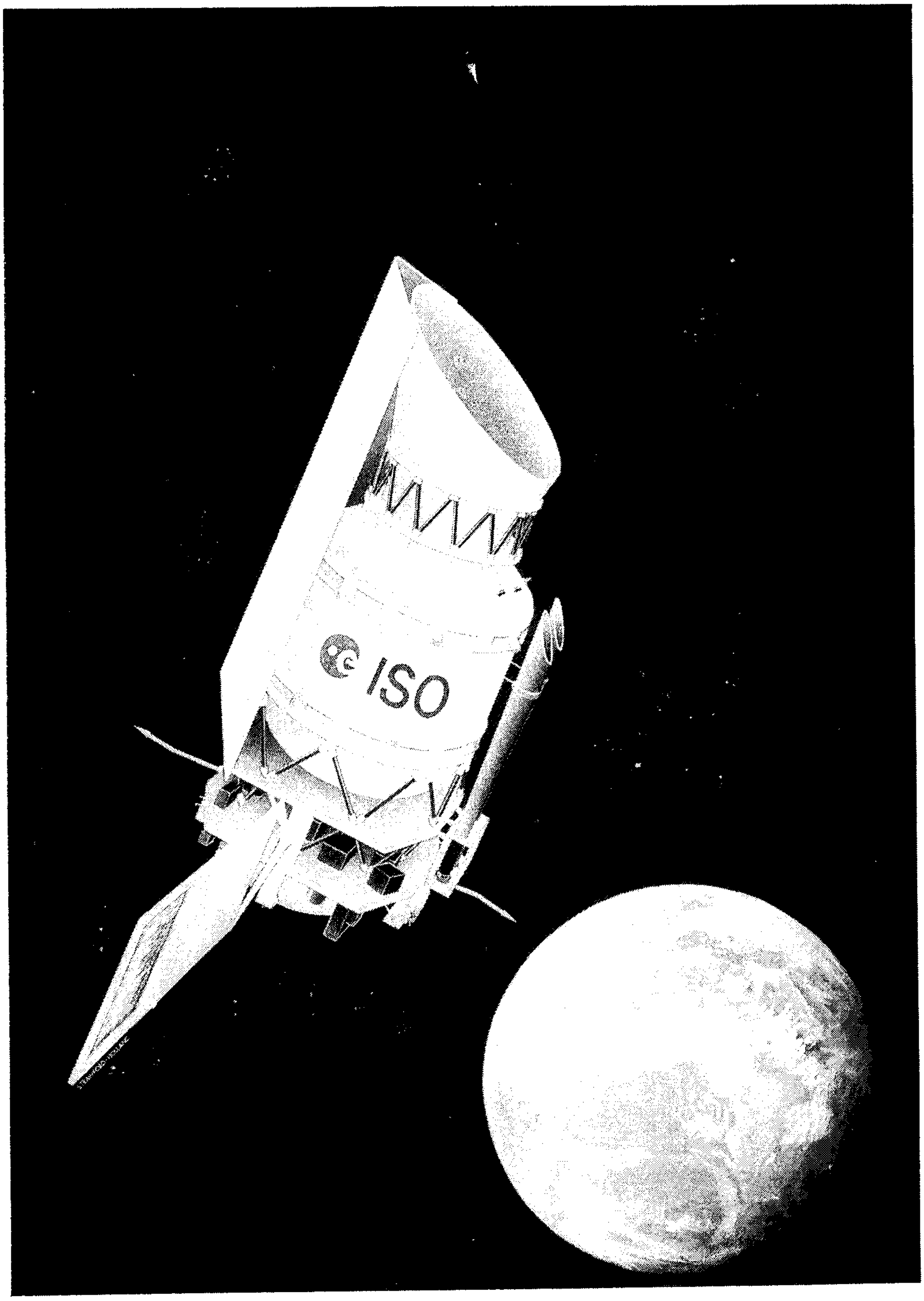
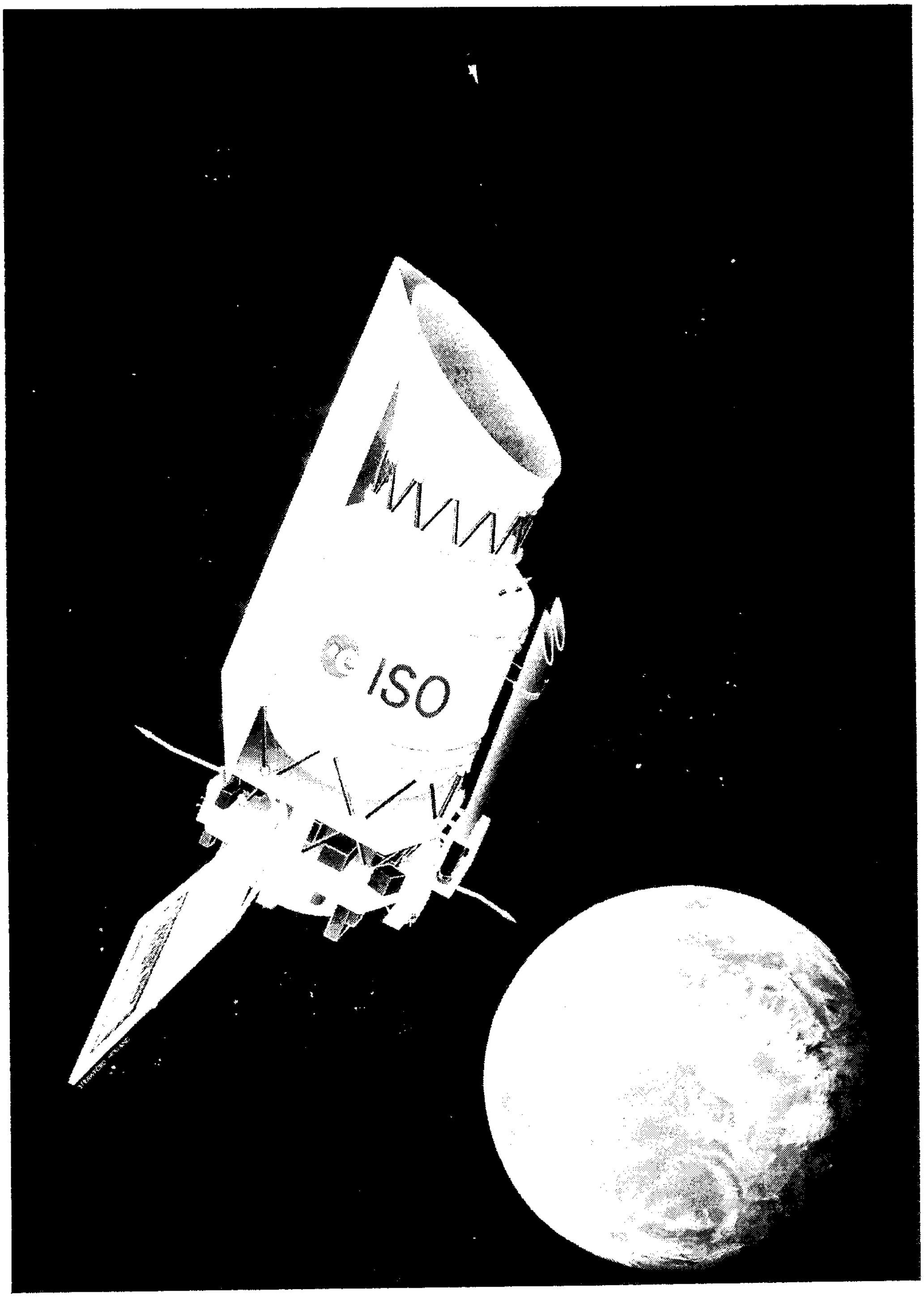
ISO INFO



esa
european space agency

No. 1 - March 1986

ISO INFO



european space agency

No. 1 - March 1986

ISO INFO

I. INTRODUCTION

Welcome to the first issue of *ISO INFO**, a newsletter on the progress of the Infrared Space Observatory. During the development phases, the main aim of *ISO INFO* will be to keep the community abreast of the status and scientific capabilities of the satellite and its instruments. As the launch approaches, the emphasis will naturally shift towards the observing programme including details on applying for observing time. *ISO INFO* will become a regular publication; initially, however, it will only appear when there are new developments to report.

Because this is the first issue, some background is included as well as news. Section II provides an overview of the entire project, while recent developments and current activities (including schedule) are discussed in sections III-VII. The need for a space-borne IR observatory is briefly recalled in section VIII, which goes on to sketch some of the expected scientific highlights and the distribution of observing time. Section IX gives some references which may be consulted for more detailed information and section X deals with the establishment of a mailing list for those interested in ISO.

II. ISO IN BRIEF

The original proposal for ISO was submitted to the European Space Agency (ESA) in 1979. After several studies and assessments, ISO was chosen in March 1983 to be the next new start in the ESA Scientific Programme. This selection carries with it the funds necessary for the entire mission. The launch date is 1992 and the expected operational lifetime will be at least 18 months.

ISO will provide astronomers with a unique facility of unprecedented sensitivity for a detailed exploration of the universe, ranging from objects in the solar system right out to the most distant extragalactic sources. Its wavelength coverage, 3-200 μm, spans a region rich in scientific interest but which has hitherto not been studied in detail. The cryogenically-cooled 60-cm telescope will be equipped with four complementary and versatile focal plane instruments, which will enable imaging and also photometric, spectroscopic and polarimetric observations. Consortia of national scientific institutes, in close collaboration with ESA, are already building these instruments, which will be delivered to the Agency for launch and operations in orbit.

ISO is designed to be a true observatory with its scientific instrumentation capable of tackling a wide range of astrophysical problems. In keeping with this philosophy, two-thirds of the observing time will be made available to the general astronomical community, via submission and selection of proposals.

---

* *ISO INFO* is published by:
Space Science Department of ESA,Postbus 299, 2200AG NOORDWIJK, The Netherlands.

III. RECENT DEVELOPMENTS

Major developments in the recent past have been:

- Adoption of a helium-only cryogenic system rather than the previous hydrogen and helium design (section VI).
- Selection of four instruments to be the scientific payload of ISO (section V).
- Establishment of the ISO Science Team (section IV).

The last two followed evaluation of the responses to a "Call for Experiment and Mission Scientist Proposals" issued to the European and American scientific communities in July 1984. As its name suggests, this Call requested not only proposals to provide instruments for the telescope's focal plane but also from individuals to become a Mission Scientist.

IV. ISO SCIENCE TEAM

The ISO Science Team advises ESA on all scientific aspects of ISO throughout the lifetime of the project. In addition to the Principal Investigators (PI) of the instruments, the Science Team contains five Mission Scientists. Their rôles are to provide scientific input to the project and to represent the interests of the general astronomical community. The members of the Science Team are:

C. CESARSKY Service d'Astrophysique, CEN-Saclay, F	PI, ISOCAM Instrument
P. CLEGG Queen Mary College, London, GB	PI, LWS Instrument
Th. ENCRENAZ Observatoire de Paris-Meudon, F	Mission Scientist
W. FRANK ESA/ESTEC, Noordwijk, NL	Payload Manager
Th. de GRAAUW Laboratory for Space Research, Groningen, NL	PI, SWS Instrument
H. HABING Sterrewacht, Leiden, NL	Mission Scientist and Vice Chairman
M. HARWIT Cornell University, New York, USA	Mission Scientist
M. KESSLER Space Science Department of ESA, Noordwijk, NL	Project Scientist and Chairman
D. LEMKE Max-Planck-Institut für Astronomie, Heidelberg, D	PI, ISOPHOT Instrument
A. MOORWOOD European Southern Observatory, Garching, D	Mission Scientist
J.-L. PUGET Radioastronomie, Ecole Normale Supérieure, Paris, F	Mission Scientist

In addition to its regular activities of monitoring the scientific development of the satellite and instruments, the Science Team is also refining the concept for the observatory ground segment and drawing up a "Model Observing Plan". This plan is to be a realistic astronomical programme, filling two weeks of ISO observing time and fully utilising the satellite, its instruments and its ground observatory. Lessons learnt from this exercise will benefit all aspects of the mission design.

V. FOCAL PLANE INSTRUMENTS

The instrument complement of ISO consists of a camera, an imaging photo-polarimeter and two spectrometers. Each instrument is being built by a consortium of institutes using national non-ESA funding. As shown in Table 1, the total payload provides photometric and imaging capabilities at various spatial and spectral resolutions from 3 μm to 200 μm and spectroscopic capabilities at medium and high spectral resolution from 3 μm to 180 μm. The four instruments view adjacent areas of the sky and switching between them will be accomplished by re-pointing the satellite. In principle, only one will be operated at a time; however, when the camera is not the main instrument, it will be used in a serendipity mode.

	Main Function	Wavelength (Microns)	Spectral Resolution	Spatial Resolution	Description
ISOCAM	Camera and Polarimetry	3 - 17	Broad-band, Narrow-band, and Circular Variable Filters	Pixel f.o.v.'s of 3,6 or 12 arc/seconds	Two channels each with a 32x32 element array.
ISOPHOT	Imaging Photo-polarimeter	3 - 200	Broad-band and Narrow-band Filters. Near IR Grating Spectrometer with R=100	Variable (Diffraction - limited and wide beam)	Four sub-systems: .Multi-band, Multi-aperture Photo-polarimeter .Far-Infrared Camera .Spectrophotometer .Mapping Arrays
SWS	Short-wavelength Spectrometer	3 - 45	1000 across wavelength range and 3×10^4 from 15-30 microns	14 and 20 arc sec.	Gratings, and Fabry-Pérot Interferometers
LWS	Long-wavelength Spectrometer	45 - 180	200 and 10^4 across wavelength range	1.65 arc minutes	Grating and Fabry-Pérot Interferometers

Table 1. Main Characteristics of the Instruments.

An indication of the expected performance of these instruments is shown in figures 1–4. The unit used for flux density is the *Jansky*, which is equivalent to 10^{-26} $\mathrm{Wm^{-2}Hz^{-1}}$, where Hz is the spectral bandwidth. As more detailed information becomes available, it will be contained in future issues of *ISO INFO*.

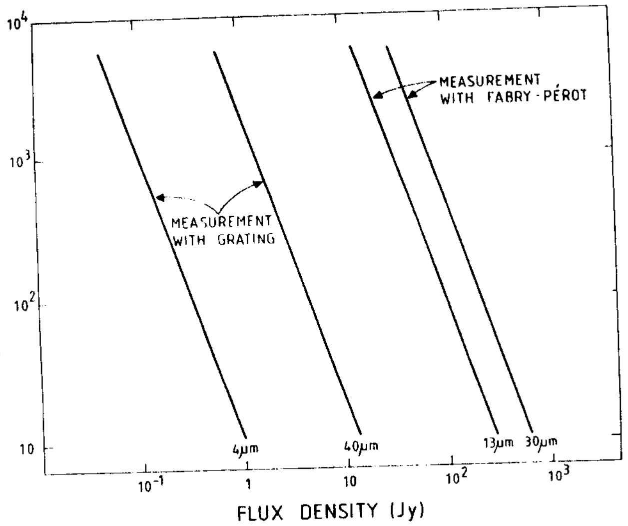


Figure 1. Observing times required for SWS to detect IR flux within a spectral element at a signal-to-noise ratio of 10. The cases shown are (i) Measurement in grating mode with a resolving power of ~1000 at wavelengths of 4 and 40μm and (ii) Measurement in Fabry-Pérot mode with a resolving power of ~30000 at wavelengths of 13 and 30μm. A conservative Noise Equivalent Power of $10^{-17} W Hz^{-0.5}$ *has been assumed. (A number of spectral elements are measured simultaneously while in grating mode).*

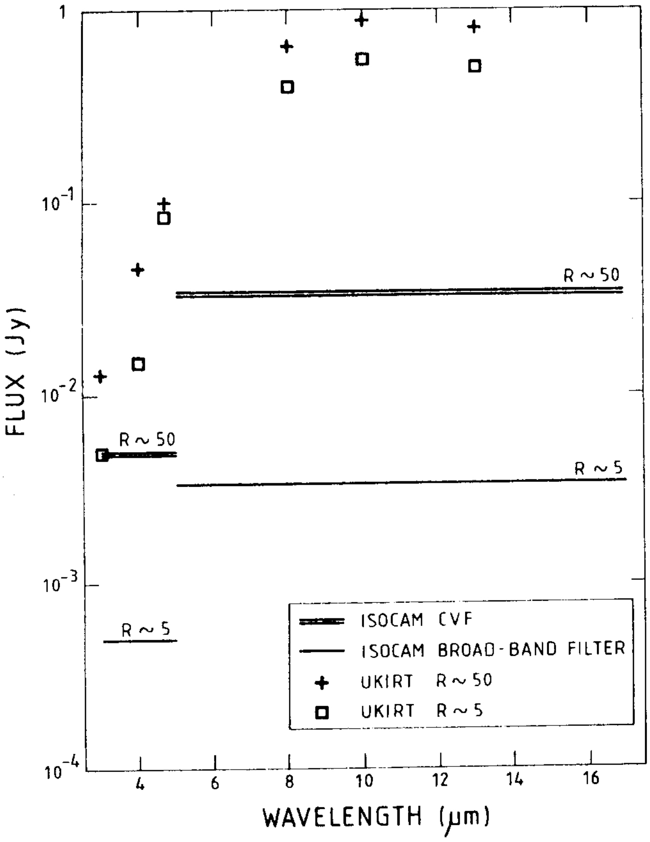


Figure 3. Flux detectable by ISOCAM at a signal-to-noise ratio of 10 in an integration time of 100s for broad band (resolving power ~5) filters and narrow band (resolving power ~50) circular variable filters. A point source has been assumed. For comparison purposes, the performance of current instruments operating on UKIRT at or near the quoted resolution is given. A 5 arc second field of view has been assumed for these instruments.

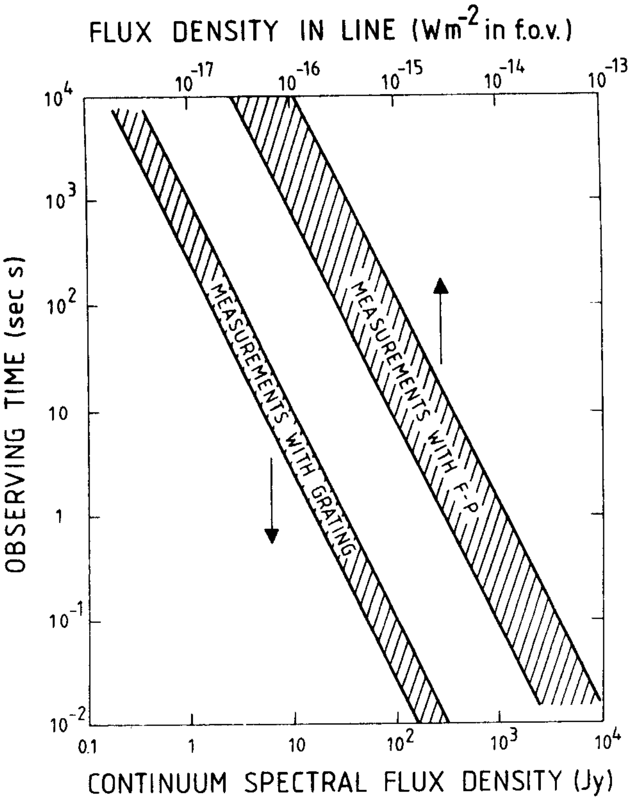


Figure 2. Observing times required for LWS to detect IR flux within a spectral element at a signal-to-noise ratio of 10. The cases shown are (i) Measurement in grating mode with a resolving power of ~200 and (ii) Measurement in Fabry-Pérot mode with a resolving power of ~10000. The spread in each case is due to the variation in instrument efficiency across its operating range of 45–180μm.

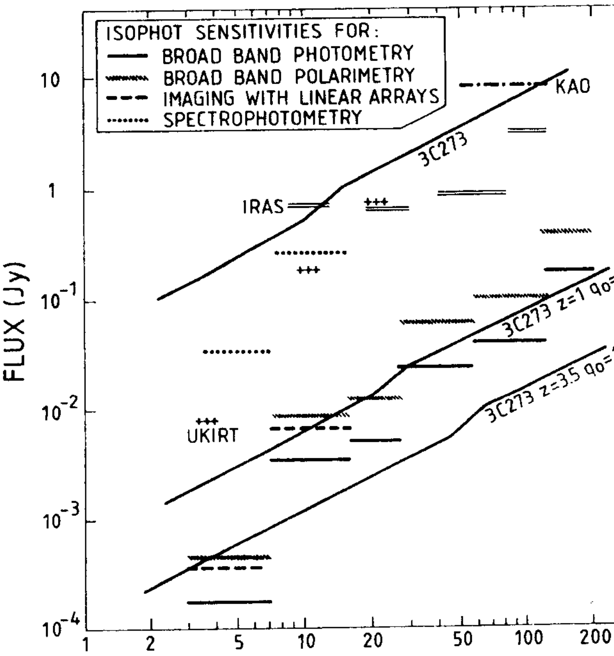


Figure 4. Flux detectable with ISOPHOT at a signal-to-noise ratio of 10 in an integration time of 100s in its different operating modes (broad band photometry, broad band polarimetry, spectrophotometry and near-IR imaging). For comparison purposes, the sensitivities of IRAS (survey mode), the KAO and UKIRT are also given.

VI. OUTLINE TECHNICAL DESIGN

The satellite consists of a Service Module and a Payload Module. The former provides the 3-axis stabilisation, with a pointing accuracy of some arc seconds, and other basic spacecraft functions, such as power and telemetry. The Payload Module is essentially a cryostat containing the scientific instruments and the optical system, with its 60-cm diameter primary mirror. The total height of the satellite is 5.2 m and it will weigh 2300 kg at launch. The elliptical operational orbit has a period of 12 hours of which 10 hours will be available for astronomical observations.

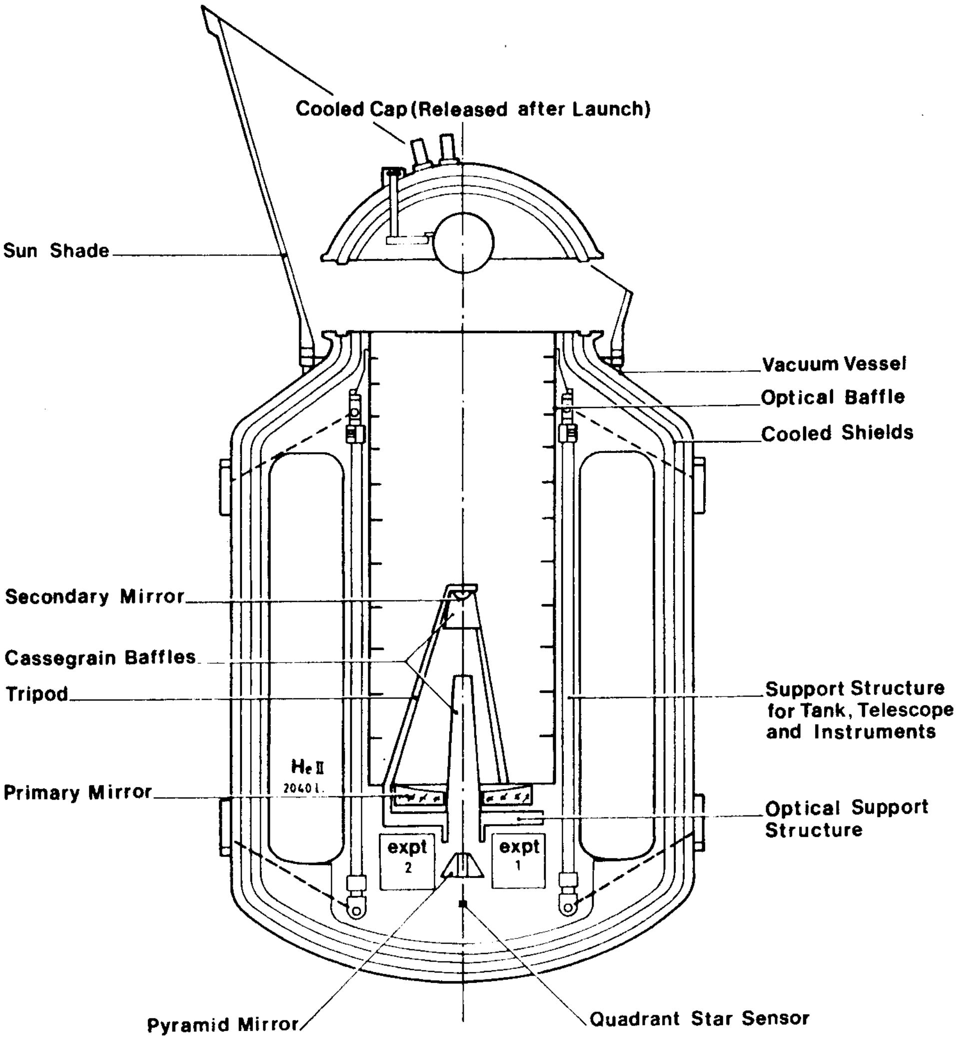


Figure 5. Schematic Representation of the Payload Module.

The phase A design of the Payload Module used a dual cryogen system, consisting of 750 l of liquid hydrogen and 750 l of liquid helium, to achieve the required 18 months lifetime within the constraints imposed by an Ariane II launcher. It is now clear that by 1992 this vehicle will have been replaced by the more powerful Ariane IV. The extra performance permits the same lifetime to be achieved using a single cryogen system. Thus, it was decided, in December 1985, to adopt a new design, consisting of 2040 l of liquid helium. In addition to reducing the development risk, this solution provides lower temperatures (about 3K for the instruments and primary mirror) for the optics inside the dewar; a considerable asset to the long wavelength instruments.

VII. PROJECT ACTIVITIES AND SCHEDULE

Much of the recent work within ESA has been centred on preparations for the industrial phase B (detailed design) study, which will start in October 1986.

A "Request for Quotation" for this study is being prepared by the ESA project team and will be released in March 1986. The ESA member state delegations have given their permission for direct negotiation with a particular group of companies, led by Aerospatiale, for the main ISO development. Further details of the ISO schedule are given in figure 6.

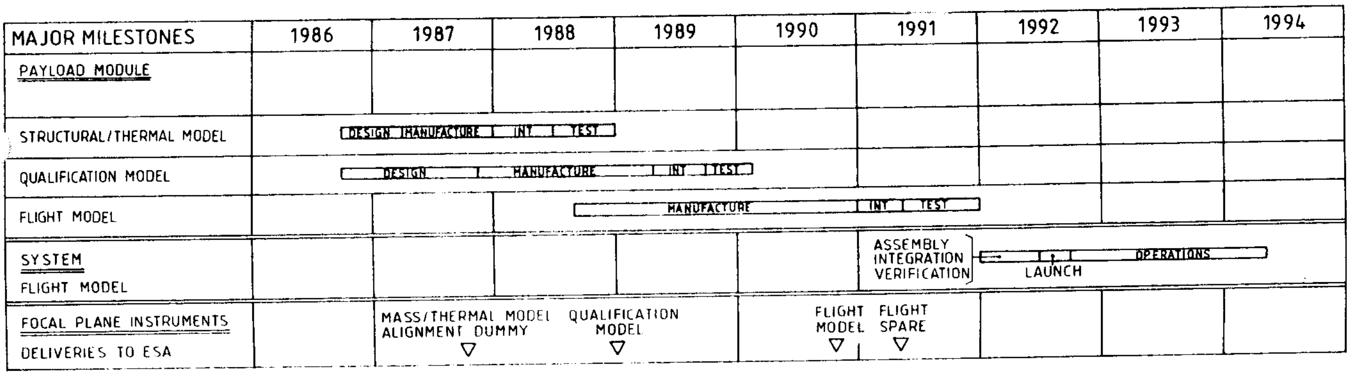


Figure 6. Simplified Overall Schedule. (Under discussion with contractor).

A number of working groups have been set up to investigate the requirements of the instruments. These groups are active in the areas of Alignment, Calibration, Straylight Suppression and Pointing and involve personnel from ESA, the instrument builders, the ISO Science Team and industry. Various industrial and in-house studies are underway in preparation for the next project phases.

VIII. SCIENTIFIC AND OPERATIONAL ASPECTS

• Why in Space?

Modern astrophysics has greatly benefited from the ability to make observations throughout the widest possible range of the electromagnetic spectrum. However, at infrared wavelengths work is either severely hampered, or totally excluded, by the opaqueness of the terrestrial atmosphere. Additionally, the sensitivity is limited by the thermal emission of the telescope and the atmosphere. Therefore, for maximum sensitivity, it is necessary to cool the telescope and its instruments and to operate them in space.

The first major step in this direction was taken with the highly successful Infrared Astronomical Satellite (IRAS), a joint project of the U.S., the Netherlands and the U.K. The main accomplishment of this satellite was to survey almost the entire sky in four broad bands centred at wavelengths of 12, 25, 60 and 100 μm. The results and the insights obtained from IRAS data form an important input to ISO, which is designed to make detailed measurements of selected regions of the sky. Compared to IRAS, ISO will have a longer operational lifetime, more sophisticated instrumentation (especially for spectroscopy), wider wavelength coverage, better angular resolution and, by a combination of detector improvements and longer integration times, a sensitivity gain of up to several orders of magnitude.

• Why Infrared Observations?

The infrared part of the spectrum is of great scientific interest not only because cool objects (15–300K) radiate the bulk of their energy at these wavelengths but also because a rich variety of ionic, atomic, molecular and solid state spectral features fall in this range. Measurements at these wavelengths permit determination of many physical parameters, for example energy balance, temperatures, abundances, densities and velocities. Because interstellar extinction in the infrared is much less than in the visual part of the spectrum, infrared observations are particularly well suited for studying the properties of obscured objects.

The scientific programme of ISO will touch upon practically every field of astronomy, ranging from solar system studies to cosmology. Some possible highlights are summarised below.

• Selected Observational Highlights

In the *solar system* the giant planets are among the best targets. They can be imaged at various wavelengths. Spectroscopic observations offer many possibilities such as discovery of new molecules, tracing of minor atmospheric constituents, or determination of isotopic ratios. Detailed measurements of molecular line shapes could provide a critical test of atmospheric models. The helium and deuterium abundance ratios can be measured in Uranus and Neptune, where the abundances are expected to have their primordial values. Titan is the only satellite known to have an atmosphere and a spectroscopic study of this may lead to a better understanding of the Earth's original atmosphere. Low resolution spectroscopy of asteroids could reveal the mineralogical composition of different families of asteroids, thus settling the question of whether or not all have a common origin. Similarly, spectroscopy of cometary heads may give insight into the gas to dust ratio and into molecule formation. Such information will be appreciated even more after Giotto's visit to Halley. There is good hope for the detection of comets in the outskirts of the solar system. Because they have been sitting in the cold since the solar system —including the Earth— was formed, these comets offer an excellent chance to study the material of the pre-solar nebula.

Stellar evolution will be studied via observations of circumstellar shells, especially around cool giant stars. How large is the mass loss rate? What is the nuclear enrichment of the outflowing material as compared to the material from which the star once formed? Absorption lines of several molecules and their isotopes are predicted to be easily detectable. When studied at high resolution, these lines will permit the conditions in the stellar wind to be determined. Planetary nebulae will be mapped in various forbidden lines. Such lines, together with hydrogen and helium recombination lines can also be studied in Wolf-Rayet stars. IRAS has discovered a large number of stars with thick circumstellar shells in the bulge of our Galaxy. Are these stars truly Asymptotic Giant Branch stars similar to those in the galactic disk? Are the planetary nebulae in the galactic bulge similar to the planetary nebulae in the disk of the Galaxy?

Rich rewards are expected from ISO studies of *protostars* and *regions with star formation.* IRAS has discovered point sources and small scale structure in a large number of dark clouds. The nature of these sources will probably be revealed in the next few years through ground-based and airborne observations. However, especially for the many weak sources, such follow-up observations will be inadequate. ISO offers colour/colour diagrams for large numbers of weak point sources and it may also discover multiple objects or small clusters of stars. At the present time no generally accepted examples of stars in their Helmholtz contraction phase are known, but they may be discovered through detailed spectroscopy in the far infrared. Determination of the excitation levels and the line shapes of several molecular transitions may show that some point sources are indeed contracting spheres.

The nature of *dust particles* will be an important topic. By studying the outflow from cool giants (see above) one may hope to obtain insight in the formation of the particles. A study of the spectral features between 3 and 16 μm could explain the nature of the "hot cirrus" discovered by IRAS. Do small particles such as polycyclic aromatic hydrocarbons (PAH's), transiently heated by single UV photons, account for the emission from these dust clouds? In cold clouds, one can study the 158 μm [CII] line, which is the major cooling line of this gas. This line is often expected to be so strong that the hyperfine satellite lines of $^{13}C^+$ may also be visible. *Shock waves*, an important phenomenon in the interstellar medium, produce rich line spectra.

Easy and accurate measurement of fine structure lines in the infrared will contribute significantly to the determination of energy budgets and accurate abundances in *HII Regions.* This is especially true for the HII regions in the inner Galaxy. They are optically invisible because of the interstellar extinction but their existence is known through radio observations. Galactic gradients in metal abundances and in isotope ratios may be derived more reliably than was possible so far and will greatly help to understand the *evolution of the Galaxy.* It may prove also possible to determine the abundance differences between our Galaxy and its neighbours, such as M31 and M33.

Much information is expected to be gathered about the *interstellar medium in nearby galaxies*, complementing present and future millimetre line observations. Especially promising is the 158 μm [CII] line, that may be detectable out to a redshift of z=2. Maps of galaxies at near and medium IR wavelengths will be made through narrow filters with angular resolutions of 6 arcsec (at 6 μm) and 180 arcsec (at 180 μm). In combination with radio maps, one will see the location and condition of the interstellar material and will get a birds-eye view of the star formation process. Short wavelength maps will also be obtained that will be very useful for the study of the population of evolved stars.

IRAS has detected thousands of *galaxies*. Is the radiation from the centre or the disk, from starburst or merging galaxies? The improved angular resolution and the high sensitivity between 50 μm and 200 μm of ISO will answer this question in a large number of cases. Galactic nuclei can be studied spectroscopically without being troubled by interstellar extinction. Infrared fine structure and recombination lines offer very good opportunities. Broadband photometry will be obtained between 5μm and 200μm. Whether a nucleus is 'normal' or 'active' may be a matter of gradation, although active galaxies are also more 'active' in the infrared. The redshift of a 3C273-like object can be measured out to $z=6$.

Finally one comes to *cosmology*. A difficult but exciting task is the search for the large amount of invisible matter thought to be in the universe. This mass could exist in the form of brown dwarfs (stars which never entered a nuclear-burning phase) or cool low mass stars in the haloes of galaxies. If this matter does exist, the cosmic expansion could come to a stop in the distant future. The era of galaxy formation is usually placed at $z \geq 3$. How galaxy formation proceeded is largely a matter of speculation, but all scenarios agree that much infrared radiation is produced in the process. ISO may pick up galaxies out to $z=6$. It may even find out whether the brighter ones are surrounded by a cluster of other galaxies.

• Observing Time

About two-thirds of the observing programme of ISO will be determined by the scientific community via the submission and selection (by peer review) of proposals. The rest of the time will be reserved for (i) the groups who provided the instruments (ii) the Mission Scientists and (iii) the observatory team, who will conduct the operations of ISO. Details of the observations to be carried out in the guaranteed time will be included in a first "Call for Observing Proposals" to be issued to the entire community about 18 months before launch. The data received from the satellite will be processed in the observatory ground segment and within a few hours of an observation being completed, the observer will be provided with a "quick-look" output adequate for judging the scientific quality of the data. A final product, with more detailed reduction and calibration to be used for the astronomical analysis, will be supplied later.

IX. FURTHER INFORMATION

A workshop was held in Alpbach in early 1984 to discuss the scientific possibilities of ISO. Copies of the proceedings can be obtained from T. Westerink, Lab. for Space Research, Universiteits-Complex Paddepoel, P.O. Box 800, 9700 AV Groningen, The Netherlands. More details on the results of the Phase A study are contained in document ESA SCI (82)6, which can be obtained from M.F. Kessler at the address below. Papers on ISO and the four focal plane instruments were presented at a symposium on "Instrumentation for

Optical Remote Sensing from Space" in November 1985. These will be published in the Proceedings of SPIE, vol 589.

X. ISO MAILING LIST

A mailing list of those interested in receiving information on ISO is being compiled. If you received a copy of this newsletter correctly addressed to you and also wish to receive future issues, no further action is needed. Otherwise, please complete and return the attached slip. Would you also bring this newsletter to the attention of your librarian and/or that of colleagues who might be interested.

Please complete and return to:

M.F. Kessler, ISO Project Scientist,
ESTEC-SA, Postbus 299, 2200 AG Noordwijk, The Netherlands.

ISO MAILING LIST

LAST NAME: ....

FIRST NAME (S): ....

FULL POSTAL ADDRESS: ....

....

....

....

....

TELEPHONE: ....

TELEX: ....

○ Please add my name to the ISO Mailing List

○ There is an error in my name/address on the ISO Mailing List. The correct version is above.

○ Please delete my name from the ISO Mailing List.