FUNDAMENTAL SCIENCE WITHIN THE HORIZON 2000 PROGRAMME

Roger M. Bonnet

European Space Agency

Abstract

The content of ESA's Science Programme is reviewed. First, we deal with Solar System Exploration and describe the scientific objectives and the main characteristics of the missions. Second, we describe in more details the content of the Astronomy programme, separating the near term missions from those which are either part of ESA's Long-term plan in Space Science "Horizon 2000", i.e. XMM and FIRST, or not yet approved like the five missions presently in competition to be selected at the end of 1988, i.e. Cassini, GRASP, Lyman, Quasat and Vesta.

1. INTRODUCTION

As of now, ESA has successfully launched and operated 14 scientific missions ; the last of them, Giotto, successfully flew by the nucleus of Halley's comet during the night of 13 March 1986 making the first ever observation of this object at a distance of only 600 km (Figure 1). Giotto is certainly a perfect example of the scientific excellence and of the originality of ESA's Science programme.

Figure 1:
The nucleus of Halley's comet "imaged" by the Halley multicolour camera, on board Giotto, developed by a consortium of European institutes lead by the Max-Planck-Institut für Aeronomie, in Lindau.

The Science programme in its present definition, excludes Earth Sciences and microgravity, which because of their strong association with application sensitive activities, are dealt with at ESA within the optional framework.

The Science programme has developed a privileged association with NASA : out of 23 accomplished or programmed missions, 5 were or will be conducted in association with NASA. Although not all in detail can be directly compared, it can be estimated that within the same areas of scientific activities, NASA is spending roughly 7 times more than ESA does at the present time. This shows that ESA can hardly - in terms of its overall volume of activities - compete with its partners across the Atlantic and can only hope to be competitive if it succeeds in maintaining a high degree of originality in its missions, while constraining them to fairly modest sizes in order to limit on average, the spending per mission to within 1.5 to 2 times the yearly budget, which is in 1988 of 184 MAU (1 Accounting Unit (AU) = 1.14093 US $). This is necessary in order to maintain a regular series of missions and of flight opportunities.

We will now review the current and future projects of the Programme, starting with the exploration of the Solar System, followed by Astronomy.

2. EXPLORATION OF THE SOLAR SYSTEM

Figure 2 illustrates in a schematic way, the missions which ESA plans to launch between now and the beginning of the next century. It should be noted that with the exception of the Giotto Extended Mission (GEM), all other missions are undertaken in cooperation with NASA or with another Agency.

A Decade of UV Astronomy with IUE, Proc. Celebratory Symposium, GSFC, Greenbelt, USA, 12–15 April 1988, ESA SP-281, Vol. 2 (June 1988)

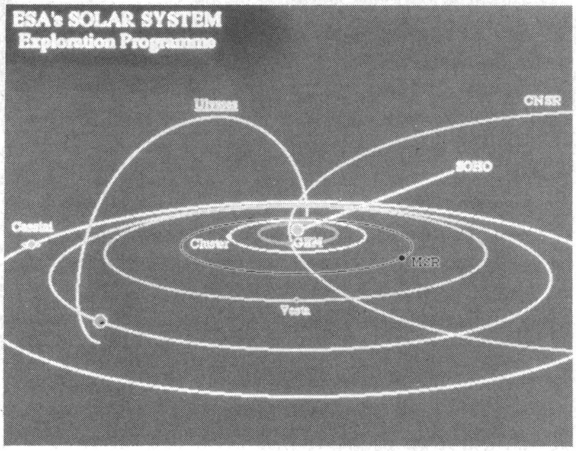

Figure 2:
A schematic representation of ESA's missions, to explore the solar system.

1.1 The Giotto Extended Mission (GEM)

The spacecraft, after its momentuous encounter with comet Halley in March 1986, is following in a dormant mode its heliocentric trajectory. It is bound to swing by the Earth in early 1990 at a distance of 20000 km. The spacecraft and its instruments have suffered some damage during the encounter. It is now almost certain that the baffle of the camera has been ripped off during the encounter and about half of the experiments are non functional.

A proposal has been made to redirect the spacecraft to another comet, notably comet Grigg-Skjellerup, in 1992. The scientific value of such a new mission can only be judged and financed after having ascertained the health of the spacecraft subsystems and of the surviving instruments. This check-out is foreseen to take place in early 1990, when the spacecraft will be in an optimum position for reactivation from the ground and for tests. Subsequent to this check-out, it will be decided whether or not there is scientific value in redirecting the spacecraft to another cometary encounter and if funds can be allocated to such a new mission.

1.2 Ulysses

Ulysses is a joint ESA/NASA project in which each agency spends roughly the same amount of funds. ESA and the European member states fund the spacecraft and experiments, while NASA is responsible for the launch, the operation, the fabrication of the radio-isotope thermal generator, and for some experiments too.

Ulysses is a mission to fly above the poles of the Sun in a unique journey of more than 4 years. Prior to Ulysses, no other man-built object has ever flown in this portion of the universe and it will be the first time that we will explore our solar system in the third dimension, since up to now, all interplanetary artificial satellites have travelled along trajectories which remained within or very close to the plane of the ecliptic. Ulysses will observe the Sun from "above", make measurements of its magnetic field and study the properties of the solar wind, which as of today, are only established on the basis of theories which have never been confirmed, except from in-ecliptic measurements.

Ulysses was undergoing active preparation at Cape Kennedy, in view of its launch on Challenger, on 15 May 1986, when the Challenger tragedy occurred. The subsequent delays will have grounded Ulysses for nearly 4.5 years, since the launch is now scheduled for October 1990.

1.3 The Solar Terrestrial Science Programme (STSP)

The STSP mission is the first major project, a cornerstone, of the first Long-Term plan of ESA in Space Science, the so-called "Horizon 2000" plan.

The implementation of the STSP cornerstone is a cooperative undertaking by ESA and NASA, and now consists of two space missions : SOHO, the Solar and Heliospheric Observatory, and Cluster, a four spacecraft space-plasma-physics mission (Figure 3). The prime objective of the STSP is to attack outstanding scientific problems in solar, heliospheric and space-plasma physics through a unified and coordinated approach.

As a multi-disciplinary solar observatory, SOHO and Cluster will address the major issues of the Sun-Earth relationships. Current plans are for SOHO to be launched by NASA in 1994 into a halo orbit around the L_1 Lagrangian point, about 1.5 million kilometres sunward from the Earth. It will observe the Sun, its corona and the solar wind continuously by remote-sensing as well as in-situ techniques. The Cluster mission, to be launched into polar orbit by an ESA Ariane 5 test flight in 1995, will study the reactions of the magnetospheric space plasma to the varying solar conditions. It will investigate in detail the physical processes that occur in key regions of geospace.

The experiments have just been selected by ESA and NASA, and both projects will enter phase B in industry, in early 1989.

1.4 Cassini

Cassini is a joint ESA/NASA mission to the Saturn system. The spacecraft is composed of a Saturn orbiter, whose construction is under

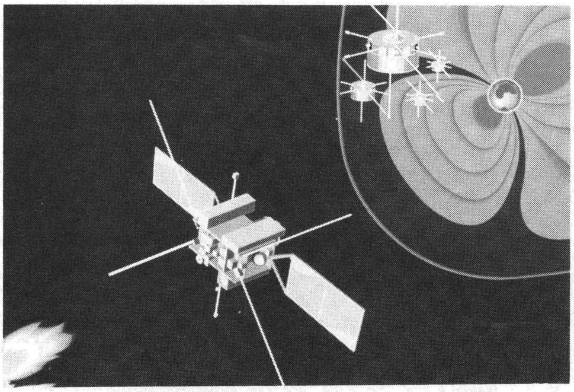

Figure 3:
The SOHO and Cluster projects, which form the Solar Terrestrial Science Programme, the first cornerstone of ESA's space science "Horizon 2000" Long-term plan.

NASA's responsibility, and an ESA detachable Titan Probe. The present mission baseline foresees a launch in April 1996 by a Titan IV/Centaur G'. The flight time is of the order of 5 to 6 years, along a trajectory which includes both Earth and Jupiter gravity assists and the fly-by of the 66 Maja asteroid.

The ESA probe, which is supposed to perform both atmosphere entry and descent on Titan dayside, should have an asymptotic velocity of 6.8 km/s. Interaction with the Titan atmosphere should allow the entry probe to decelerate at Mach 1, at an altitude of approximately 170 km. Soft landing should be guaranteed by subsonic deployment of a parachute, although a safe landing is not a mission driver.

Measurements of the structure and composition of the Titan atmosphere and possibly the surface, are the main objectives of the ESA probe mission. Remote sensing of Saturn and of its rings and satellites will constitute the prime objective of the NASA orbiter mission.

Cassini is one of the five projects in competition for the next selection in the ESA programme to be made in November 1988. The four other projects are GRASP, Lyman, Quasat and Vesta, which we describe also below.

1.5 Vesta

Vesta is a trilateral (USSR, CNES and ESA) mission to the small bodies of the Solar System. The mission baseline includes the launch in 1996 of two identical spacecraft. Each spacecraft is composed of a service module, a mobile turret, containing most of the scientific instruments, and an approach module provided with two penetrators.

CNES will have responsibility for spacecraft design, construction and payload integration. USSR will launch the two spacecrafts and will provide the approach modules with penetrators. ESA will have responsibility for a number of subsystems. The general scheme of the mission includes separate launches of the two spacecraft by soviet rockets of the Proton class. Each spacecraft will fly-by a minimum of three asteroids in a nominal time frame of about five years. A cometary fly-by will also be included. Such complicated trajectories will be made possible by a Mars gravity assist during which some observations of the red planet will be performed as well.

1.6 The Comet Nucleus Sample Return Mission (CNSR)

The CNSR mission also called "Rosetta", is one of the last two cornerstones of ESA's "Horizon 2000" Long-term plan.

The Comet Nucleus Sample Return Mission constitutes the next logical step in cometary exploration after flyby (Giotto) and rendezvous (CRAF) missions. It has been studied as a collaborative mission by a joint ESA/NASA Science Definition Team and studies are currently underway to develop technologically feasible mission profiles. These studies include various propulsion systems, such as chemical and solar electric propulsion as well as hybrid systems.

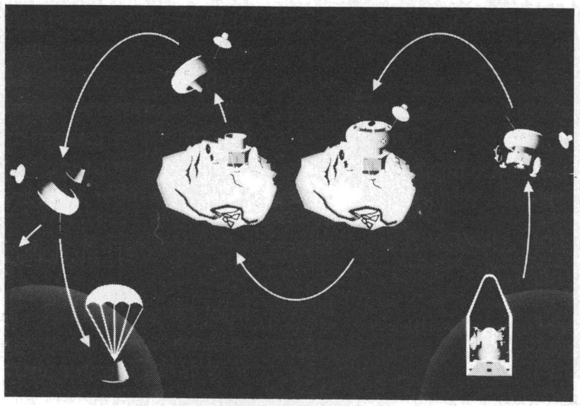

Figure 4:
The Comet Nucleus Sample Return mission "Rosetta", to be launched early next century. It is the second and only planetary cornerstone of ESA's solar system exploration programme.

The baseline mission aims for a launch at the turn of the century and return of the samples after a total mission duration of six to eight years. Such a mission may make use of the space station as a staging facility and for the analysis and storage of the samples.

The mission sequence and concept are illustrated in Figure 4.

1.7 The return of Mars soil samples

Although a mission to Mars is not explicitely included in the Long-term plan of ESA, in view of the broad and sustained interest, both in the USA and the USSR, a small study group of planetary scientists is presently assessing to what extent and in what areas might ESA participate at the end of this century, in a Mars Sample Return mission. Areas of interest already identified are martian seismology, on the spot chemical analysis and meteorology of the red planet.

2. SPACE ASTRONOMY

Space Astronomy represents a large portion of ESA's space science programme, as can be seen on Figure 5, which lists as a function of spectral domain and launch date, the various astronomy missions which ESA conducts or is involved in. We will first review the near term missions and then describe the missions which will or may form the future Long-term plan.

2.1 The near term already approved missions

2.1.1. IUE

This ultraviolet observatory which is the very reason for this symposium on the occasion of the celebration of its tenth successfull year in orbit, is a joint venture between ESA, NASA and the Scientific and Engineering Research Council of the United Kingdom.

Its scientific performance continues unimpaired in spite of the degradation of the solar array output and of the gyros composing the attitude control system. The scientific community is taking maximum advantage of this only observa-

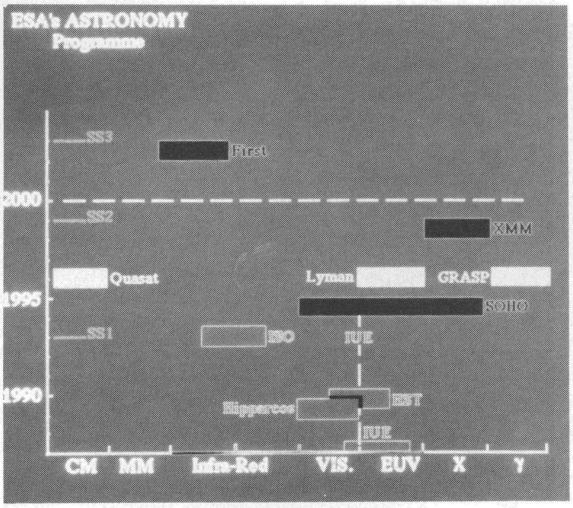

Figure 5:
The various ESA space astronomy missions are shown here, as a function of spectral range and of launch date.

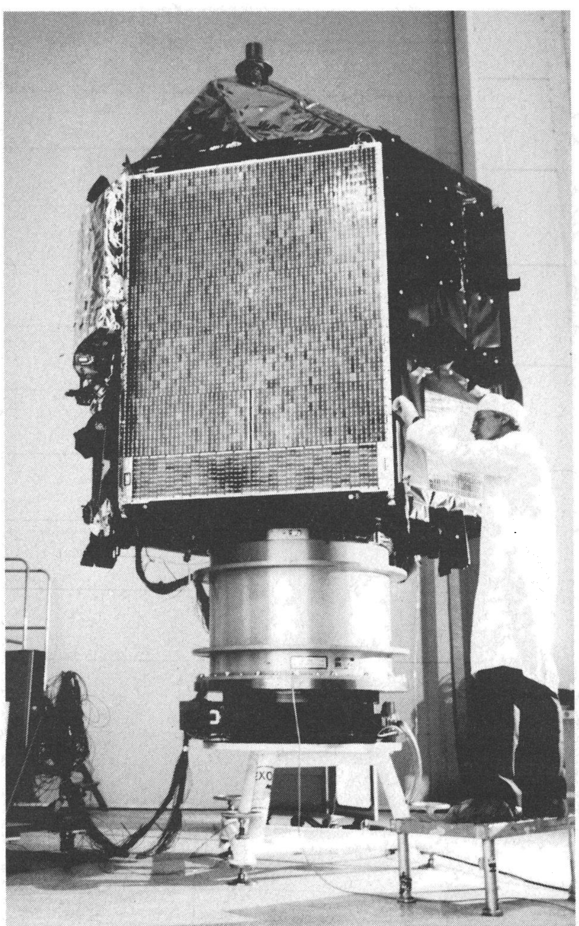

Figure 6:
The Hipparcos satellite, its main characteristics and physical parameters.

tory in orbit in this wavelength region. Its observation time is oversubscribed by a factor three, a sure testimony of the enduring success of the satellite.

The extension of operations is periodically discussed every year on the basis of the scientific content of the results already achieved and of the proposed programmes for the next year. Since the amount of money required for the extension is in competition with that which is or may be attributed to other projects, it is not surprising that the commitment to continue is based on the scientific excellence of the programme. Due to the continued excellence of the scientific output, it is likely that the operations of IUE will be recommended for extension to the ESA Science Programme Committee, at its June meeting, throughout 1989.

2.1.2. Hipparcos

Hipparcos is an astrometry satellite, designed to measure the position and the displacement of stars in the sky with an accuracy of 0.002 arc second, nearly an order of magnitude better than the best ground based measurements whose accuracy is severely limited by the turbulence of atmospheric air (Figure 6). Hipparcos is a unique mission of its kind with no competitor in the world. It will place astronomy on an absolute scale of stellar distances, increasing by several orders of magnitude the number of stars whose absolute luminosities can be known and measured. After completion of the present phase of activities, Hipparcos which was originally scheduled for a launch next July, will be stored into an air-tight container until a few months before June 1989, which is now the planned launch date, nearly one year later than originally foreseen, due to the interruption of the Ariane launches during the 1986-1987 period.

2.1.3. The Hubble Space Telescope (HST)

Hipparcos and Ulysses are not the only missions in the Science programme to suffer delays. The Challenger accident of January 1986 has also grounded for nearly 3 years the Hubble Space Telescope. The HST is built by NASA with a 15 % participation from ESA. ESA is responsible for the building of the Big solar Array which powers the spacecraft and of one of the five focal plan instruments : the Faint Object Camera (FOC). The FOC will take pictures and make spectra of the faintest objects with a magnitude larger than 28. ESA also contributes 15 persons to the HST Institute in Baltimore, and 7 to the European Coordinating Facility at ESO, Garching.

The Hubble Space Telescope was scheduled for a launch in the fall of 1986. If the shuttle flights resume in August 1988, NASA intends to launch the Telescope in June 1989.

2.1.4. The Infrared Space Observatory (ISO)

ISO is a telescope observatory for making measurements of astronomical objects in the infrared at wavelengths from 2.5 to 200 microns. The requirements dictate that the infrared detectors of the scientific instruments be cooled to near-absolute zero temperature, at about 3 °K. The satellite therefore has, as the dominating feature, a very large superfluid helium cooled cryostat which cools the scientific instruments through slow boil-off of helium over its one and

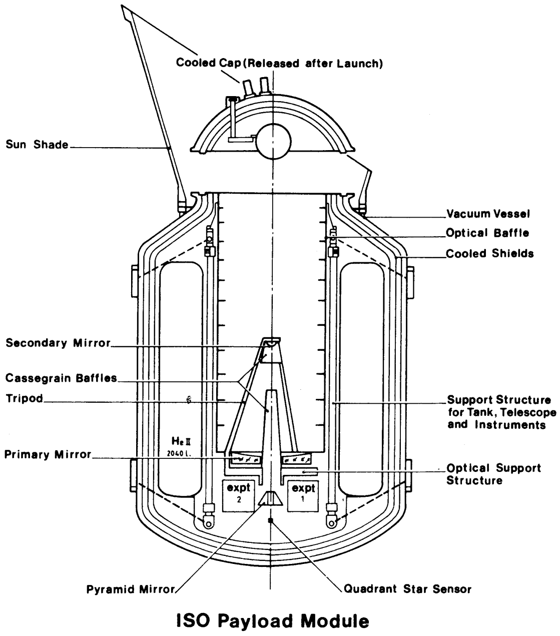

Figure 7:
A schematic view of ESA's Infrared Space Observatory (ISO) payload module.

a half year lifetime. The satellite contains a telescope of 60 cm diameter and the various scientific instruments (Figure 7). Table 1 gives the list of the four focal plan instruments and of their principal investigators.

ISO together with its complement of instruments is an ambitious step forward in infrared astronomy. It will make detailed measurements of a large number of selected astronomical objects with up to 3 orders of magnitude higher sensitivity and over a wider wavelength range than has been achieved up to now. It is likely to remain the only infrared observatory until the end of this century. ISO will fly on an Ariane IV rocket and the launch is presently scheduled for April 1993. The orbit is eccentric, with a 1000 km perigee, a 70000 km apogee, and a period of 24 hours which provides in principle, nearly 20 hours of continuous observations.

ESA has the provision for only one ground station which covers 12 hours of observation. Negotiations are on-going with NASA, Japan and Australia for the contribution of a second ground station, in return for some guaranteed time of observation. By-and-large the observing time of this observatory will be open to the astronomical community. Proposals will be solicited in due time through appropriate announcement of opportunities.

Table 1

ISO : Characteristics of Scientific Instruments

Instrument and Principal Investigator	Main function	Wavelength (microns)	Spectral Resolution	Spatial Resolution	Outline description
ISOCAM (C. Cesarsky, CEN-Saclay, F)	Camera and Polarimetry	3 - 17	Broad-band, Narrow-band, and Circular Variable Filters	Pixel f.o.v.'s of 1.5, 3, 6 and 12 arc sec	Two channels each with a 32 x 32 element detector array
ISOPHOT (D. Lemke, MPI für Astronomie Heidelberg, D)	Imaging Photo-polarimeter	3 - 200	Broad-band and Narrow-band Filters Near IR Grating Spectrometer with R = 100	Variable from diffraction limited to wide beam	Four sub-systems : i) Multi-band, Multi-aperture photo-polarimeter (3-110 μm) ii) Far-Infrared Camera (30-200 μm) iii) Spectrophotometer (2.5-12 μm) iv) Mapping Arrays (3 bands at 4,11 and 22 μm)
SWS (Th. de Graauw, Lab. for Space Research, Groningen, NL	Short-wavelength Spectrometer	3 - 45	1000 across wavelength range and 3×10^4 from 15 - 30 μm	7.5 x 20 and 12 x 30 arc seconds	Two gratings and two Fabry-Pérot interferometers
LWS (P. Clegg, Queen Mary College London, GB	Long-wavelength Spectrometer	45 - 180	200 and 10^4 across wavelength range	1.65 arc minutes	Grating and two Fabry-Pérot interferometers

2.1.5. SOHO

SOHO is one of the two projects of the STSP cornerstone described in section 1.3 above. Its main aims, as far as astrophysics is concerned, lay in the area of helioseismology and the study of the chromosphere and of the corona through high resolution spectroscopy.

2.2. Long-Term Astronomy missions

2.2.1. The X-ray multi-mirror mission (XMM)

XMM is the second cornerstone of the "Horizon 2000" plan and represents a major project aimed at studying X-ray sources with good spectral resolution (Figure 8). The main characteristic of the mission are represented in Table 2. The scientific objectives require a powerful imaging instrument, with the largest possible collecting area, for high-quality spectral measurements on faint sources, i.e. down to a level of 10^{-15} ergs $cm^{-2}s^{-1}$, and fast, low and medium resolution spectroscopy on the brighter objects.

The mission will have a major impact on the following topics :

- The determination of the large and medium scale structure of (hot) matter in the universe. This requires spatially resolved spectroscopic X-ray studies of extended sources with very low surface brightness.

- The establishment of the evolutionary tracks and the physical structure of the inner regions of a wide range of active galactic nuclei, including their contribution to the diffuse X-ray background.

Table 2

XMM System Paramaters

Mass at Launch	2374 kg	
Focal Plane instrument mass	250 kg	
Mirror module mass	660 kg	
Sunlight power	1007 W	
Eclipse power	313 W	
Instrument power	250 W	
Mirror Heating power	293 W	
Height	9.5 m	
Diameter	3.6 m	
Solar Aspect angle	± 20°	
Pointing	- Absolute pointing error	1 arc min
	- Pointing reconstitution	10 arc min
Bit rate	40 kbps	

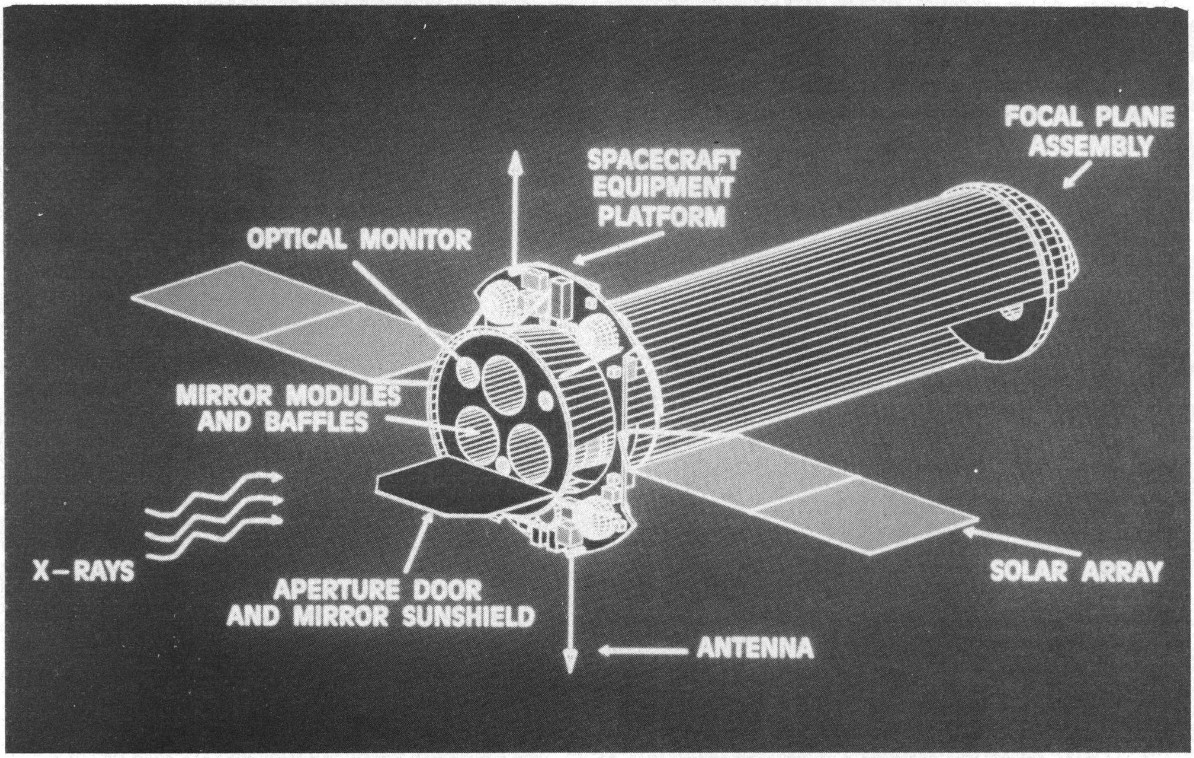

Figure 8:
The X-ray multimirror mission (XMM) is the second cornerstone of ESA's long-term plan in space science "Horizon 2000". It is a high throughput medium resolution spectroscopy mission. The spacecraft is 10 m long and weighs around 2400 kg at launch. It is made of three telescopes, each one made of 58 individual concentric reflecting hyperboloïd and paraboloïd reflection mirrors.

- The physical state and morphology of the optically thick boundary regions near the inner accretion disk and the surface of compact objects. This requires wide-band X-ray spectral measurements with high time resolution commensurate with the characteristic dimensional scale of the X-ray producing regions.

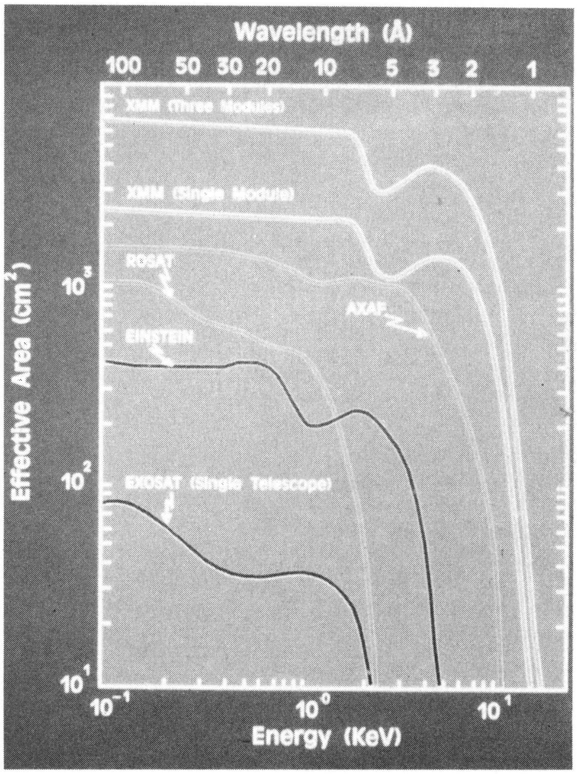

Figure 9:
The effective area of the XMM X-ray optics as a function of photon energy. A single module as well as the full three module array is shown.

Table 3

The XMM X-ray Optics

Telescope design	Nested Wolter I
Number of telescopes	3
Number of shells/telescope	58
Maximum shell thickness	1.40 mm
Minimum shell thickness	0.64 mm
Focal length	7.5 m
Mirror outer diameter	70 cm
Mirror inner diameter	32 cm
Mirror length	60 cm
Telescope material	"Carbon fibre"
X-ray mirror coating	Iridium or Gold
Mirror surface area/ Telescope module	52.3 m^2
Field of view	30 arc min
Spatial resolution better than	30 arc sec (HEW)
Effective area (3 modules)	6000 cm^2 at 2 KeV 3000 cm^2 at 6 KeV

- Distribution in density, temperature, ionisation state and elemental abundance of optically thin hot plasma regions on a local and a galactic scale. This requires high resolution spectra to accommodate detailed emission lines and absorption edges.

The major element of the mission is a set of three grazing incidence X-ray optics which will provide the required grasp (cm^2) and angular resolution. The area of the cluster of four mirror modules is shown in Figure 9 as a function of X-ray photon energy. For comparison, the effective areas of other missions past and future are also indicated. Each telescope module is made of 58 individual nested Wolter type I telescopes. The principal characteristics of the optics are summarised in Table 3.

A model payload is provided in Table 4. This arrangement will provide a simultaneous medium resolution spectrum of an X-ray target. The camera will record the target's broad band spectrum and temporal characteristics, whilst also imaging the whole field.

The mission is to be launched in 1998 and would be a natural follow-on to the highly successful Exosat ESA mission. It would provide the European scientific community with continuity of research and a major X-ray facility in a time frame consistent with NASA's AXAF project, with which cross-coordination would be of the utmost scientific value. The mission is now undergoing extensive analysis, both in ESA and in industry.

Table 4

The XMM model payload*

Objective	Instruments
Broad-band imaging spectrophotometry	Prime instrument: a CCD camera on each telescope with a field of view of 20' x 15'. The camera has resolving powers of 7 and 40 at 1 and 6 keV respectively.
Medium-resolution spectroscopy	Reflection grating module fitted to 2 telescopes. The readout element is a strip CCD array. The gratings cover the waveband 4 - 25 Å with a resolving power of 200 - 400.

(*) *In addition to the basic X-ray instrumentation an optical monitor (2000-6000 Å) provides the dual rôle of a bore-sight tracker and a high-sensitivity spectrophotometric instrument. The limiting magnitude is ~ 24. Alternative methods of providing medium/high resolution spectroscopy are also under investigation.*

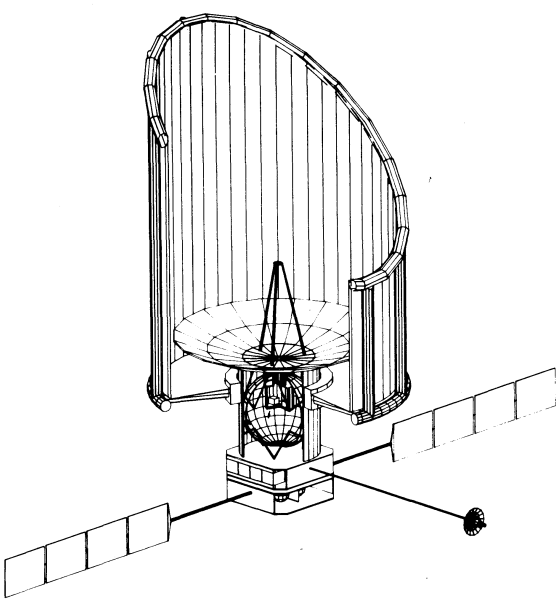

Figure 10:
The Far Infra Red Space Telescope, FIRST, to be launched early next century is the second astronomy cornerstone of "Horizon 2000".

2.2.2. The Sub-millimetre spectroscopy mission

The Far Infrared Space Telescope (FIRST) is competing with the CNSR (see section 1.6) for the third rank among the four cornerstones of the "Horizon 2000" plan.

The cornerstone will explore the 50 µm - 1 mm region of the electromagnetic spectrum. This region, apart from providing unique information on the continuum, hosts a large number of very important atomic and molecular spectral lines.

One mission concept (Figure 10) foresees an 8-m passively cooled telescope equipped with high resolution heterodyne spectrometers. The telescope would be operated as a real time observatory. The launch vehicle would be an Ariane V. Scenarios involving servicing by the Space Station and by Hermes have been studied. The launch date could be 2002.
The objectives of the mission were reviewed by the scientific community at an ESA workshop held in June 1986 in Segovia, Spain. During the workshop, areas in astrophysics were identified that depend very critically on major progress in submillimeter observations. These were :

a) The physics of the interstellar medium and its fragmentation into protostellar clouds :

- determination of the physical conditions and chemical composition of dense clumps through high excitation, rotation-vibration transitions ;

- the energy balance of the various phases of the interstellar gas, including shocks (role of H_2, hybrides, fine-structure lines etc.) ;

- mapping of star-forming regions in external galaxies with much better angular resolution to investigate triggering mechanisms, search for low-mass stars and protostars in molecular clouds.

b) The physics of star formation :

- the dynamics and physical conditions (through studies of high-excitation transitions) in accretion disks and bipolar flows as clues to the main problem of star formation ; the mechanism which allows the gas of a protostellar cloud to get rid of its angular momentum and to be accreted to the protostar ;

c) Cosmological studies :

At $\lambda >$ 350 µm, deep continuum surveys for :

- the detection of star-burst galaxies at large redshifts ; (Such surveys will be confusion-limited with telescopes smaller than 8 m) ;

- the search for small-angular-scale (10 arc min) fluctuations of the cosmological background which will provide the main observational constraints on galaxy-formation models, and in conjunction with the Sunyaev/Zeldovich effect, will yield a new method of determining the Hubble constant and the absolute velocity of clusters with respect to the microwave background.

Table 5

Submillimetre spectroscopy mission
Summary of performance characteristics

Antenna	
Size	8 m, f/10
Surface quality	8 - 10 µm
Temperature quality	$\frac{d^2T}{dt^2} \leqslant 10^{-6}$ Ks^{-2}
Chopper throw	10 arc min
Field of view	3 arc min (goal : 10 arc min)
Diffraction limit	down to 150 µm
Pointing accuracy	1 arc sec
Pointing stability	0.5 arc sec
Coherent spectroscopy	
Wavelength	down to 157 µm (C II line)
Resolution	0.3 km s^{-1} ($\nu / \Delta\nu = 10^6$)
Instantaneous frequency coverage	1 %
Sensitivity	0.5 ν_{GHz}K
Noncoherent spectroscopy and photometry	
Line spectroscopy and imaging	$50 < \lambda < 350$ µm
Sensitivity	1 mJy (wideband)
Line imaging	30 x 30 pixels, resolution up to 10^4
Photometry	$>$ 350 µm
Sensitivity	0.2 MJy sr^{-1} at 1 mm
Beam throw	10 arc min

d) The properties of primitive solar-system material through molecular (especially H_2O) studies of comets.

The present requirement of the payload consists of a set of coherent receivers for heterodyne spectroscopy, providing resolution up to 10^6, a package of incoherent spectrometers providing imaging and modest resolution, at about 10^4, and a set of photometers. The performance characteristics required of the mission are summarised in Table 5.

Preparatory work on the mission is still in progress, but the technology which needs to be developed has already been defined and industrial study contracts have been awarded. This mission would, in fact, build on the development experience gained with ESA's ISO mission.

2.3. The medium size missions

In addition to these four "cornerstones" which now form the basis for European space science activities for the remainder of the century, a number of medium and smaller sized (i.e. less costly) projects will also be carried out. For example, in November 1988, the Science Programme Committee should decide on the next mission of this class to be selected among five (including Cassini and Vesta, already described) which are presently undergoing phase A preparatory work in industry. The mission which wins this competition is scheduled for a flight in 1996.

2.3.1. GRASP

GRASP (Gamma-Ray Astronomy with Spectrometry and Positioning) is a fully European project. Two industrial consortia led respectively by Matra and Dornier are conducting parallel studies, concentrating on the utilisation of a common standard bus which could also be used for other missions (e.g. XMM and the submillimetre cornerstone).

The most essential features of the GRASP telescope will be :

- Large energy range from 15 KeV to 100 MeV in order to close the gap between X-ray and Gamma-ray astronomy.
- Application of cooled germanium detectors at 85 °K to provide an energy resolution of 1 KeV in the range of 1 MeV.
- Use of a coded mask in order to provide an angular resolution of 1 arc min.
- High sensitivity for both extended and point sources (10 MCAB in 10^5 sec).

At present, GRASP is considered either in a low inclination low earth orbit or in a highly eccentric orbit.

2.3.2. Lyman

Lyman is a European far UV spectroscopy mission with international participation from Canada and very likely NASA. The design concept is compatible with a dual launch on the Ariane 4. The model payload described in Table 6, includes a grazing incidence telescope feeding three high resolution spectrographs covering the far and extreme UV ranges, with the 900 - 1240 A waveband as the prime region.

Table 6

Lyman : Current ESA Payload concept

- 80 cm, 240 cm Long Glancing Incidence Telescope
- Dual Echelle Prime Spectrograph
  . Resolution : R $\simeq$ 30.000 and R $\simeq$ 1700
  . Sensitivity and coverage :
  . SiC channel : $A_{eff} \simeq 10$ cm^2, 900-1240A
  . LiF channel : $A_{eff} \simeq 70$ cm^2, $>$1050A
- Subsidiary FUV (1200-2000A) Echelle Spectrograph
  . Coverage : 1200-1900A
  . Resolution : R $\simeq$ 10.000 and R $\simeq$ 1.000
- Subsidiary EUV (100-900A)
  . Coverage : 100-300A and 350-900A
  . Resolution : R $\simeq$100 and R $\simeq$ 1.000
- Detectors : Open Photon-Counting Microchannelplates

Lyman will be operated as a real time multidisciplinary observatory with a maximum of responsibility and freedom, left to users. The final orbit characteristics are : 48 h, 120000 km x 1000 km.

2.3.3. Quasat

Quasat is a very long baseline radio-interferometry space project using ground VLBI arrays. It is a European mission with international participation from Canada and the USA. Table 7 gives an overview of the mission. The present phase A study demonstrates the feasibility of including a 15 m diameter inflatable antenna with dual polarization receivers within the lower compartment of an Ariane 4, in dual launch configuration.

Table 7

Quasat main characteristics

- 15 m diameter inflatable space rigidized antenna
- 4 frequency dual polarization coaxial feed:
  . 0.327, 1.6, 5 and 22 GHz
- Cooled 22 GHz and 5 GHz receivers (90 K and 150 K)
- 14/15 GHz 144Mb/s up/down digital data link
- 2 orbits (i-30 deg) :
  . maximum baselines of 47000 km (12 h period)
  . maximum baselines of 34000 km (7.8 h period)
- 5 year expected lifetime
- 1200 kg spacecraft
- Shared Ariane launch to GTO

3. CONCLUSION

The ESA Programme, as described above, is the minimum balanced programme needed to satisfy the vast majority of European scientists, while maintaining at a reasonable level, the activities of the more than 50 scientific institutes working in all ESA member states. It guides the various national programmes which can adjust their domestic planning accordingly.

It is a crucial instrument for international cooperation which is able to cement the scientists world wide ; a fact which was beautifully exemplified during the Halley mission, and will continue in the case of the SOHO and Cluster missions, as well as for Vesta, Lyman, Quasat or Cassini.