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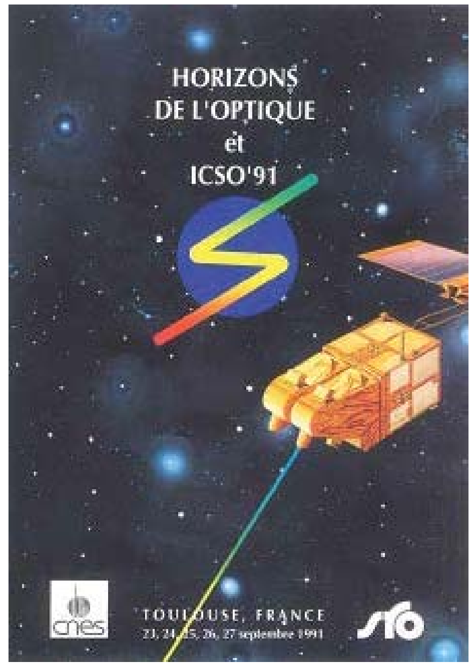

Session 3: Atmospheric Sounding

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HSRS: A STUDY FOR A SPACEBORNE HIGH SPECTRAL SOUNDING INTERFEROMETER

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ABSTRACT

This paper deals with a High Spectral Resolution Sounder (HSRS) for 3 axis stabilized METEOSAT Second Generation satellite, dedicated to meteorological survey. This study has been performed under ESA contract by AEROSPATIALE as Prime Contractor, with OFFICINE GALILEO (ITALY) for optics and mechanisms, and NORSK ELEKTRO OPTIKK (NORWAY) for focal plane (with its cooling) and signal processing, as Subcontractors.

From the parametric analyses of several candidate designs (dispersive spectrometer, Fourier Transform spectrometer, hybrid -Fourier Transform with grating- spectrometer), the second one, with on-board signal processing, has been selected as the only solution able to meet the requirements of a high spectral resolution sounding from geostationary altitude. The proposed instrument covers the 670-2700 cm^{-1} spectral range (split into 3 spectral bands) with a relative spectral resolution of 1 to 2.10^{-3}. The pixel size on ground is 10 km. The sampling distance between two recordings can be modified, allowing to satisfy, with the same instrument, the constraints on both operational modes, namely the Mesoscale mission (Europe coverage within 1 hour) and the Synoptic Scale mission (the whole Earth coverage witin 2 hours with a wider sampling distance).

The instrument volume is less than 1 m^3, its mass in the order of 230 kg and the needed power roughly 400 W.

SONDAGE ATMOSPHERIQUE INFRA-ROUGE PAR INTERFEROMETRIE INSTRUMENT IASI

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Les sondages atmosphériques obtenus à partir des instruments satellitaires actuels deviennent marginalement utiles du fait de leur précision insuffisante.
Les besoins de la recherche et de la météorologie opérationnelle ont conduit le CNES en coopération avec l'ASI à étudier un sondeur infra-rouge à haute résolution spectrale. Le concept d'un interféromètre a été retenu pour des raisons de faisabilité technologique et de complémentarité avec les développements de la NASA sur un spectromètre à réseau (AIRS).
Les spécifications mission couvrent essentiellement la détermination des profils de température et d'humidité avec une résolution verticale de 1 km et une précision de 1 K, respectivement 10 % et une résolution horizontale compatible avec les modèles de prévision de l'atmosphère à l'échéance 2000. Elles se traduisent par la spécification radiométrique suivante :

- domaine spectral : 3.3 à 15.5 um
- résolution : 0.5 cm^{-1} apodisé
- précision radiométrique : nedt 0.2 K à 280 K
- calibration : 0.5 K à 280 K
- échantillonnage ssp: 22 km

Les études système menées au cours de la phase A ont permis de préciser les fonctionnalités de l'instrument, en particulier au niveau de la nécessité et la précision de la correction de défilement, au niveau de l'interface utilisateur avec comme corollaire la réalisation à bord de la calibration et l'évolution de l'instrument permettant de simplifier au maximum le traitement de bord.

INTERFEROMETRE IASI

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Le sondeur infra-rouge IASI est conçu pour mesurer depuis un satellite en orbite polaire l'émission vers l'espace de l'atmosphère terrestre.

L'instrument se compose d'un dispositif de balayage à compensation de défilement, d'un interféromètre de Michelson, d'une référence laser pour un échantillonnage régulier des interférogrammes, d'une électronique d'acquisition et d'un traitement du signal qui a pour fonction de calculer la T.F. et de comparer la valeur absolue de l'émission de l'atmosphère avec l'émission de corps noirs de référence.

L'étendue spectrale de l'instrument est subdivisée en trois canaux par des lames dichroïques. Les détecteurs HgCdTe sont photovoltaïques ou photoconducteurs selon les canaux. Ils sont refroidis, ainsi que l'éclateur spectral, à la température de 100 K par l'intermédiaire d'un radiateur qui rayonne vers l'espace.

IASI doit assurer pendant 5 ans la couverture du globe et délivrer des spectres d'émission de l'atmosphère à l'usage de la météorologie et des sciences de l'environnement. Il pourrait être embarqué sur une plate-forme européenne dès 1997.

Michelson Interferometer for Passive Atmospheric Sounding (MIPAS)

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MIPAS is a high resolution limb sounding Fourier transform spectrometer intended to be flown on the first Polar Platform and the German environmental research satellite ATMOS. Main scientific objective of MIPAS is the simultaneous and global measurement of abundances of atmospheric trace gases by limb observations in the medium and thermal infrared from the upper troposphere to the thermosphere. The data gathered by the instrument will be of prime importance for the study of upper tropospheric and stratospheric chemistry, dynamic atmospheric processes and climatology.

MIPAS scans the horizon in elevation and detects the radiation emitted by the atmospheric volume elements. The instrument will cover a spectral range from 4µm to 15µm with an apodized spectral resolution of 0.05cm-1. The Instantaneous Field Of View (IFOV) corresponds to 3km in elevation and 30km in azimuth in the tangent plane. The instrument Line Of Sight vector in azimuth and the step size in elevation are programmable. Additional attitude sensors at the MIPAS base stabilize the instrument pointing in elevation during an interferometer sweep.

An anamorphic telescope, also defining the Field Of View, adapts the shape of the beam to the interferometer. The interferometer is designed according to the Michelson principle with two moving retroreflectors and two output ports. The spectral separation concept optimizes the combined performance of the individually processed signals of both output ports. Special care had been taken to reduce the instrument's thermal self-emission and thus increase the radiometric sensitivity.

An overview of the current instrument design will be given, emphasizing the optical system and the performance assessments.

OBSERVATION OF STELLAR OCCULTATION FOR THE MONITORING OF OZONE TRENDS : THE GOMOS INSTRUMENT

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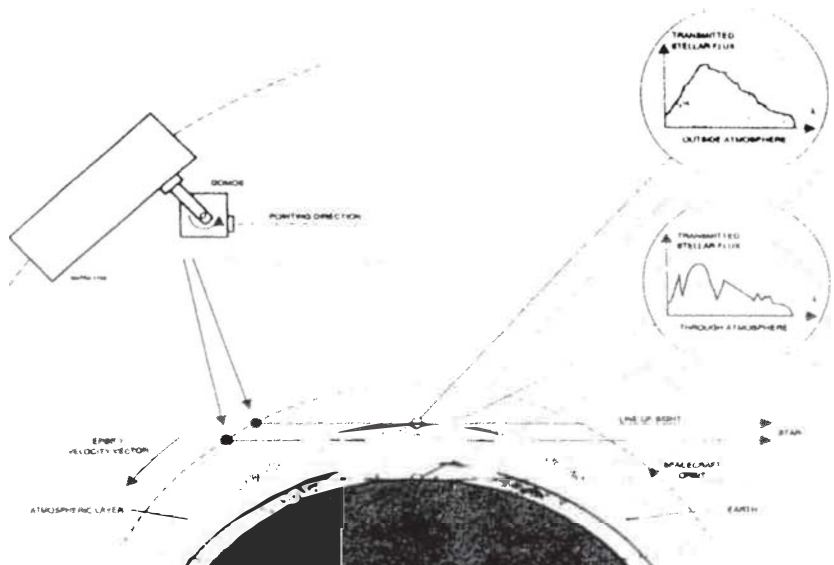
1. INTRODUCTION

In response to the growing concern about the threatened ozone equilibrium in the stratosphere, the GOMOS instrument (Global Ozone Monitoring by Occultation of Stars) was proposed to ESA by a group of 25 European Scientists from 10 institutes and 6 countries, to be flown on the first European Polar Platform. A phase A study of GOMOS was conducted by MATRA Espace and a group of Finnish industries, at the joint request of CNES and Finnish Meteorological Institute, resulting in a stage of definition of the instrument sufficient to warrant feasibility and scientific performances.

2. GOMOS MEASUREMENT PRINCIPLE

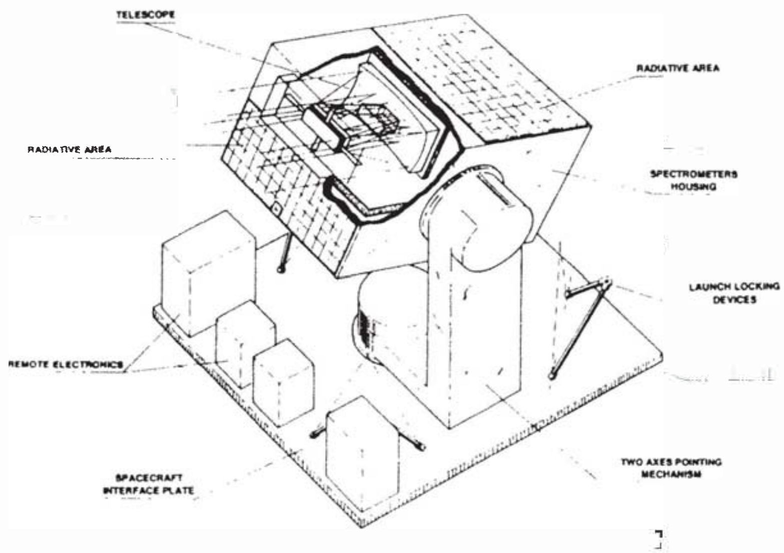
GOMOS consists of a telescope feeding two spectrographs, mounted on a dedicated steerable platform. It can be successively oriented towards preselected stars and maintained on each of them while the star is setting behind the atmosphere observed at the horizon. During the occultation, the full UV-Vis-Near-IR stellar spectrum is continuously recorded; it is of course more and more attenuated because of the absorption by various species. A full-spectrum differential method is then applied; it ensures that the various absorbing species can be safely identified and their tangential column densities easily derived from a comparison to the unattenuated stellar spectrum measured outside the atmosphere a few seconds before.



This method is also self calibrated as it allows to derive an absolute concentration of atmospheric molecules from relative measurements; it is therefore protected from instrumental drifts. The stellar occultation methodology provides measurements with a high vertical accuracy (+/- 50m) independant of platform attitude uncertainties. About 25 stellar occultations per orbit, and 350 per day, spread over all latitudes can be performed from 90 km down to 20 km of altitude. Over a four year mission, GOMOS will be able to measure an ozone decrease as small

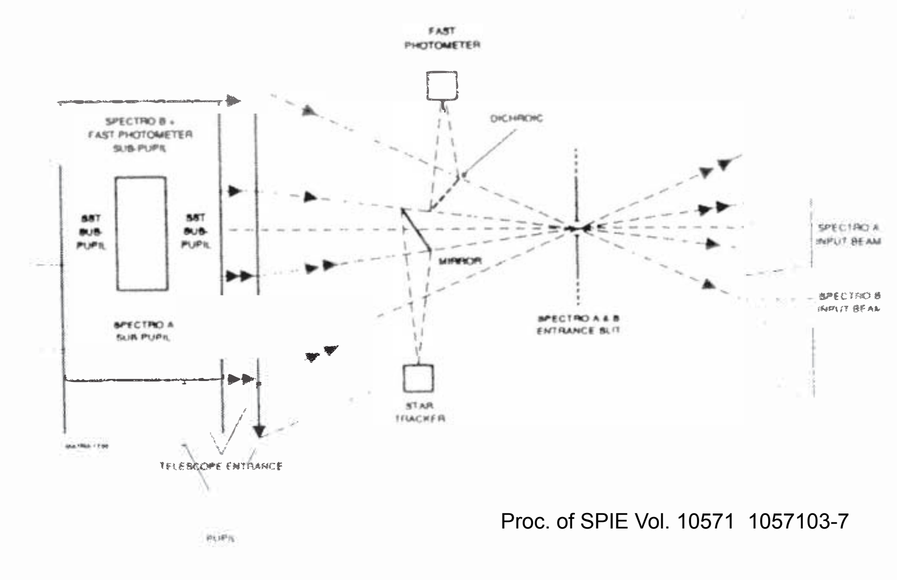
3. INSTRUMENT CONCEPT OVERVIEW

The instrument optical design is based on a single telescope concept : a Cassegrain telescope simultaneously feeds a UV-Vis medium resolution (0.6 nm) spectrometer - for signal measurements in the Huggins and Chappuis bands (250-675 nm) - and a near-IR high resolution (0.07 nm) spectrometer - for O2 (760 nm) and H2O (930 nm) observations. A CCD based star tracker, which may operate either in dark limb or in bright limb conditions, shares the same focal plane and provides the pointing and tracking accuracy required to maintain the star image at the center of the spectrometers input slit. A fast photometer diverts part of the telescope signal for a high frequency monitoring (1 kHz) of the input signal scintillation. The single telescope concept has been selected for spectrometers and star stracker co-alignment considerations. The telescope focal plane allows a common slit for both spectrometers, close to the star tracker detectors, and thus avoids any additional alignment correction mechanism. All the optics, detectors and related signal acquisition electronics are implemented within a common housing - aluminium honeycomb sandwich mounted on a pointing mechanism. This mechanism is in charge of the pointing of the telescope toward successive stars and is made of two perpendicular axis motorized hinges connected together by a CFRP L-bracket structure. This assembly provides GOMOS with a +/- 90° pointing capability in azimuth and 0° (Nadir) to +90° or more in elevation. The overall mobile assembly is fixed on the payload carrier through a spacecraft interface plate. The latter also supports three locking devices which immobilize the instrument during launch and then release it for operation. It carries several electronic boxes which contain the data handling, command and control, and power distribution electronics.



4. GOMOS OPTICAL DESIGN

The selected telescope is a Cassegrain telescope with a rectangular pupil (150 mm x 300 mm). This shape eases the optomechanical implementation and provides slow input beams to each spectrometer. The UV-Vis and Near-IR beams are separated after the spectrometer common input slit (telescope pupil separation). A central obscuration band (folding mirror) is reserved for star tracker light pick-up. The fast photometer it-self is addressed via a dichroic beam splitter located in the near-IR spectrometer input beam. The UV-Vis spectrometer uses a concave aberration corrected holographic grating. The full spectrum is dispersed linearly at first order and then split and dispatched toward three CCD mosaics. These detectors are backside illuminated thinned CCDs, cooled with Peltier devices, for high sensitivity and low noise. The near-IR spectrometer disperser is a plane blazed grating used in Littrow mounting. The two spectral bands are diffracted at the same angle but then separated by a cross-dispersion prism and focused on a single CCD mosaic.



5. GOMOS POINTING MECHANISM

A pointing sequence, associated to each stellar occultation, includes three successive phases: a first rallying phase aims at mooving the instrument from one star for which occultation is completed, to the next one just about to be occulted. This open-loop motion ends with the star entering the star tracker field of view. The acquisition phase is then briefly activated and consists in a closed-loop centering of the star within the star tracker FOV. The tracking phase which follows on automatically, maintains the star, by means of a closed-loop control, at the center of the FOV, i.e. at the center of the spectrometer entrance slit.
The wide clearance and accurate motion of the instrument mobile part around both azimuth and elevation axes is achieved with two stepper motors. Mounted with a direct coupling to their output shaft (no gear box), they are powered with a micro-stepping control and an active damping loop for high accuracy (better than +/- 30µrad). This concept and related devices, including the L-bracket structure, directly derive from equipments already developed for other space programmes (IOC,SILEX).

6. GOMOS ELECTRICAL FUNCTIONAL ARCHITECTURE

The instrument contains all the electrical and electronic equipments, including on-board computer, required for its operation. This self-sufficient approach awards it a large autonomy - the instrument pointing and observation programme may be up-loaded only once a week and takes 6 kbits for continuous observations - and makes easy the coupling with the spacecraft - restricted number of standard electrical interfaces.
The major sub-assemblies of this architecture are the detection chains (from the detectors up to the digital science data interface with the payload carrier), the pointing sub-system (built around a computer based pointing loop control electronics which drives the star tracker and pointing motors) and the instrument control unit, responsible for the instrument sequencing and control.

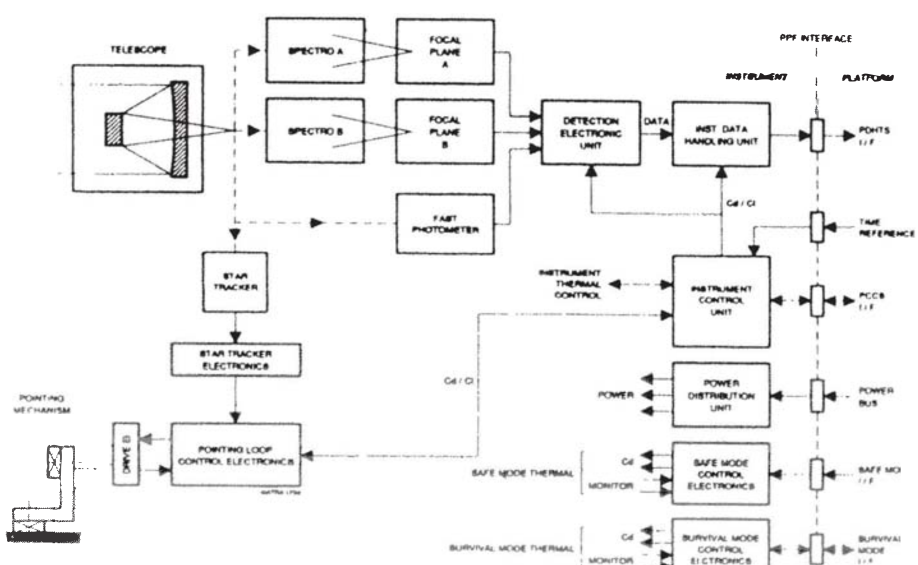
7. GOMOS MAIN BUDGETS

- Mass :
Mobile part = 31 kg
Pointing mechanism = 13 kg
Remote electronics = 33 kg
Spacecraft interface = 12 kg
Total (with 20% margin) = 106 kg

- Power :
operational mode = 160 W
safe/survival mode = 30 W
(including 20% margin)

- Science data rate
operational mode = 215 kbit/sec
- Telecommand rate
observation programme
up-loading = 6kbit/week

- Reliability objective :
> 0.8 for a 4 year mission



8. CONCLUSIONS

From space, the GOMOS instrument will provide every day a global geographical coverage of ozone vertical distribution with an unprecedented precision and reliability thanks to the self-calibration capability of the stellar occultation technique. It will monitor seasonal, latitudinal and long term trends, in response to recommandations issued by the Ozone Trend Panel set up by NASA and WMO. GOMOS provides also simultaneous measurements of NO2, NO3, H20, aerosols and temperature vertical distribution, species and parameters of primary importance for the ozone equilibrium, allowing a better understanding of the ozone depletion mechanism. From the European

THE MEDIUM RESOLUTION IMAGING SPECTROMETER (MERIS)

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ABSTRACT

MERIS instrument, Medium Resolution Imaging Spectrometer, is an optical instrument which is intended to be flown on the First European Polar Platform scheduled on launch in 1997.

One of the two definition studies of this instrument is currently carried out by an international team led by **AEROSPATIALE**, within the frame of an overall First Polar Mission study conducted by **DORNIER** behalf of the European Space Agency **ESA.** This study follows the Advanced Ocean Color Monitoring (Advanced OCM) led by **AEROSPATIALE** in 1983, and the feasability study led by **SIRA** (prime) with **AEROSPATIALE.**

MERIS is a space optical instrument with a high radiometric resolution and directly applicable to the measurement of the ocean evolution. Its main application will be monitoring the colour of the oceans and coastal regions, and in particular quantative determination of the spectral signature of the ocean leaving radiance. Interest also exists to use MERIS for land and atmospheric applications.

MERIS performs simultaneous spatial and spectral imaging in push-broom mode. The instrument is capable of transmitting 15 visible spectral bands programmable in width and position, with a FOV of 81°. Scenes with albedos of 1 can be measured without saturation. The noise equivalent reflectance at sea level (NeΔr) is better than 5E-4.

To achieve this high performances level an in-flight calibration system is required to perform a radiometric correction. The calibration allows first correction of both the spatial and spectral inhomogenous sensitivity of the sensor (spatial and spectral relative), in a second place the acquisition of the image in absolute. Furthermore an board wavelenght calibration is required to known the absolute position of spectral bands

The goal of this paper is to describe all aspects of this instrument included the image quality performances.