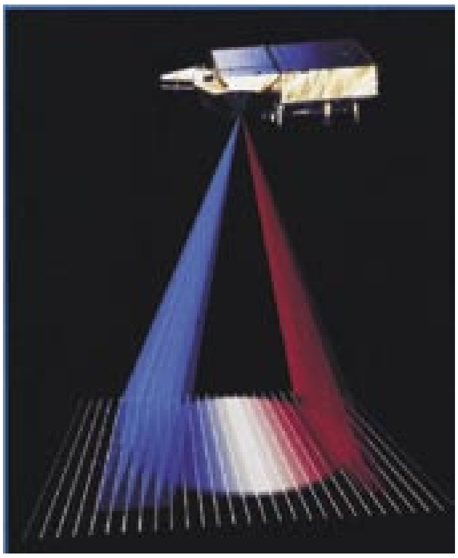
Cryosat

The satellite is lost, but the technology developed to carry it out is not



After several successful launches, both for ESA's satellites and for the launch provider Eurockot, something went wrong October 8. After successfully having started off the two first stages, the third stage, Breeze-KM, never began operating and the satellites fell in the area the satellite should monitor, the Arctic area. At this point it is not yet decided whether to build or launch a new satellite for the same mission. Cryosat was built for 70 million Euros, and possibly, one can build a second version for somewhat lesser, but financial possipossibilities will not be known before the next multiyear budget is adopted at ESA's ministers meeting in December.

The following article is written before the launch, but we publish the article in its whole, since the technology developed for the mission almost certainly will be used in the future.

Saab Ericsson Space antennas enable precise polar ice measurements from space

When ESA's Cryosat satellite is launched from Plesetsk in Siberia in October this year, it carries a state-of-the-art carbon fibre reflector antenna assembly from Saab Ericsson Space. The antenna assembly used by the Siral instrument onboard the Cryosat satellite has been designed and manufactured by Saab Ericsson Space, making use of 20 years of experience in reflector antenna development. The requirement for light weight and extreme thermal stability led to the design of an antenna assembly that has a pointing error of less than 0.005 degrees under the thermal conditions in-orbit.

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Design drivers

The Cryosat satellite and its mission were described to great detail in the May 2005 edition of the esa bulletin. The mission orbit of the Cryosat satellite will be non-sun-synchronous at a mean altitude of ~717 km. A shift of the orbital plane every day means that the satellite and the antennas will be illuminated by the sun from arbitrary angles during operation. The Siral instrument operates at Ku-band in three different modes. In the SAR-Interferometric mode the phase difference between signals received by the two antennas is measured, setting tough requirements on the similarity of the two antennas. The instrument will be able to measure the ice thickness with a precision of a few millimetres. To achieve this, the instrument must be absolutely stable and its position well known, i.e. the antennas and the star-trackers (see NSA no 1 2005) must under all conditions be accurately lined up and give precise data. The requirement for thermal stability of the base-plate and reflectors was to achieve a pointing error of less than 20 arc seconds (~ 0.005 deg) under all thermal condition. This is the angle subtended by a football at a distance of 2.5 km.

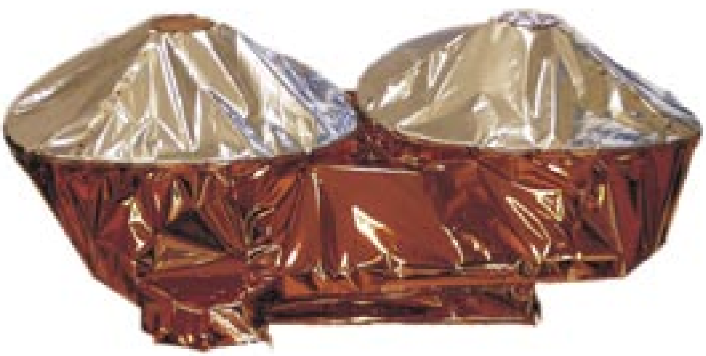
The overall size of the Siral antenna assembly is 2.3 x 1.7 x 0.7 m and the total mass without thermal blankets is 31kg. Three star-trackers will be mounted on the other side of the base-plate facing space.

Siral Antenna Assembly

The Siral Antenna Subsystem consists of 2 double reflector antennas including feeds and waveguides and a base-plate designed to hold Star Trackers on one side and the antennas on the other. Multilayer insulation (MLI) and sunshields completes the design.

Compact Electrical design

The antennas are Cassegrain double reflector systems. The reflectors are shaped to reduce the effect of blockage and reflections between feed and subreflector. They are linearly polarised and work at 13.57 GHz with 350 MHz bandwidth. The main reflector size is 1.15 x 1.4 m. The ellipticity was necessary because of the limitation of available space combined with a requirement for 42 dBi antenna gain. The sub-reflectors are circular with a diameter of 0.23 m.



The Siral Antenna assembly is dressed for launch. The MLI (golden) and the sunshield (grey) have been fitted and manufactured by Austrian Aerospace in Vienna.

Thermos design to keep a constant temperature

The system is built from ultra high module CFRP (Carbon Fibre Reinforced Plastic) in balanced sandwich designs. The building blocks are to a great extent made from the same material in order to minimize the CTE (Coefficient of Thermal Expansion). The CTE of the sandwich panels are close to 0. The feed horn and waveguides are machined from Invar, which has a CTE of 2.0 ppm.

Multi-layer insulation (MLI) covers the antennas from the rim of the main reflectors down to and including the base-plate plus the back of the subreflectors. A microwave transparent sunshield made from germanium coated Kapton covers the area between the subreflector and the main reflector.

The reflectors have a very thin coating of aluminium, creating a high isolation between the antennas and the MLI and sunshield. Each antenna thus functions like a thermos keeping the active antenna parts at as constant a temperature as possible independent of the sun illumination.

Manufacturing – a challenge

The challenge for the production team was to manufacture two identical, extremely thermally stable antennas and a 1.7 x 1.5 m large base-plate, 7 cm thick with a mass of less than 16 kg including all inserts.

Manufacturing of the reflectors and the base-plate is a handicraft requiring long experience. The base-plate proved to be a challenge due to the requirement for flatness and temperature stabil-

The CFRP reflectors are coated with a 1µm thick aluminium layer and the horn and the waveguides are silver plated to give good thermal reflectivity. The reflector struts are also built in CFRP material and have been covered with aluminized tape. The surfaces are very sensitive to moisture and precautions must be taken during manufacturing and assembly.

ity over the large plate. The manufactured base-plate was measured to be planar within an RMS value of 6µm.

The manufacturing tools that determine the shape of the reflectors need also to be accurate and extremely temperature stable since curing of the carbon fibre prepreg is done at almost 200 degrees. In order to make the reflectors as identical as possible it is essential to be very meticulous when it comes to carbon fibre lay-ups and curing processes. The difference between the reflector shape and the manufacturing tool has been measured to be less than 15µm RMS for the main reflector and 2µm for the subs. The thermal deformation difference between the two reflectors is in the same order as the measurement accuracy, i.e. around 2.5µm for in orbit temperature variations. These values correspond very well to the requirements set up for the CFRP parts.

The antenna has shown to meet all the requirements in an extensive test campaign. The final performance of the instrument will however not be seen until the first measurement data are available from space.

Building know-how at Saab Ericsson Space

Saab Ericsson Space's personnel have built Carbon fibre reflector antennas since the early 1980'ies, when Tele-X started out. Since then a number of Telecom antennas have been delivered, e.g. for Sirius 2, EW4, and AMC9. The RF sensing antennas for Astra 1K and Hot Bird 6 made use of the know-how gained through the Odin programme. The Odin reflector antenna has a surface accuracy of <10 µm RMS and is thermally extremely stable to cope with the requirements of the 575 GHz telescope. Other CFRP antennas for ESA programmes, include e.g. the Columbus Ka-band, the SOHO S-band reflectors and the 2.2 m Rosetta HGA.

The most recent deliveries are two Gregorian reflector antennas for AMC23, a telecom satellite that will be launched late this year.

Saab Ericsson Space also delivers Payload Adapters and Satellite Structures in CFRP technology. These are built at the same facility as the antennas, i.e. at SAAB Aerostructures in Linköping.

*The Gregorian reflector antennas delivered for **AMC23** are light-weight, robust and thermally very stable antennas of a standard type (used also for AMC9). The projected diameter of the main reflector is 1.1 m and the total height of the antenna is less than 1.3 m. Each complete antenna weighs 15 kg including thermal blankets. The sunshield covering the main reflector was delivered by EMS in Canada.*