

Interview

ENVISAT: A Giant Leap for Mankind

Interview with Ir. Evert Attema, ESA-ESTEC

By Jacques Sipkes, Contributing Editor, GIM International

When, in the night of 28th February to 1st March 2002, the Ariane 5 rocket with the European Environmental Satellite Envisat on board lifted off from its launch pad at Kourou, the ESA-European Space Agency's launching centre in French Guyana and after 23 minutes reached its sun-synchronous polar orbit at an altitude of 800km above the surface of the earth, many scientists and technicians at Ariane Space and other ESA facilities took a deep breath of relief. The new rocket, Ariane 5, had experienced problems during previous launches but had been totally overhauled to enable a smooth ride this time. The launching vehicle Ariane 5 was developed by ESA to make sure that Europe could maintain its leading role in heavy launching capacity. The Ariane 5 is gradually phasing out the highly successful Ariane 4 and ultimately eight to ten launches per year are envisaged with the Ariane 5. To mark this important moment, GIM International interviewed Ir. Evert Attema, attached to the European Space Agency-ESA-ESTEC in Noordwijk, The Netherlands.

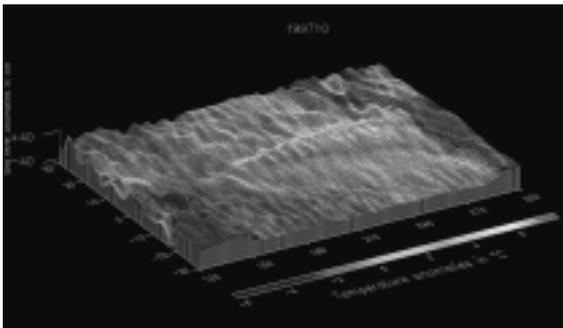
Envisat should, over the coming five years, answer questions on the environment of planet Earth such as those concerning the hole in the ozone layer of the atmosphere, pollution by industry and traffic (the CO₂ cycle), the influence of worldwide deforestation, the way the climate is developing (green house effect) and other issues. The satellite was designed, assembled and tested by the European Space Agency (ESA-ESTEC) based in Noordwijk, The Netherlands, and was produced jointly by European industries. Using ten sensors which will cover the whole earth every three days, it will closely monitor the sea (waves, plankton, global energy transport via the ocean etc.), ice, the atmosphere and a wide variety of aspects on land. The

strength of the project lies in the ability of ten sensors exactly simultaneously to measure at the same spot different phenomena, yielding data which may then be correlated during interpretation of received data at various participating institutes.

Ir. Evert Attema graduated from Delft Technical University in The Netherlands in 1969 as an electro-technical engineer with a specialisation in microwave techniques and applications.

Artemis

Artemis is another European Space Agency 3,100 kilogram communication satellite which was launched in 2001, also with an Ariane 5 rocket, into a geo-stationary orbit some 36,000 km above the surface of the Earth and which failed to arrive precisely in the originally planned orbit. Since that launch, software has been written to correct the deviant orbital path of Artemis and, thanks to ion propulsion which dramatically improved its usefulness, Artemis will now play a pivotal role in the huge data relay and rapid transmission from the Envisat satellite to the Earth receiving stations. A new kind of communications link called SILEX (Semi-conductor Laser Inter-satellite Link Experiment) forms one component of the satellite's data-relay payload. This will facilitate the transmission of large amounts of data from low Earth orbit satellites such as Envisat, the French Spot Image satellites and the International Space Station, to smaller ground data receiving terminals. The reason this is so valuable is because Earth observation satellites which fly at relatively low altitudes, typically at about 800km, are not always able to send their information to the most convenient Earth station. Some reasons for this are that these are out of reach of the footprint, that they lack suitable antennae or that there is no co-operation agreement. Artemis, from its much higher orbital position can, however, remain in communication with satellites in low Earth orbits for more than 50 per cent of each of its own orbits, during which time it can beam gathered data globally from these low flying satellites directly to the relevant ground stations: Kiruna in North Sweden, see <http://www.snsb.se>; Svalbard - Spitsbergen, Norway, <http://www.spacecentre.no> acting as a backup receiving station and to the data processing centre ESA-ESRIN in Frascati, a Rome suburb in Italy, http://www.esa.int/export/esaC/GGGYA78RVDC_index_0.html



3D view of El Niño effect in the Pacific Ocean as seen from Envisat.

He specialised in 1976 at the University of Kansas, USA and in 1984 became an advisor with ESA on the ERS-1 system mission group, later to work in the same capacity with the ERS-2 satellite and some time later with the Envisat project.

In his present position, Ir. Evert Attema acts as an intermediary between the scientists of the Earth Sciences Division of ESA and others in the field of applications.

His specialisation within ESA is the determination of the wind speed over water bodies with the help of aeroplanes and buoys. He is also involved with the 3-metre resolution panchromatic PROBA satellite, launched by an Indian rocket on 22nd October 2001.

Ir. Attema has an important role to play in the Envisat validation phase and in contacts with potential Envisat data customers

Can you tell us something of international space research co-operation and the role of Envisat in the international context?

During the years of the Cold War there was a lot of competition between NASA, ESA, the Russians, the Canadians and the Japanese. We all have our wish lists for space research but due to financial constraints we now have to work together. At present, we discuss these issues in the CEOS (Committee of Earth Observation Satellites) on which I am the chair of the Calibration and Validation workgroup. This co-operation is now realised at all levels. We work together in the conceptualisation phase but the implementation of the various projects is still done separately, a strategy of which Envisat is a good example.

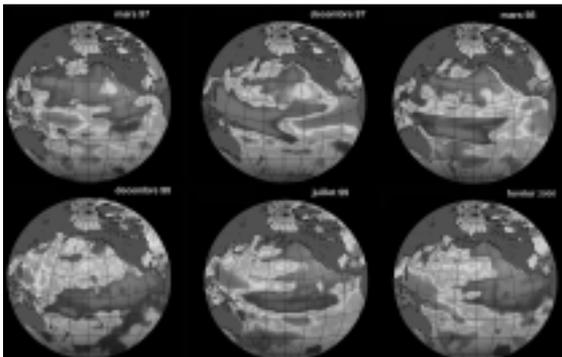
What is the philosophy behind Envisat?

The concept for Envisat went through a long time-span in terms of development. It is based, among other things, on the European Union's GMES (Global Monitoring for Environment and Security) initiative. The ESA council took the decision to start the Envisat project in 1995, a decision which resulted in three phases:

Phase A: the concept study

Phase B: detailed design

Phase C: physical realisation of the project



View of El Niño effects in the Pacific Ocean over time.



Artist's impression of the Envisat satellite in orbit.

Envisat was initially designed independent of the data users world but recently this project was incorporated into the European Union's GMES initiative. Via workshops it became clear what the data users community actually desired from the performance of the satellite and it became apparent that here there existed a time-related point of friction. ESA designs its satellites for the long term and it takes many years from the concept to the actual realisation phase. Data users, however, want to have the most up-to-date ideas incorporated – some of which did not even exist in 1995 at the start of the Envisat project - and want to have such ideas immediately available, preferably tomorrow!

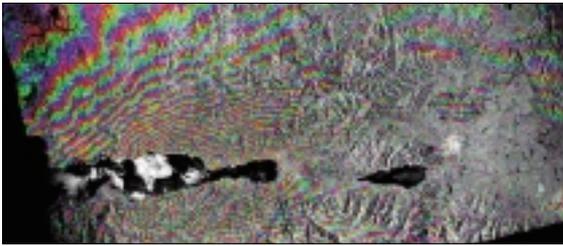
Another issue was the vehicle for the sensors. Initially, we considered the idea of attaching the sensors to the ESA part of the ISS (International Space Station) but in the end the separate Envisat satellite concept was chosen, which thus grew into the largest satellite ESA has ever built. A totally new aspect associated with Envisat is that it uses no gyros.

Are you happy with this final result?

Yes, most definitely. But it is a very risky enterprise to have so many different and costly instruments on one satellite. Nonetheless, processes in space will have to be measured and understood in relation to each other and scientific puzzles may be solved by exploiting the synergy of the ten sensors. Another positive factor is that these ten sensors are measuring earth phenomena simultaneously. Earth scientists nowadays co-operate much more on a worldwide basis and there are extensive Envisat data validation programmes with, for instance, large balloons. Also, restrictions between the various disciplines are becoming vaguer.

Can you say something more about the individual sensors and the combination of the sensors?

Although the sensors are attached to the same vehicle, they are not interconnected. We have already commented



Epicentre of earthquake in Turkey as seen with radardata ESA.

on the positive aspects and there are no negative aspects. The radio compatibility tests showed that the sensors have a zero value (i.e. there is no interference with each other's performance: ed.). For details on the ten sensors attached to the Envisat vehicle, see Block II.

What is the ESA policy on data transmission from Envisat to the planet Earth?

With the ERS-1 and ERS-2 satellites there were high-rate instruments on the satellites but, because of the resulting vast radar data flow and bottlenecks incurred in relaying this data to earth, reduced resolutions were used and we were dependent on a network of data receiving stations around the world. With Envisat, however, we have a much higher capacity and we will be able to use just one station, Kiruna in Northern Sweden, with Svalbard in Norway as a backup station. Moreover, the ESA Artemis communication satellite will be used to relay data directly to the ESA-ESRIN data handling facility in Frascati, Rome. This will make us totally independent of other data receiving stations in other parts of the world. To give you an indication of the magnitude of the data, after one orbit the three recorders of Envisat are compelled to download their data to earth, as there is no more room in the data storage capacity on the satellite for data to be collected during the next orbit. Most of the sensors are permanently turned on (except ASAR). Data will be processed in Frascati, Rome, at the Italian ESA-ESRIN facility and distributed to the users around the world. As Artemis failed entirely to enter its right orbit after its launch in 2001, it is slowly being manoeuvred into the correct orbit with the help of special purpose-written software and the unique ion propulsion. Thus, in six months time this Artemis-Frascati link will be fully operational. Due to these orbit corrections still to be undergone by Artemis, less service can be provided by ESA-ESRIN over coming months.

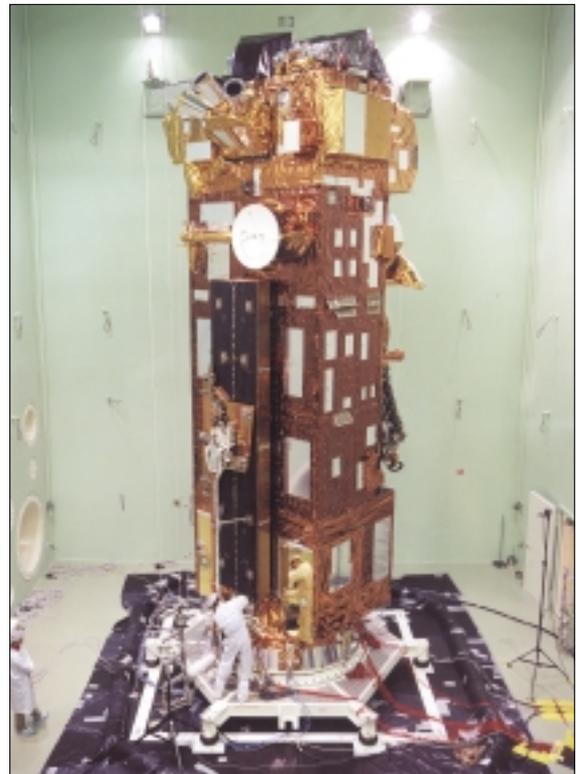
Moreover, Frascati needs a nine month calibration period, since we had problems with other satellites in the past in this respect. We do indeed have plans with ground stations in other parts of the world for training and outreach programmes and we see an enormous advantage in joint applications in all parts of the world.

Can you be more specific on the radar data of ASAR in particular?

ASAR is turned on for thirty minutes per orbit of 101 minutes duration. This depends on the size and the capacity of the solar panels, as you can hardly do anything in the eclipse (the dark side of the earth's turn, when no electricity is generated by the satellite: ed.). Another aspect is that ASAR user demands may exclude one another. The beam for some applications is upward looking (nadir) while for other applications it is looking downward. Also, the resolution depends on the demands of applying the data on earth. The global monitoring mode is 1km per pixel. ASAR can cover five times as large an area as ERS-1 did. This has now ceased to transmit data. ERS-2 is still active at this moment. The repeat cycle of Envisat is 35 days, which forms a problem for forest and water observation since it requires more frequent views. What is essential is that well-defined, constant observation points are established over the years for the performance of INSAR applications, for instance for such applications as earthquake prediction and upstream flood monitoring of rivers to predict the later downstream situation, etc.

Is there anything known already of the data formats and policies for end users?

ESA has developed software called ENVVIEW. This uses the PDS format, a specific Envisat format. A toolbox is also



Scientists of ESA-ESTEC assembling ENVISAT in their laboratory in Noordwijk, The Netherlands.

being developed at the moment. Once the calibration period is over the large Remote Sensing software vendors will undoubtedly produce their own Envisat import modules. The underlying idea is to use as much data as possible, whilst we have divided the end users into two categories:

Category I: all users that want to perform scientific research, including software development.

Category II: operational sale of data to others.

We will deliver Envisat data serving the second category to two consortiums: SATCOM/EURI-MAGE and EMMA,

who will stimulate the market and will work in the value-added domain.

Source and further information: European Space Agency Information on the Envisat and Artemis satellites is available on the ESA website at <http://www.esa.int/Envisat> Information on the rocket Ariane 5 see http://www.lanceurs.aeromatra.com/launch_vehicles/

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Brief Description of the Ten Sensors on Board of Envisat

1. ASAR

The Advanced Synthetic Aperture Radar uses a radar beam to map the surface of the planet below, with several different modes that allow broad views or detailed snapshots. It is able to map the shape of the land, profile waves and ice, to monitor land use types of vegetation and measure some of the properties of the surface. ASAR will continue and make more precise the functions performed by the ERS-1 and ERS-2 satellites before the commissioning of Envisat.

2. MERIS

The Medium Resolution Imaging Spectrometer takes images of the surface and clouds in sunlight which capture visible light and some of the infrared part of the spectrum. It is able to determine the exact 'colour' of oceans and coastal zones, which reflects biological activity and other processes. It monitors clouds and detects invisible water vapour in the atmosphere and identifies plants at various stages of their growth. MERIS measures chlorophyll levels, allowing calculation of the amount of vegetable biomass.

3. RA-2

The Radar Altimeter 2 and Microwave Radiometer measures satellite height above the surface of the earth to an accuracy of 4.5 centimetres at a satellite height of 800km. When combined with exact orbital tracking data from DORIS (see

below) RA-2 measurements yield a profile of the sea or ice surface. Further signal processing on the ground yields data on wave conditions and wind speeds in mid-oceans. It produces a topology of the sea waves and bathymetry of the average bottom of the sea, of sea currents and of effects related to climate change.

4. MWR

A Microwave Radiometer measures the amount of water vapour in the atmosphere to correct RA-2 radar signals for best accuracy.

5. GOMOS

The Global Ozone Monitoring by Occultation of Stars tracks stars and monitors their light spectra as they set

through the Earth's atmosphere. Able to build vertical profiles of water vapour and ozone through the atmosphere from altitudes 20-100km, such monitoring produces as much data as a network of 360 separate ground stations.

6. MIPAS

A Michelson Interferometer for Passive Atmospheric Sounding observes the atmosphere in the middle infrared range, mapping the profiles of a series of different trace gases and is able to map industrial pollutants and greenhouse gases to shed new light on atmospheric chemistry.

7. AATSR

The Advanced Along-Track Scanning Radiometer scans the land ocean surface at several infrared and visible frequencies to accurately measure temperature and is able to measure sea surface temperature to an accuracy of 0.3degrees Celsius. It detects hot spots from forest fires while it maps the extent of vegetation in different regions.

8. DORIS and

9. LASER RETRO-REFLECTOR

Doppler Orbitography and Radio-positioning Integrated by Satellite measures the exact orbital position of the Envisat satellite to an accuracy of 4.5cm and orbital speed to an accuracy of 0.4mm per second. It works with a radar altimeter to produce maps of the ocean surface and to derive gravitational field maps of the seabed and elevation maps of land. The Laser reflector allows ground-based laser ranging of the satellite to calibrate DORIS and RA-2. It works as an alternative for GPS. ASAR is not totally accurate but in combination with DORIS this problem can be solved.

10. SCIAMACHY

A SCanning Imaging Absorption spectroMeter for Atmospheric Chartography maps the atmosphere over a very wide wavelength range, which allows detection of trace gases, ozone and related gases, clouds and dust particles throughout the atmosphere. Sciamachy gives the total amount of gases and their profile in the atmosphere. It is a versatile instrument which will enable investigation of many different facets of atmospheric chemistry, including the effects of forest fires, industrial pollution, arctic haze, dust storms and volcanic eruptions.