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SCIAMACHY: a large wavelength range imaging spectrometer (from UV to IR) for atmospheric trace gas measurement to be embarked on the ENVISAT-1 satellite

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SCIAMACHY - A large wavelength range imaging spectrometer (from UV to IR) for Atmospheric Trace Gas Measurement to be embarked on the ENVISAT-1 satellite.

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ABSTRACT - The SCanning Imaging Absorption spectroMeter for Atmospheric CartograpHY (SCIAMACHY) is an eight channel imaging spectrometer whose main mission objective is to perform global measurements of trace gases in the troposphere and in the stratosphere.

SCIAMACHY, one of the Announcement of Opportunity payload instruments, will be embarked onboard the ESA ENVISAT-1 satellite to be launched in the second half of 1999.

In this paper the main mission and instrument requirements will be described. An overview of the challenging design and operational characteristics of the instrument will be provided.

1- INTRODUCTION

SCIAMACHY is an imaging spectrometer whose primarily objective is to perform global measurements of trace gases in the troposphere and in the stratosphere.

The solar radiation transmitted, back scattered and reflected from the atmosphere is recorded at relatively high resolution (0.2 - 0.5 nm) over the wavelength range of 240 to 2380 nm. The high resolution and the wide wavelength range enable to detect many different trace gases even of very low concentration. The large wavelength range is also ideally suited for the detection of clouds and aerosol.

SCIAMACHY has three different viewing geometries: nadir, limb and Sun/Moon occultation yielding total column values and distribution profiles in the stratosphere and in some case in the troposphere for trace gases and aerosols.

The measurements which will be obtained will enable the investigation of a wide range of phenomena which influence the atmospheric chemistry, i.e. in the troposphere: biomass burning, pollution, arctic haze, forest fires, dust storms, industrial plumes; in the stratosphere: ozone chemistry, volcanic events and solar proton events.

The instrument is designed and built as a joint German/Dutch project, funded by the German (DLR) and Dutch (NIVR) national agencies, with a contribution from Belgium to the Netherlands part. Principal contractors are Dornier Satellitensysteme and Fokker Space.

2 - MISSION OBJECTIVES

The measurements which will be obtained from SCIAMACHY will yield information about both tropospheric and stratospheric constituents. They will enable a wide range of phenomena both natural and anthropogenic in origin, which influence atmospheric chemistry and, consequently, the climate to be investigated:

- In the troposphere:
  Biomass burning, biogenic emissions, pollution episodes over populated regions, lightning production of oxides of nitrogen, Arctic haze, forest fires, dust storms, industrial plumes.

- In the stratosphere:
  Ozone chemistry including a special emphasis on the "ozone hole", volcanic events, and solar protons events.

2.1 - Primary mission objectives

The primary scientific objective is the global measurement of trace gases in the troposphere and stratosphere. The following table 1 identifies the list of molecules that will be measured by SCIAMACHY for the different viewing geometries and the different spectral regions.

Nadir		Limb/Occultations	
UV/Vis	**IR**	**UV/Vis**	**IR**
O_3 Ozone	H_2O Water Vapour	O_3 Ozone	H_2O Water Vapour
NO_2 NitrogeneDioxide	CO Carbon Monoxide	NO_2 Nitrogen Dioxide	CO Carbon Monoxide
BrO Bromine Monoxide	CO_2 Carbon Dioxide	BrO Bromine Monoxide	CO_2 Carbon Dioxide
SO_2 Sulphur Dioxide	N_2O Nitrous Oxide		N_2O Nitrous Oxide
OClO Chlorine Dioxide	CH_4 Methane		CH_4 Methane
H_2CO Formaldehyde			

Tab.1

2.2 - Secondary mission objectives

- ***Aerosol measurements***
  The large wavelength scale of SCIAMACHY makes it ideally suited to the determination of atmospheric aerosols. This analysis will be assisted by the polarization information that can be determined from the PMD (Polarization Measurements Device).
- ***Cloud measurements***
  In Nadir viewing, O_2, O_4 and CO_2 absorptions will indicate the penetration depth of light in the atmosphere and therefore will enable the cloud top heigth to be estimated. The combined use of PMD data will also yield cloud cover. Polar Stratospheric Clouds, which play a very important role in the ozone depletion mechanism will be readily measured by SCIAMACHY.
- ***Pressure and temperature measurements***
  Stratospheric density/pressure profiles can be determined from the limb and occultation profiles of the well-mixed gases O_2 and CO_2
- ***Land and Ocean measurements***
  SCIAMACHY will provide global information on the surface spectral reflectance in the range 0.33-2.5 um for large scale processes.
- ***Earth radiation budget***
  SCIAMACHY spectral observations, in conjunction with model calculations

may contribute significantly to radiation budget studies.

3 - PRINCIPLE OF SCIAMACHY OBSERVATIONS

In order to achieve the scientific objectives, SCIAMACHY will observe the Earth atmosphere under three different viewing geometries (modes) incorporating a scanning approach:

- Nadir
- Limb
- Sun/Moon Occultation

A well balanced use of the different measurements types will have to be determined by the mission scenario.

3.1 - Nadir

The global measurements of trace gases will be obtained by Nadir measurements. In this mode only the nadir/elevation mirror is used. The instrument is scanning across the flight direction (Fig.1). The maximum scan range is +/- 500 km. The scanning times are 4 seconds in the forward direction and 1 second in the backwards direction. The scanning speed is selectable among 16,8, 4 and 2 degrees/second. Corresponding to an integration time of 62,5 msec, a spatial resolution of 16 km in the scanning direction is feasible.

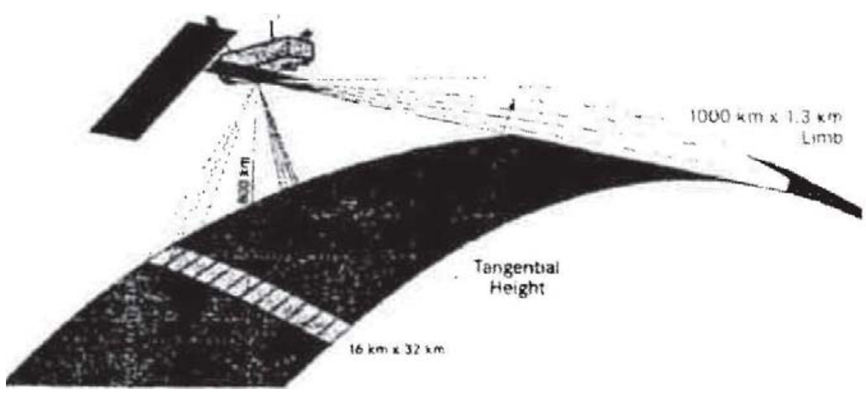

Fig.1

The long side of the Instantaneous Field of View is aligned parallel to the flight direction. It has a 1.8 deg angle corresponding to a width of 32 km in the flight direction at the subsatellite track The maximum swath width of +/- 500 km ensure a global coverage with a maximum of three days at the equator and more rapidly at higher latitudes.

The Nadir viewing is particularly suited for the following applications:

- Determination of total column amounts of trace gazes
- Stratospheric and tropospheric profiles of certain species at limited height resolution
- Cloud detection
- Aerosols
- Surface reflectance

3.2 - Limb

The limb measurements are necessary to retrieve vertically resolved profiles. In this mode, both elevation and azimuth mirrors are used to scan the atmosphere. The instruments performs a selected number of azimuth scans with different elevation steps in the limb forward direction (Fig.1). The azimuth scanning time is 1.5 sec and the speed is selectable among 11, 5.5, and 2.75 degrees/second.

The long side of the Instantaneous Field of View is aligned parallel to the horizon. The field angle of 1.8 degrees correspond to a width of 120 km and the atmosphere is scanned tangentially over a 1000 km swath. The field angle of 0.045 deg corresponds to an altitude layer of 2.6 km. At the end of each azimuth scan the elevation is increased by a step of 3 km. This scanning is reproduced until the maximum altitude of 100 km is reached. During Limb mode, the same atmospheric volume will be observed as in Nadir about ten minutes later.

The main applications of the limb viewing are:

- Determination of trace gas stratospheric profiles with a improved resolution (compared to nadir)
- Aerosol profiles

3.3 - Sun and Moon Occultation

In this mode SCIAMACHY selects the Sun or the Moon as target and tracks it as soon as it comes above the horizon and until the line of sight reaches a maximum tangent height of 100 km. Due to the accommodation of SCIAMACHY on ENVISAT-1, Sun occultation can be performed once per orbit during sunrise. Moon occultation can be performed typically a few days per month.

During the Sun occultation the long side of the IFoV is aligned parallel to the horizon centred to the Sun or scanning across the Sun. The IFoV in azimuth is reduced by a second slit to 0.72 deg corresponding to a width of 40 km at tangent point. The IFoV in elevation is limited to 0.045 deg corresponding to an altitude layer of 2.6 km. The atmosphere will be observed by following the centre of the Sun or by scanning across the Sun.

The Sun occultation is the ideal application for the absorption spectroscopy. The high light fluxes results in a short pixel exposure time and therefore in a high spatial resolution of the instrument The obtained spectra can be directly compared with the solar calibration spectra without any variation of the instrument setting.

Due to the high intensity of the Sun, the aperture of the instrument has to be reduced by the aperture stop mechanisms and the integration times are shortened. This results in a high data rate. Since the Moon intensity is much lower, in the Moon occultation the nominal aperture will be used like in Limb or Nadir. In Moon occultation the obtained spectra can be directly compared with the lunar calibration similar to Sun Occultation.

4 - INSTRUMENT DESCRIPTION

The SCIAMACHY instrument consists of the **Optical Assembly** (OA), the **Electronic Assembly** (EA), the **SCIAMACHY Radiant Cooler assembly** (SRC), the **Encoder Electronics** (ENEL) and the **instrument harness**. These assemblies are shown in their ENVISAT-1 accommodation in Fig. 2.

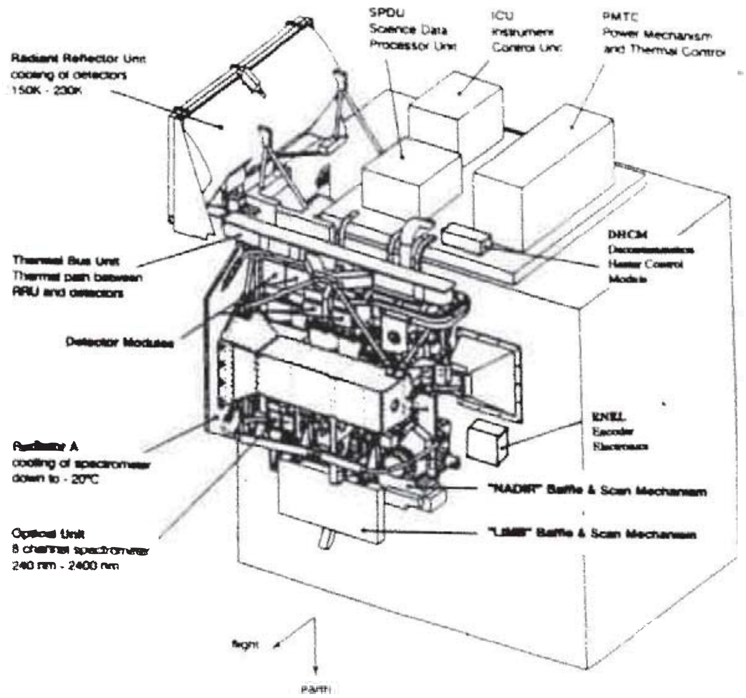

Fig. 2

4.1 - Functional Description

The SCIAMACHY functional Block Diagram is shown in Fig.3.

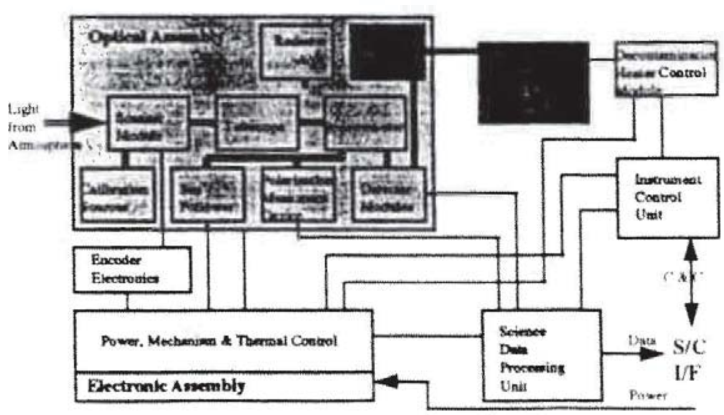

Fig. 3

In the ***Optical Assembly*** the light from the atmosphere is fed by the scanner unit consisting of an azimuth and an elevation scanner into the telescope which directs it onto the entrance slit of the spectrometer. The spectrometer contains a pre-disperser separating the light into three spectral bands followed by a series of dichroic mirrors which further divides the light into a total of eight channels. A grating is located in each channel to diffract the light into a high resolution spectrum which is then focused onto eight arrays of detectors.

The pre-disperser also serves as a Brewster window to separate polarized light, a part of which is sensed by the ***Polarization Measurement Device*** (PMD). This polarized beam is split into six different bands. In the case of limb where both elevation and azimuth mirrors are used, the 45 degree polarization components is measured by a seventh PMD sensor. The output of the PMD is thus used to correct for the polarization effects.

Each spectrometer channel is equipped with a ***Detector Module*** (DM). Each DM consists of a Focal Plane Assembly which is mounted on a cold finger, and an electronic subassembly. The focal plane assembly are linear arrays containing 1024 detectors pixels except for channel 1 which contains 512 pixels. Two technologies are used to cover the large SCIAMACHY wavelength range. Channels 1 through 5 use of the shelf Silicon arrays procured from Reticon in California. The detector material for channels 6 to 8 is Indium-Gallium-Arsenide (InGaAs). These are state-of-the art detectors especially developed for SCIAMACHY. Each Detector Module Electronic controls the associated detector, reads out the integrated charge, amplifies the analogue signal and then digitises the signal.

The ***Calibration submodule*** provides spectral and relative radiometric calibration capability internal to the instrument. It consist of a series of mirror and lenses which inject into the optical path the light of two possible calibration lamps. A platinium-chromium-neon lamp which provided fine spectral lines with well known and stable wavelengths and a current controlled Tungsten-Halogen lamp (white light source).

The Optical Unit is equipped with two one-axis scanner mechanisms. The nadir - ***Elevation Scan Mechanism*** which rotates around the Flight axis, is the only one used during nadir measurements, sub solar calibration as well for all calibration using internal sources. For limb and occultation measurements, this mirror controls the IFOV elevation. The ***Azimuth Scan Mechanism*** which rotates around the nadir axis is used to control the azimuth of the IFOV when performing limb or occultation measurements. It is also used to perform particular sun and moon calibrations.

SCIAMACHY is also equipped with a four quadrant sensor, the ***Sun Follower***, which evaluates the images reflected from the blades of the spectrometer entrance slit. Once the target of the Sun has been acquired the control of azimuth and possibly elevation scanners can rely on this unit.

To achieve the required instrument performance the detectors of the Optical Assembly have to be cooled to around 200 K for the visible and NIR channels 1 to 6 and to around 135 K for the IR channels 7 and 8. This Cooling is provided by the ***Radiant Cooler*** which is coupled through a Thermal Bus Unit (TBU) to the detectors. The TBU is built up from two cryogenics heat pipes which cool the two IR-detectors. A tube shaped shroud which envelopes the cryogenic heat pipes transport the heat load from the detectors of the other six channels.

The ***Electronic Assembly*** is composed by four electronic boxes. The ***SDPU*** (Science Data Processing Unit), where the digital signal of each channel is transferred to. The SDPU controls the Detector Module Electronics, acquires and processes science and auxiliary data and transmits them to the spacecraft measurement data interface.

The *ICU* (Instrument Control Unit) receives the macrocommands from the spacecraft on board computer, performs autonomously the overall management and control of the instrument and feeds back telemetry information.

The *PMTC* (Power, Mechanism and Thermal Control) provides secondary power to all equipment and controls the scanners via the *ENEL* (Encoder Electronics), the different mechanisms, the calibration source and the temperature of the optical bench and of the detectors. Furthermore the PMTC acquires analogue housekeeping signal indicating the health and status of the instrument.

The *DHCM* (Decontamination Heater Control Module) performs Radiant Cooler decontamination on/off control and thermal knife control for the opening of the protective door.

5 - PERFORMANCES REQUIREMENTS

5.1 - Spectral Requirements

The following table 2 shows the spectral coverage of the eight SCIAMACHY channels:

Channels	Spectral Range (nm)	Spectral Resolution (nm)
1	240-314	0.24
2	309-405	0.26
3	394-620	0.44
4	785-1050	0.48
5	1000-1750	0.54
6	1940-2040	0.22
7	1940-2040	0.22
8	2265-2380	0.28

Tab. 2

The spectral stability shall be better than 1/50 of a pixel between two calibration points. This objective will be fulfilled by controlling the temperature of the optical bench and by performing dedicated calibration measurements based on internal spectral line source.

In order to correct for polarization effects SCIAMACHY uses the Polarization Measurements devices. The spectral bands given in the following table 3 are quite broad and overlap with large regions of channels 2,3,4,5,6 and 8:

PMD Band	Wavelength range (nm)
1	320-380
2	450-520
3	620-700
4	800-900
5	1500-1700
6	2265-2380
45 deg. Detector	800-900

Tab. 3

5.2 - Radiometric Aspects

The following table 4 shows the upper and lower limit of radiance to be measured in the different spectral bands for the four possible viewing geometries:

Spectral Radiance (Photons/sr.cm2.nm.s)								
	Nadir Measurement		Limb Measurement		Solar Measurement		Moon Measurement	
Band	min. Rad	max. Rad	min. Rad	max. Rad	min. Rad	max. Rad	min. Rad	max. Rad
1a	3.7e8	1.7e12	6.0e9	5.7e11	5.1e16	2.0e18	2.0e10	1.4e12
1b	9.4e10	1.3e13	5.9e11	2.5e12	9.5e17	2.5e18	7.0e11	1.5e12
2a	5.3e11	2.6e13	6.2e11	9.9e12	1.0e18	2.4e18	9.0e11	2.0e12
2b	1.5e12	1.1e14	4.8e11	9.3e13	1.5e18	5.4e18	1.4e12	6.8e12
3	3.9e12	1.7e14	6.8e11	1.2 e14	3.8e18	8.3e18	6.7e12	2.3e13
4	2.8e12	1.7e14	4.2e11	9.9e13	6.9e18	8.3e18	2.1e13	2.6e13
5	1.6e12	1.6e14	2.7e11	9.4e13	5.5e18	7.1e18	2.1e13	2.6e13
6	3.6e11	1.3e14	7.9e10	5.8e13	2.5e18	5.7e18	1.7e13	2.3e13
7	2.7e10	3.0e14	4.8e10	8.1e11	1.6e18	1.9e18	1.0e13	1.2e13
8	8.9e10	2.4e13	2.3e13	6.7e11	9.4e18	1.2e18	6.4e12	8.2e12

Tab. 4

5.3 - Instantaneous Field of View

The IFOV defines the instantaneous solid angle from which spectral radiance is detected. The size of the IFOV is defined by the contour, where the energy is 50% of the maximum energy inside the IFOV. The following table 5 defines those field of views for the different viewing geometries:

Geometry	IFOV		
Nadir	0.045 1.8	+/- 0.003 deg. +/- 0.200 deg.	Across track Along track
Limb	0.045 1.8	+/- 0.003 deg. +/- 0.200 deg	In elevation in azimuth
Solar Occultation	0.045 0.72	+/- 0.003 deg. +/- 0.200 deg.	In elevation in azimuth
Moon Occultation	0.045 1.8	+/- 0.003 deg. +/- 0.200 deg.	In elevation in azimuth

Tab. 5

5.4 - Thermal Requirements

SCIAMACHY is very sensitive to changes of the Optical Bench temperature level and gradients which could affect the spectral and radiometric stability as well as the scanner performances. Therefore the optical bench is cooled at a temperature of -20 C. Three active thermal control loops using heaters circuits are used to stabilize the temperature and minimize the temperature gradients.

The cooling of the Detectors is ensured by a passive radiator which combined with a cryogenic heat pipes cools the channels to the following temperatures:

Channel	Temperature Range	Stability over 1 orbit
1,2	185-215 K	6000 mK
3,4	215-235 K	2000 mK
5	225-235 K	200 mK
6	190-210 K	300 mK
7,8	130-160 K	125 mK at 135K/30 mK at 160K

Tab. 6

5.5 - Signal to Noise Requirements

The table below shows the required Signal to Noise values for the different modes, begin of life hot case, minimum and maximum radiance:

Band	SNR for Limb min rad.	max rad.	SNR for Nadir min rad.	max rad.	SNR for Sun Occ. min rad.	max rad.	SNR for Moon Oc min rad.	max rad.
	Tint. = 1.5 sec	Tint.= 1.5 sec	Tint.=1sec 40 sec for ch. 1a	Tint.=1sec 40 sec for ch. 1a	Tint.= 125 msec	Tint.= 125 msec	Tint.= 2 sec	Tint.= 2 sec
1a	6	500	6	5000	130	2500	3	230
1b	300	500	75	1250	1300	3000	100	250
2a	300	2500	170	4000	1700	3000	120	300
2b	250	5000	500	4200	2400	5200	130	580
3	360	9000	200	8100	1700	2800	910	2200
4	200	9000	510	10000	2000	2300	2200	2300
5	11	2100	150	2000	350	1400	290	350
6	170	10000	170	13000	2500	3700	3500	4400
6+	170	10000	170	13000	2500	3700	3500	4400
7	35	500	16	2400	2800	3100	810	920
8	10	200	37	2400	2200	2500	580	810

Tab.7

6 - OPERATIONAL CHARACTERISTICS

The operation concept of SCIAMACHY is built on the hierarchy Mission Scenario - Timelines-

States. Mission Scenario define the high level sequence of activities. They describe what type/categories of measurements have to be performed and how the various types are related to each other. The timelines are the implementation of the mission scenario detailing the sequence of individual measurements to be performed. The States are the lowest level in the hierarchy. Each state represents a single measurement type with a specific set of parameters.

6.1 - Scientific measurements - Dayside

SCIAMACHY offers the possibility to observe within a short time delay the same volume of air under different viewing geometries (i.e. occultation, limb and nadir). In order to fulfil all the scientific objectives, it is necessary to combine the measurements of those different geometries.

The following strategy as been proposed for SCIAMACHY for the nominal scenario:

- Sun occultation shall be performed each orbit; i.e. once per orbit in the northern hemisphere, as the sun comes over the horizon.
- Perform Moon occultation in the southern hemisphere every second orbit whenever possible. Taking into account the field of view of the instrument and the moon orbit, Moon occultation is feasible every 28 days for a duration varying between 5.5 and 8 days.
- For the rest of the dayside, limb measurements shall alternate with nadir ones in such a way that the same parts of atmosphere are seen under the two geometries. In Limb Sciamachy records atmospheric spectra corresponding to a part of the atmosphere about 3290 km ahead of the platform. As the satellite moves along its orbit at the speed of 7.5 km/s after approximately 435 seconds, it flies at the vertical of the scene and can perform nadir measurements over the same volume. A typical duration for a nadir sequence is 80 seconds and 59 seconds for limb.
- Global coverage shall be achieved within 3 days at equator. This requires the use of the maximum possible swath width for nadir and azimuth range for limb so as to have 1000 km wide ground track.

Besides this nominal scenario for scientific measurements, additional scenarios may be defined for specific campaigns.

6.2 - Eclipse/Nigthtime mode

During nighttime photon fluxes are very low. There are however a variety of low level light sources, e.g. lunar radiation, stars, airglow, fires and biomass burning. Therefore, it is foreseen to share the eclipse time between dark signal measurements and nadir measurements with long integration times (from 1 to 80 seconds) to improve the signal to noise ratio when measuring those weak light sources.

6.3 - Calibration and Monitoring Measurements

In order to guarantee a long term stability of the scientific measurements Sciamachy can performs many different calibration measurements. They can be performed on an orbital, a daily, a weekly or a monthly bases. Calibration/Monitoring modes are:

- Sun occultation & calibration with sun scanning either fast sweep or nominal scan
- Sun occultation & calibration with sun pointing
- Moon occultation & calibration with moon pointing
- Moon calibration with moon scanning
- Sun observation via diffuser via neutral density filter in or out
- Sub-solar calibration in pointing or scanning mode
- Spectral lamp calibration

- White light lamp calibration
- Dark current calibration
- Nadir/elevation mirror calibration using the sun as light source
- Nadir/elevation mirror calibration using the moon as light source
- Analog Digital Converter calibration

6.4 - Instrument States

In order to cope with all the subsystems and parameters that have to be specified to perform a given measurement, Sciamachy is operated using basic building blocks called States. For a given states, several onboard table specify many parameters such as the cluster definitions, the exposure times and co-adding factor for the different channels or the scanner parameters. 70 states can be stored onboard the ICU EEPROM.

6.5 - Timelines

The basic states are grouped into timelines which can cover part or up to a full orbit of operations. Taking into account that only one activation time can be specified for a given timeline, it is mandatory that each timeline contains a maximum of one "target binded state". A timeline is thus started by a time tagged macrocommand. Up to 63 timelines can be loaded on board the Sciamachy RAM.

7 - DATA PRODUCTS

Table 8 presents the list of Sciamachy Data Products. According to the potential use of the data and the complexity of alghoritms, the product generation has been split between Near Real Time (NRT) processing (products available 3 hours after data acquisition) and off-line processing.

The column "special" lists molecules which are only present in the atmosphere under special circumstances (such as volcanic eruption for SO_2) and is so covered by both NRT and off-line processors.

	Nadir			Limb/Occultations		
	UV/Vis	IR	UV/Vis/IR	UV/Vis	IR	UV/Vis/IR
NRT	O_3,NO_2,SO_2*, OClO*, H_2CO*	H_2O,CO, N_2O,CH_4	Clouds, Aerosols			
Off-Line	O_3,NO_2,BrO,SO_2*, OClO*, H_2CO*	H_2O,CO,CO_2, N_2O,CH_4,P,T	Clouds, Aerosols	O_3,NO_2,BrO	H_2O,CO,CO_2, N_2O,CH_4,P,T	Aerosols

(*) This molecules can only be detected under special conditions

Tab. 8

Table 9 gives more details about the Near Real Time products:

	NRT Processing Level	Size/Coverage
Level 0	Raw data	323 Mbyte/Full orbit
Level 1b	Geolocated engineering calibrated scientific measurements only (Nadir,Limb, Occultations) Monitoring measurements: - Sun over diffuser - Subsolar calibration - Spectral lamp measurements - White light source measurements - Elevation mirror monitoring - ADC calibration	180 Mbyte/Full orbit
Level 2	- Geolocated vertical columns for O_3, NO_2, H_2O, CO, N_2O and CH_4. - Geolocated vertical columns for SO_2, OClO and H_2CO under special conditions (volcanic eruption, Ozone hole conditions, pollution). - Cloud top height and cloud cover - Aerosol Absorption Indicator	5 Mbyte/Day side
Level 2	Vertical column amount of Ozone for Meteo Users (BURF Format)	1 Mbyte/Day side

Tab.9

8 - DEVELOPMENT STATUS

8.1 - Model Philosophy

Due to schedule reasons, SCIAMACHY implements a Proto Flight Model philosophy, in which additional qualification models and cost are saved by developing just one model on which testing is performed to qualification levels for acceptance durations.

However to reduce some of the risk associated with the PFM approach some additional models have been developed. These models include breadboards, model for lifetime test, development and structural models. They are foreseen to gain better confidence on the technologies criticality.

The deliverable models to the ENVISAT-1 program are:

- Structural Models (StMs) for the Optical Assembly and Radiant Cooler
- Simplified Engineering Model (SEM) for the Electronic Assembly, Harness and Optical, Radiant Cooler Assembly Simulator
- Proto Flight Models (PFMs) for the Radiant Cooler, Optical Assembly, Electronic Assembly and for the Encoder Electronics.

8.2 - Structural Models

Because the minimum requirement of 100Hz structural stiffness requirement for the PFM could not be met for the Radiant Cooler and Optical Assembly, structural models have been built. Both models, which are representative with respect to form, fit and structural aspect, but do not contain optics, electrical element and MLI, had completed instrument level sine and random vibration testing before to be delivered to PPF respectively in March '96 and December '95. Thus, they participated in the spacecraft mechanical qualification testing.

8.3 - Simplified Engineering Models

The Electronic Assembly SEM is built to the same electrical specification as the PFM. The electronic parts are functionally flight representative, but of reduced quality level. All redundant parts of the electronic units are omitted for the SEM. However, the interfaces to the spacecraft are flight representative.

In addition to the Electronic Assembly, The SEM consists of an ORCA simulator, which provides the electrical functionality of the Optical Assembly and Radiant Cooler.

The SEM units are used for low level functional, thermal and low level development testing. The SEM is used for functional testing and EMC at instrument level. The SEM was delivered to the PPF programme in October '96 and was successfully integrated and tested on the EM of the spacecraft in January '97.

8.4 - Qualification Models

The SCIAMACHY Design, Development and Verification approach features qualification models for the following units:

- Encoder Electronics (ENEL) for Arc Discharge Qualification
- Cryogenic Heat pipes for Thermal and mechanical Qualification
- Thermal Bus Unit (TBU) for Thermal Qualification
- Encoder Sensor
- Detector Modules (DM)

8.5 - Proto Flight Models

Thermal Qualification of the Electronic Assembly Units and ENEL takes place on the PFM units. Thermal Qualification of the SRC and OA will be performed via thermal cycling tests on PFM SRC and OA during instrument and assembly level TB/TV tests.

Vibration tests (sine and random) on PFM assembly level represent the final mechanical qualification for the OA, EA, ENEL and SRC. In order to reduce the risk to the PFM hardware, qualification levels for acceptance durations are planned.

Shock emissivity tests will be performed on the baffle covers and SRC door.
Power quality, CE and CS qualification tests are performed at instrument level without the SRC. RE and RS tests are performed at instrument levels. CS Signal Lines, Signal Lines Isolation and Magnetic Moment qualification test are performed at PFM units levels. The PFM Scan Mechanism is tested for Magnetic Moment.

8.6 Performance tests

Preliminary performance test with optical stimuli at operational temperature were performed in September 1997 and the results are presently being evaluated. Final performance test and instrument calibration period are planned in the first part of 1998.

9. CONCLUSIONS

The main instrument mission requirements of SCIAMACHY have been here described together with a description of the operational characteristics of the instrument and its design characteristics.

The complexity of the instrument, the new design involved to satisfy the demanding operational requirements, associated with a proto flight model approach continue to constitute a big challenge in the development of this programme in the time frame imposed by the ENVISAT-1 launch date.

However the first environmental and functional tests so far performed as well as the preliminary measurements data available, although in some cases will impose some design adaptation, give enough confidence in the success of the SCIAMACHY mission.

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