The International Rosetta Mission

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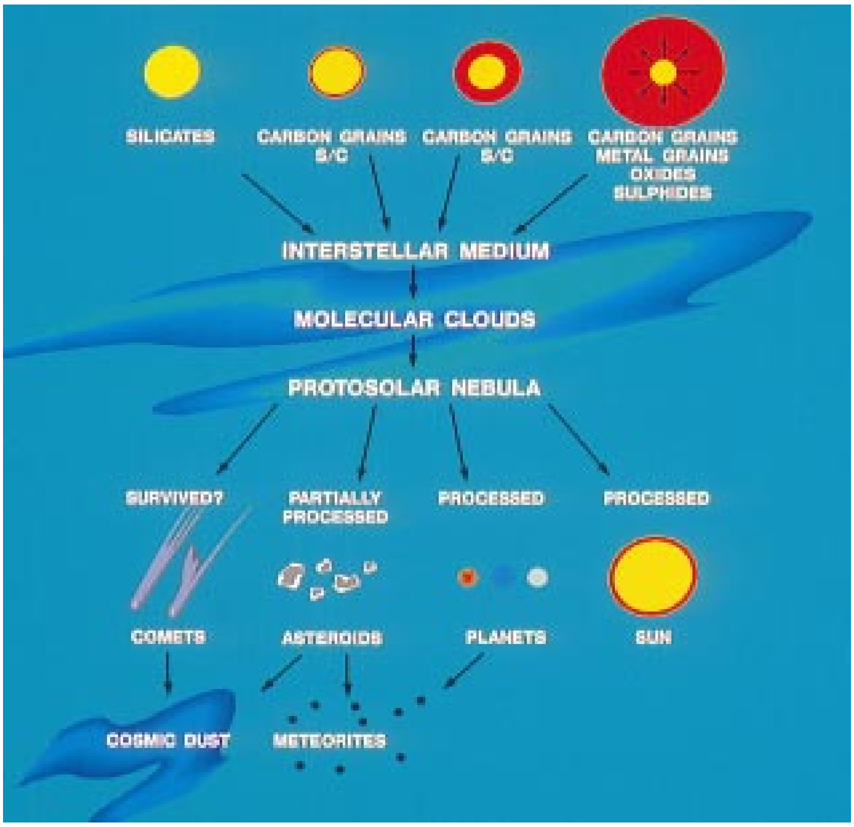
The International Rosetta Mission was approved in November 1993 by ESA's Science Programme Committee as the Planetary Cornerstone Mission in ESA's long-term programme in space science, Horizon 2000. The mission's main goal is a rendezvous with Comet 46P/Wirtanen, but it is also intended to study two asteroids during close flybys on route to the comet. Rosetta will study the nucleus of Comet Wirtanen and its environment in great detail for a period of nearly two years, the near-nucleus phase starting at a heliocentric distance of about 3.25 AU, from the onset of activity through to perihelion, close to 1 AU. On its long journey to the comet, the spacecraft will pass close to the asteroids Mimistrobell and Siwa or Rodari.



Introduction

Direct evidence of the constitution of cometary volatiles is particularly difficult to obtain, as the constituents observable from Earth and even during the flybys of Comet Halley in 1986, result from physico-chemical processes such as sublimation and interactions with solar radiation and the solar wind. What we know today about cometary material from those earlier missions and ground-based observations does, however, demonstrate the low degree of evolution of cometary material and hence its tremendous potential for providing us with unique information about the make up and early evolution of the solar nebula.

The study of cometary material presents a major challenge due to the very characteristics that make it a unique repository of information about the formation of the Solar System, namely its high volatiles and organic-material contents. A fundamental question that the Rosetta mission has to address is, to what extent can the material accessible for analysis be considered representative of the bulk of the material constituting the comet, and of the early nebular condensates that constituted the cometesimal 4.57×10^9 years ago? This representativeness issue has to be addressed by first determining the global characteristics of the nucleus, namely its mass, density and state of rotation, which can provide us with clues as to the relationship between the comet's outer layers and the underlying material.

The dust and gas activity observed around comets, as well as its rapid response to insolation, guarantees the presence of volatiles at or very close to the surface in active areas. Analysing material from these areas will therefore provide information on both the volatiles and the refractory constituents of the nucleus. The selection of an appropriate site for the surface-science investigations should be relatively straightforward, given the mission's extensive remote-sensing observation phase and the advanced instrumentation, covering a broad range of wavelengths, that is to be carried by the Rosetta Orbiter.

The dust-emission processes are induced by very low density gas outflows and should preserve the fragile texture of cometary grains. These grains can be collected at low velocities (a few tens of metres per second) by the spacecraft after short travel times (of the order of minutes), which will minimise alterations induced by any interaction with solar radiation. Similarly, gas analysed in jets or very close to the surface should yield reliable information on the volatile content of the cometary material in each source region.

Comet 46P/Wirtanen

Comet 46P/Wirtanen was discovered on 15 January 1948 at Lick Observatory by Carl A. Wirtanen. Its two subsequent close approaches to Jupiter, in 1972 (0.28 AU) and 1984 (0.46 AU), changed the perihelion of the comet's orbit from 1.63 to 1.06 AU and its period from 6.71 to 5.46 years.

46P/ Wirtanen belongs to a large group of the short-period comets in the Solar System, known as the Jupiter comets. Their orbits with an aphelion around Jupiter's orbit make them observable in principle along their entire orbit. Comet Wirtanen has been observed during all but one (1980) of its apparitions since its discovery. However, only the coordinated observation campaign conducted in 1996/ 1997 in the context of the Rosetta mission has promoted it to being one of the best-monitored (Fig. 1).

Assuming that it has an albedo of 0.04, a radius of about 700 m has been derived for the comet. Given its smallness, the nucleus can be rated as fairly active, producing about 10^{28} water molecules per second.

The spacecraft and its payload

The spacecraft design is driven by the key features of this very complex and challenging mission:

– the fixed and fairly short launch window for Comet 46P/Wirtanen: due to the launch capability required, even with Ariane-5 there are only very few backup scenarios within a reasonable time frame
– the long mission duration of 10.5 years
– the critical gravity assists at Mars and the Earth and the close asteroid flybys, during which both the spacecraft and the payload will be active
– the wide variation of spacecraft-Earth-Sun cycles and distances, which pose strong thermal-design challenges and require large solar arrays (approx. 60 m^2) with novel cells optimised for low-intensity low-temperature operation
– the lengthy operations just a few comet-nucleus radii away from 46P/Wirtanen's surface, in an environment of nucleus-emitted dust and gas that will not be known in great detail during the spacecraft's development.

The long round-trip light times of up to 90 min call for a highly autonomous spacecraft that can also survive the long hibernation periods without any ground contact during the cruise phases.

A preliminary design for the spacecraft is shown in Figure 2, which also gives a good impression of the modular approach used. Striking features are the huge solar arrays and the 2.2 metre diameter High Gain Antenna (HGA), which is steerable in two axes. The payload is mounted on one spacecraft wall, which during the close comet approach phase will be pointed continuously towards the nucleus. All instruments will be body-mounted and the proper attitude will be achieved by rotating the spacecraft with the HGA always Earth-pointing and the solar array pointing towards the Sun.

Scientific payload

Rosetta Orbiter

During its meeting on 21 February 1996, ESA's Science Programme Committee (SPC) endorsed the Rosetta Orbiter payload (Table 1), and originally two Surface Science Packages: Champollion to be provided by NASA-JPL/CNES and Roland to be provided by a European consortium led by MPI and DLR from Germany. Programmatic difficulties subsequently led to NASA's withdrawal from Champollion in September 1996. CNES has since joined the original Roland consortium in an effort to provide a European Lander.

After a one-year 'science verification phase' intended to lead to a clearer definition of interfaces and to identify critical areas where more development work was required, all instruments for the Orbiter's payload were reconfirmed by the SPC in 1997. During this study phase, the investigator teams were required to demonstrate the feasibility of several novel techniques to be applied for the first time with Rosetta flight hardware.

The Orbiter payload will have unprecedented capabilities for studying the composition of both the volatile and refractory material released by the cometary nucleus with very high resolution. The remote-sensing instrument suite will allow characterisation of the nucleus surface in a wide range of wavelengths (UV to mm) with high resolution. The OSIRIS Narrow-

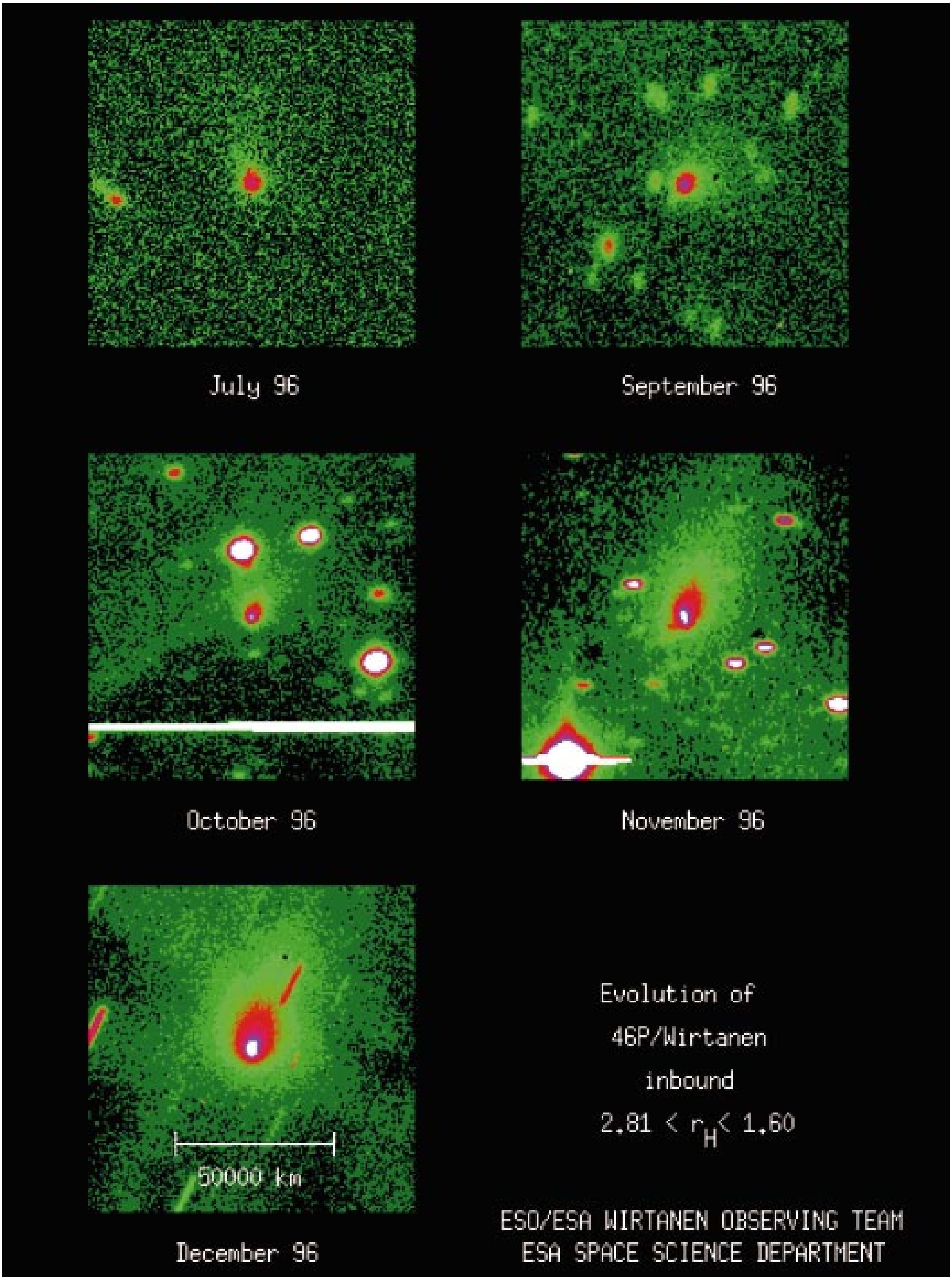


Figure 1. Ground-based observations of Comet 46P/Wirtanen: July – December 1996

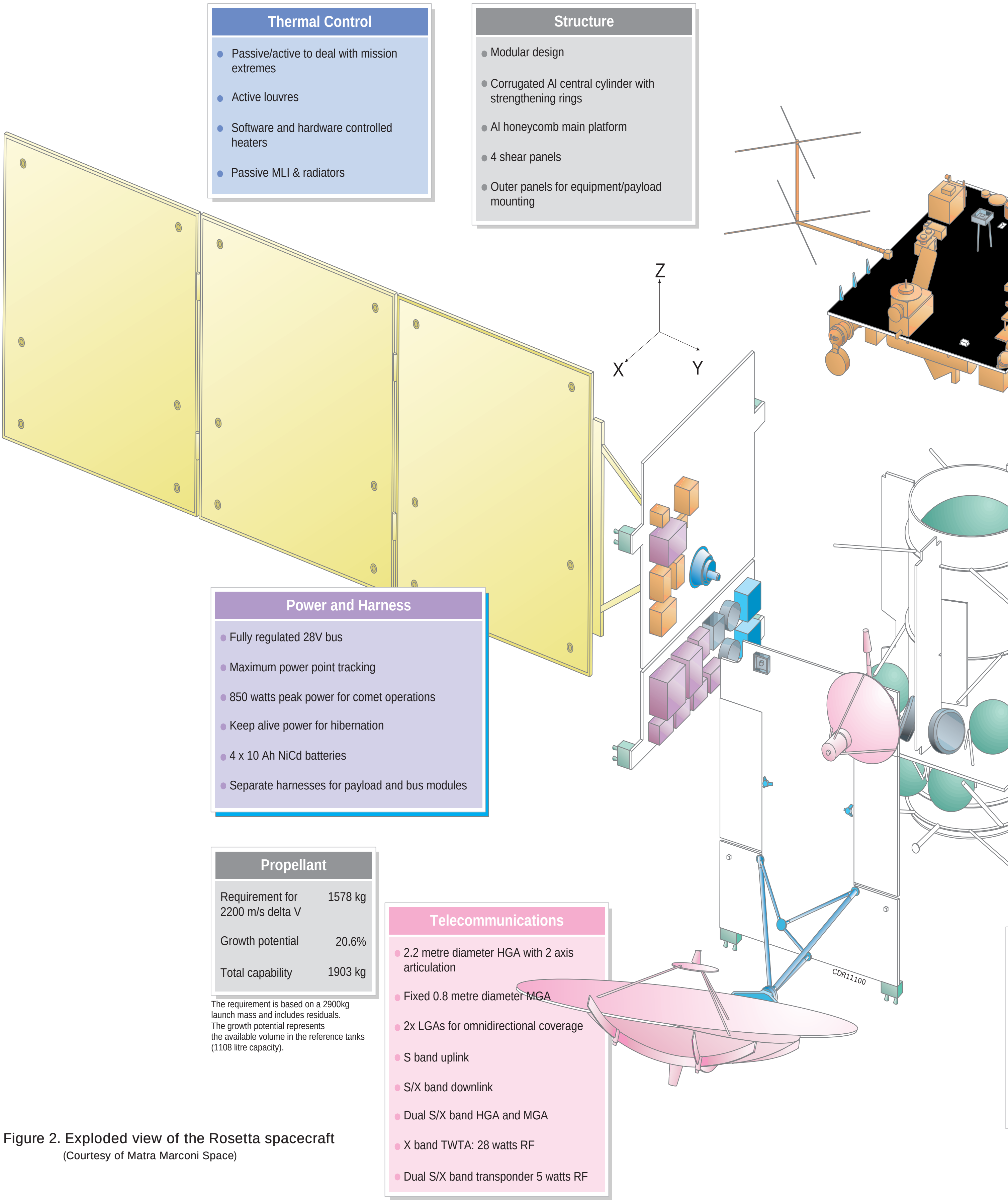


Figure 2. Exploded view of the Rosetta spacecraft
(Courtesy of Matra Marconi Space)

Mass (kg)

Structure	198.9
Thermal	40.7
Mechanisms	38.6
Solar Array	169.7
Power	90.4
Harness	55.2
Propulsion	171.5
Telecommunications	44.8
Total	**809.8**

All masses include contingencies at equipment level, based on development status

Power Consumption (W)

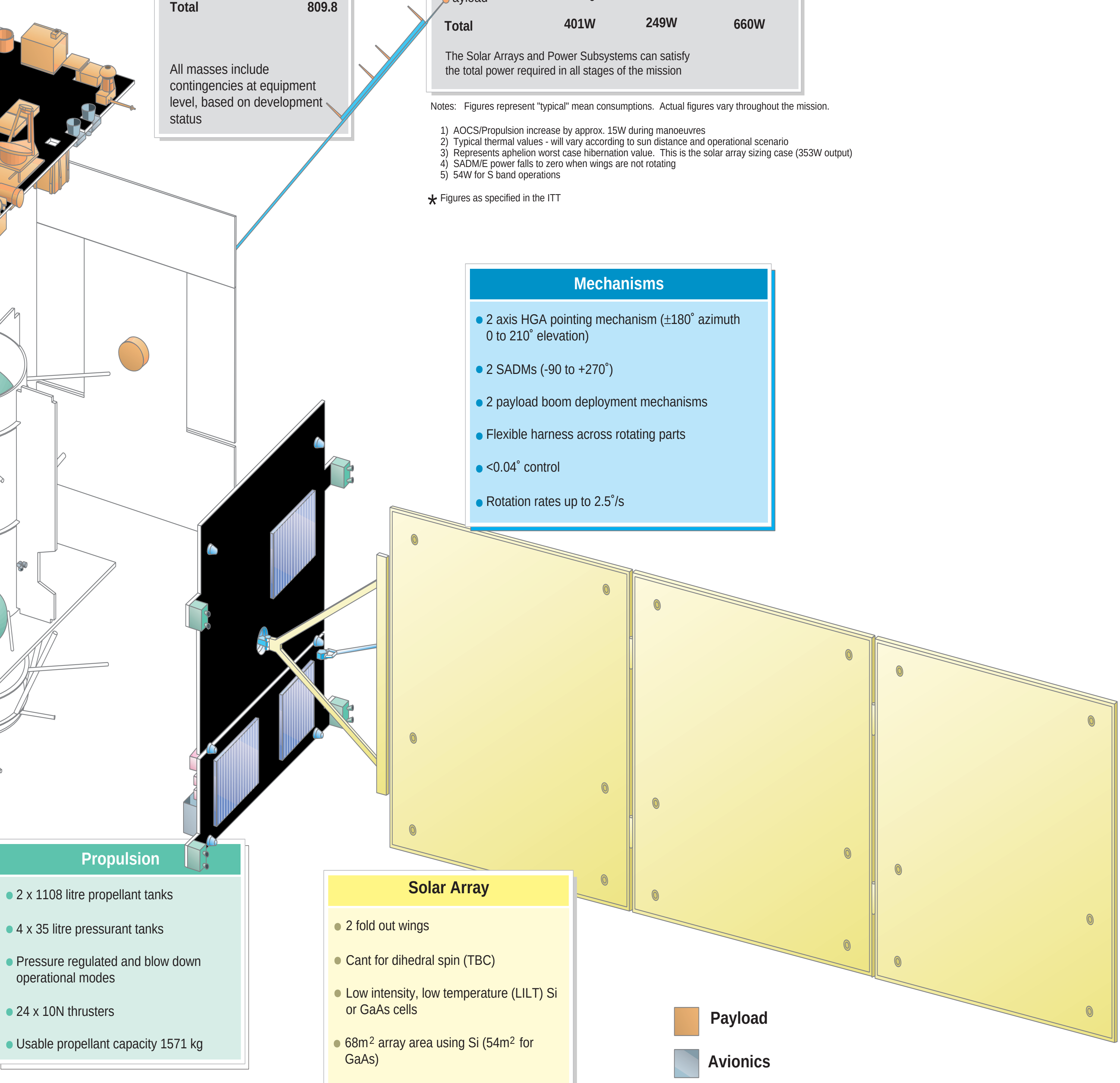
	Active Cruise X Band	Hibernation	Near Comet
Telecommunications	102(5)	8	102
AOCS/Propulsion *	89(1)	0	134
DMS *	66	29	66
SADM/E	18(4)	0	18
Power	26	22	30
Thermal	100(2)	190(3)	40(2)
Payload *	0	0	270
Total	**401W**	**249W**	**660W**

The Solar Arrays and Power Subsystems can satisfy the total power required in all stages of the mission

Notes: Figures represent "typical" mean consumptions. Actual figures vary throughout the mission.

1) AOCS/Propulsion increase by approx. 15W during manoeuvres
2) Typical thermal values - will vary according to sun distance and operational scenario
3) Represents aphelion worst case hibernation value. This is the solar array sizing case (353W output)
4) SADM/E power falls to zero when wings are not rotating
5) 54W for S band operations

* Figures as specified in the ITT



Mechanisms

- 2 axis HGA pointing mechanism (±180˚ azimuth 0 to 210˚ elevation)
- 2 SADMs (-90 to +270˚)
- 2 payload boom deployment mechanisms
- Flexible harness across rotating parts
- <0.04˚ control
- Rotation rates up to 2.5˚/s

Propulsion

- 2 x 1108 litre propellant tanks
- 4 x 35 litre pressurant tanks
- Pressure regulated and blow down operational modes
- 24 x 10N thrusters
- Usable propellant capacity 1571 kg

Solar Array

- 2 fold out wings
- Cant for dihedral spin (TBC)
- Low intensity, low temperature (LILT) Si or GaAs cells
- 68m^2 array area using Si (54m^2 for GaAs)
- 850 watts at 3.4 AU
  353 watts at 5.2 AU

Table 1. The Rosetta Orbiter payload

Acronym	Objective	Principal Investigator
Remote Sensing		
OSIRIS	Multi-Colour Imaging NAC (Narrow Angle Camera) 2.35°x2.35° WAC (Wide Angle Camera) 12°x12° (250 nm-1000 nm)	H.U. Keller, MPI für Aeronomie, Katlenburg-Lindau, Germany
ALICE	UV-Spectroscopy (70 nm-205 nm)	A. Stern, Southwest Research Institute, Boulder, CO, USA
VIRTIS	VIS and IR Mapping Spectroscopy (0.25 µm - 5 µm)	A. Coradini, IAS-CNR, Rome, Italy
MIRO	Microwave Spectroscopy (1.3 mm and 0.5 mm)	S. Gulkis, NASA-JPL, Pasadena, CA, USA
Composition Analysis		
ROSINA	Neutral Gas and Ion Mass Spectroscopy; Double-focusing, 12-200 AMU, M/ΔM~ 3000 Time-of-flight, 12-350 AMU, M/ΔM~ 500 incl. Neutral Dynamics Monitor	H. Balsiger, Univ. of Bern, Switzerland
MODULUS	Isotopic Ratios of Light Elements by Gas Chromatography (D/H; $^{13}C/^{12}C$; $^{18}O/^{16}O$; $^{15}N/^{14}N$)	C. Pillinger, Open University, Milton Keynes, UK
COSIMA	Dust Mass Spectrometer (SIMS, m/Δm ~ 2000)	J. Kissel, MPI für Extraterrestrische Physik, Garching, Germany
MIDAS	Grain Morphology (Atomic Force Microscope, nm Resolution)	W. Riedler, Univ. of Graz, Austria
Nucleus Large-Scale Structure		
CONSERT	Radio Sounding, Nucleus Tomography	W. Kofman, CEPHAG, Grenoble, France
Dust Flux, Dust Mass Distribution		
GIADA	Dust Velocity and Impact Momentum Measurement, Contamination Monitor	E. Bussoletti, Istituto Univ. Navale, Naples, Italy
Comet Plasma Environment, Solar-Wind Interaction		
RPC	Langmuir Probe, Ion and Electron Sensor, Flux-Gate Magnetometer, Ion Composition Analyser, Mutual Impedance Probe	R. Boström, Swedish Institute of Space Physics, Uppsala, Sweden J. Burch, Southwest Research Institute, San Antonio, TX, USA K.-H. Glassmeier, TU Braunschweig, Germany R. Lundin, Swedish Institute for Space Physics, Kiruna, Sweden J.G. Trotignon, LPCE/CNRS, Orleans, France
RSI	Radio-Science Experiment	M. Pätzold, Univ. of Cologne, Germany

Angle Camera, for example, will achieve a resolution of better than 10 cm on the nucleus surface from the closer orbits.

To complement these instruments and to provide for proper monitoring of the comet environment and its interaction with the solar wind, a Dust Flux Analyser and a Plasma Instrument Package have been selected.

Rosetta Lander

The Lander science (Table 2) will focus on in-situ study of the composition and structure of the material that constitute's Comet Wirtanen's nucleus. Measurement goals include the determination of the elemental, molecular, mineralogical, and isotopic compositions of both the cometary surface and subsurface material. The highest priority will be given to the elemental and molecular determinations, as it is believed that some mineralogical and isotopic measurements can be carried out adequately via the Orbiter science investigations. In addition, properties like near-surface strength, density, texture, porosity, ice phases and thermal properties will be derived. Texture characterisation will include microscopic studies of individual grains.

The CONSERT experiment, with hardware on both the Lander and the Orbiter, will attempt to reveal the coarse structure of the nucleus through radio sounding.

Interdisciplinary scientists

Five Interdisciplinary Scientists have been nominated for an initial period of three years to support the mission's implementation:

– *M. Fulchignoni*, DESPA, Observatoire de Paris, France, to develop physico-chemical models of the possible target asteroids in order to provide the Rosetta Project and the Rosetta Science Working Team with a reference data set.
– *P. Weissman*, NASA-JPL, Pasadena, California, USA, to provide thermophysical modelling of the cometary nucleus and of the inner coma of comets.
– *R. Schulz*, MPI für Aeronomie, Katlenburg-Lindau, Germany, now with ESA Space Science Department, to liaise with the astronomical community and to derive a basic characterisation of the target comet from ground-based observations.
– *E. Grün*, MPI für Kernphysik, Heidelberg, Germany and *M. Fulle*, Trieste Astronomical Observatory, Italy, to provide empirical 'engineering models' for the dust environment of the nucleus of the target comet in order to establish a reference data set for the Rosetta Project and the Rosetta Science Teams.

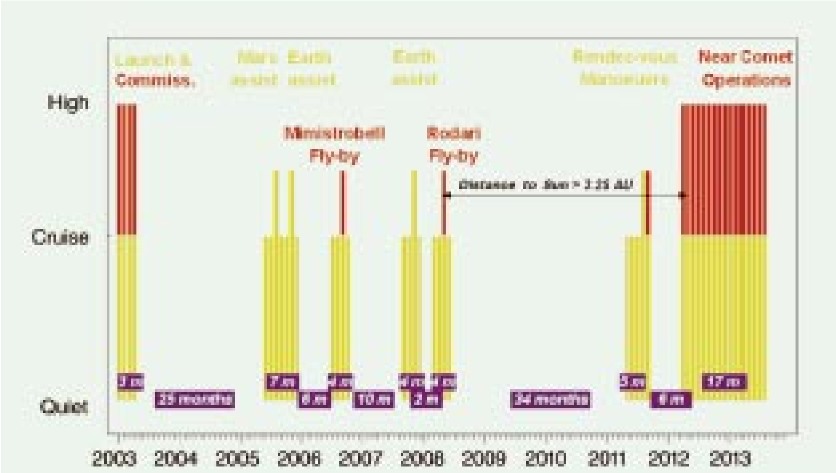


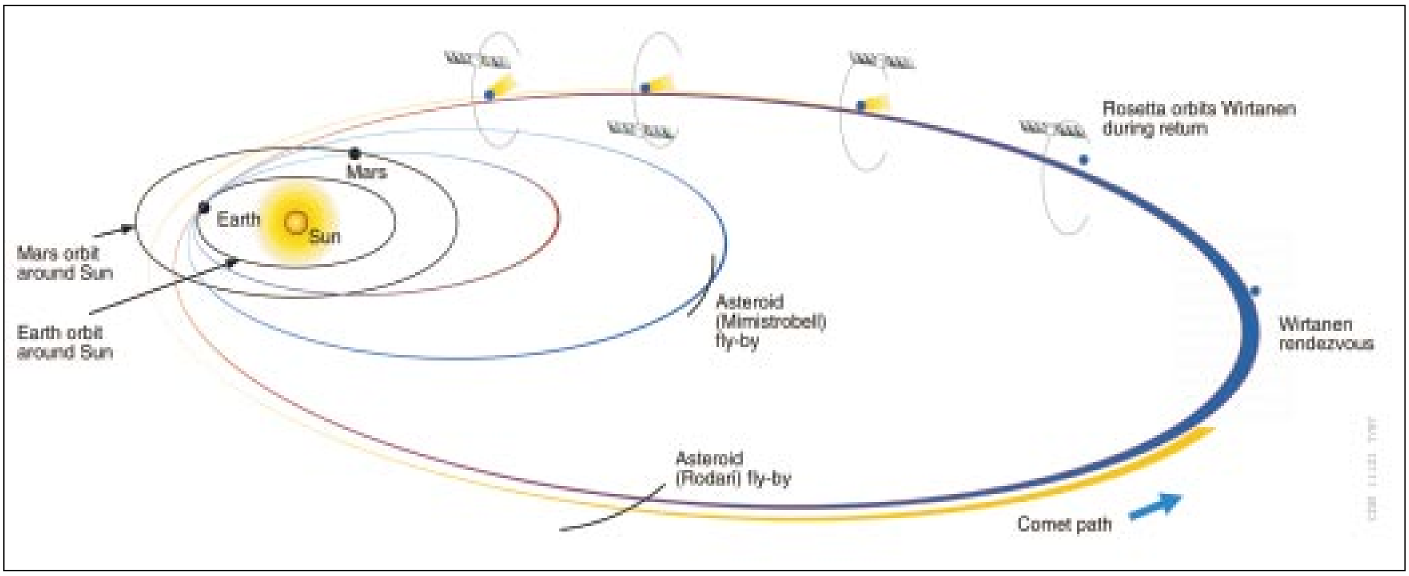
Figure 3. Ground-activity mission profile

Mission overview

Rosetta will by launched in January 2003 by an Ariane-5 vehicle from Kourou, in French Guiana. To gain enough orbital energy for Rosetta to reach its target, one Mars and two Earth gravity assists will be required (Figs. 3,4). The long duration of the mission requires the introduction of extended hibernation periods. The mission can be subdivided into several distinct phases (Table 3).

Table 2. The Lander payload

APXS	Alpha-p-X-ray Spectrometer Sample Acquisition System	R. Rieder, MPI Chemistry, Mainz, Germany ASI, Italy
MODULUS	Evolved Gas Analyser	C. Pillinger, Open University, UK
CIVA ROLIS	Rosetta Lander Imaging System	J.P. Bibring, IAS, Orsay, France S. Mottola, DLR Berlin, Germany
SESAME	Surface Electrical and Acoustic Monitoring Experiment, Dust Impact Monitor	D. Möhlmann, DLR Cologne, Germany H. Laakso, FMI, Finland I. Apathy, KFKI, Hungary
MUPUS	Multi-Purpose Sensor for Surface and Sub-Surface Science	T. Spohn, Univ. of Münster, Germany
ROMAP	RoLand Magnetometer and Plasma Monitor	U. Auster, DLR Berlin, Germany I. Apathy, KFKI, Hungary
CONSERT	Comet Nucleus Sounding	W. Kofman, CEPHAG, Grenoble, France



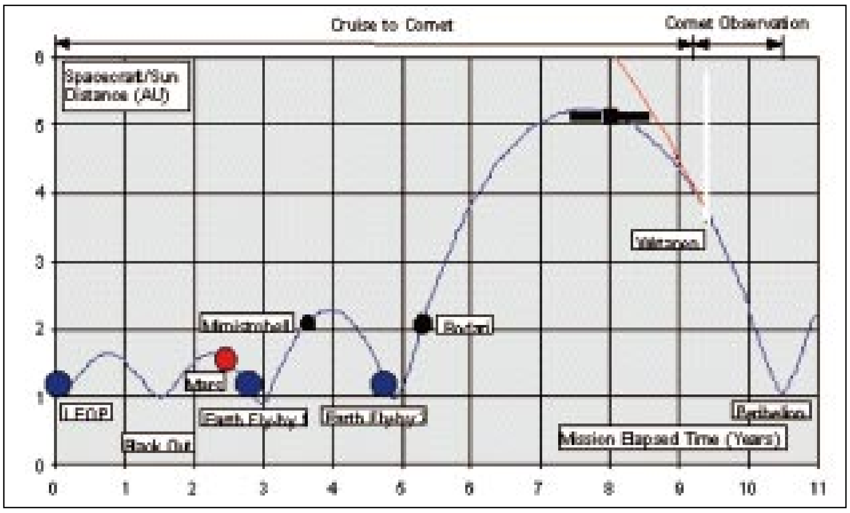


Figure 4a,b. Geometric and temporal schematics of mission phases

Launch (January 2003)

Rosetta will be launched on an Ariane-5. After burnout of the lower composite, the upper stage L9.7 will remain together with the spacecraft in an eccentric coast orbit for about 2 hours (4000 x 200 km), during which the attitude of the composite can be controlled. Before perigee passage, the upper stage will perform a delayed ignition and inject the Rosetta spacecraft onto the required escape hyperbola towards Mars, with an excess velocity of about 3.4 km/s. The spacecraft will be separated from the launcher upper stage in a three-axis-stabilised attitude.

Commissioning Phase (3 months)

Immediately after separation, the spacecraft will autonomously de-tumble, deploy its solar arrays and acquire a coarse three-axis-stabilised Sun-pointing attitude. Ground operations will acquire the downlink in S-band, using the ESA network, and control the spacecraft to a fine-pointing attitude with the High-Gain Antenna (HGA) Earth-pointing using X-band telemetry. Tracking and orbit determination will then be performed and the departure trajectory verified and corrected if necessary. All spacecraft functions required during the cruise to the comet, and in particular the hibernation functions, will be checked out. The scientific payload will then be commissioned, before putting the spacecraft into hibernation mode for the cruise phase to Mars.

Earth-to-Mars Cruise (about 950 days from launch to Mars)

The spacecraft will be put into hibernation mode, during which no ground support is baselined. A long solar conjunction prevents any spacecraft operations being performed from the ground between days 440 and 690. The scientific instruments will be switched off during this cruise.

Mars Gravity Assist (pericentre height about 200 km)

Daily operations will be resumed three months before Rosetta's arrival at Mars. Two orbit-correction manoeuvres are planned at the incoming and outgoing asymptote, which will allow for some science operations during the swingby. During the swingby, there will be an occultation of the Earth by Mars which will last about 37 minutes, causing a communications blackout.

Mars-to-Earth Cruise (about 90 days from Mars to Earth)

The spacecraft will be kept in active cruise mode for this 'short' interplanetary phase.

First Earth Gravity Assist (perigee height about 3400 km)

Operations will be mainly devoted to tracking and orbit determination and maintenance from three months before, until one month after swingby. Orbit-correction manoeuvres are to be executed before and after the swingby itself.

Earth-to-Asteroid Cruise (about 300 days from Earth to Mimistrobell)
The spacecraft will be put into hibernation mode, during which no ground support is baselined.

Mimistrobell Flyby (around day 1330)
Flyby operations will last from three months before, until one month after the flyby. In parallel with the daily tracking, with orbit determination and corrections, the scientific payload will be checked out. The goal is to pass within 600 km of an asteroid, on the sunward side. The relative asteroid ephemeris will be determined with a cross-track accuracy of 20 km by spacecraft optical navigation. The cameras and scientific payload will be pointing in the direction of the asteroid until after the flyby. Scientific data will be recorded onboard in the mass memory and transmitted after the flyby when the Earth link via the HGA is recovered.

After the flyby, the necessary orbit correction will be performed to put the spacecraft on course for the second Earth gravity assist.

Mimistrobell-to-Earth Cruise (about 400 days from asteroid to Earth)
The spacecraft will be put into hibernation mode, during which no ground support is baselined.

Second Earth Gravity Assist (perigee height about 2200 km)
The operations conducted will be the same as for the first Earth swing-by. Before the second Earth gravity assist, however, there is a decision point regarding the further operations up to comet encounter. The nominal mission includes a flyby of a second asteroid and Rodari is the nominal candidate, but Siwa may be selected if there is sufficient propellant available. The exact rendezvous manoeuvre strategy will also be selected based on the available battery power, solar-array degradation and the propellant situation. The nominal rendezvous manoeuvre is to be executed post-aphelion at 4.5 AU to minimise power demands and allow the solar array to be made as small as possible.

Earth to Second Asteroid Cruise (about 160 days)
The spacecraft will be put into hibernation mode as soon as the necessary tracking operations have been completed and an orbit-correction manoeuvre has been performed.

Rodari Flyby (around day 1930)
The operations here will be similar to those for the Mimistrobell flyby, but the flyby distance itself will be greater to be commensurate with the spacecraft angular-rate capabilities because the Mimistrobell flyby occurs at a lower relative velocity.

Table 3. Major mission events

	Nominal Timing
Launch	21 January 2003
Mars gravity assist	26 August 2005
Earth gravity assist #1	26 November 2005
Mimistrobell flyby	15 September 2006
Earth gravity assist #2	26 November 2007
Rodari flyby	4 May 2008
Rendezvous manoeuvre	24 August 2011
Start of near-nucleus operations at 3.25 AU (from Sun)	22 August 2012
Perihelion passage (end of mission)	10 July 2013

Asteroid to Comet Cruise (about 1200 day from asteroid to comet rendezvous manoeuvre)
The whole period - apart from an optional deep-space manoeuvre - will be spent in hibernation mode. Rosetta will be at its furthest from the Sun and from the Earth during this period, i.e. 5.2 AU (aphelion) and 6.2 AU, respectively.

Comet Orbit Matching Manoeuvre (or rendezvous manoeuvre; around day 3140)
This is the major orbit manoeuvre that will ready the spacecraft for the rendezvous, by reducing the spacecraft/comet relative drift rate to about 25 m/s. It will be performed before the comet is detected by Rosetta’s onboard cameras, using ground determination of the comet nucleus’ orbit based on a dedicated observation campaign.

Near-Comet Drift Phase
The drift phase will be designed such that, when the spacecraft is less than 4.2 AU from the Sun it reaches an appropriate point relative to the comet for the final approach operations to begin, such that cometary debris can be avoided and that good comet illumination conditions are obtained. The final point of the near-comet drift phase will be the Comet Acquisition Point (CAP), where the comet will be observed for the first time by Rosetta’s onboard navigation camera or by OSIRIS.

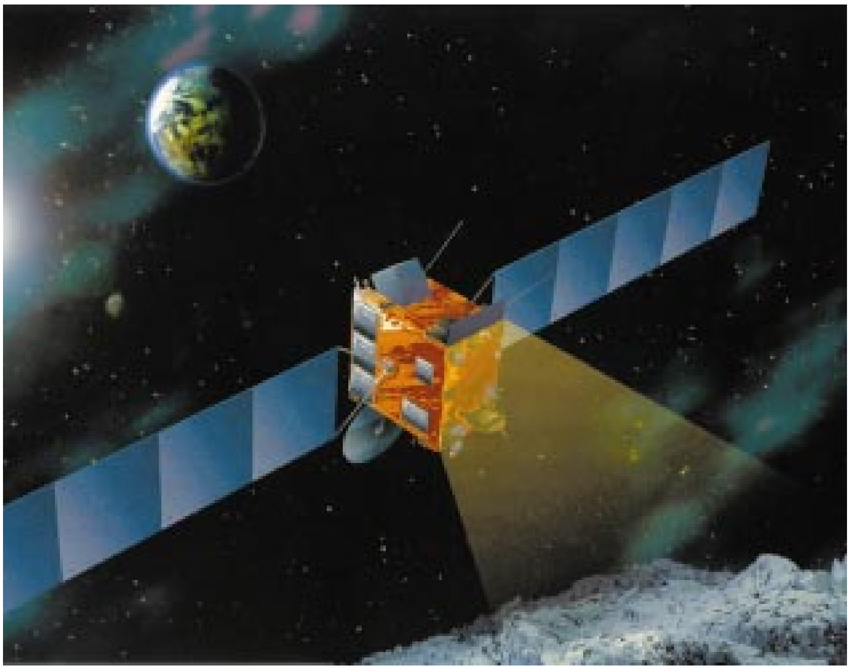
Throughout this phase, the spacecraft will be in active cruise mode.

Far-Approach Trajectory Phase (up to 90 days)
The far-approach operations start at the Comet Acquisition Phase. After detection, knowledge of the comet ephemeris will be drastically improved by the processing of the onboard observations. Image processing on the ground

will derive a coarse estimation of the comet's size, shape and kinematics.

The approach manoeuvre sequence will successively reduce the relative velocity between spacecraft and comet, so that it is just 2 m/s after 90 days. The manoeuvre strategy will be designed to:
– retain an apparent motion of the comet with respect to the star background
– keep the illumination angle (Sun-comet-spacecraft) below 70 deg
– avoid any danger of an impact with the cometary nucleus in the event of manoeuvring difficulties.

The Far-Approach Trajectory ends at the Approach Transition Point (ATP), where a first estimate of the comet's attitude and angular velocity will derived from the analysis of the navigation-camera or OSIRIS images and



'landmarks' will be identified. The ATP is in the Sun direction at about 300 comet nucleus radii from the nucleus. The spacecraft will be in active cruise mode during this phase, with the navigation camera system and some Orbiter payload items switched on.

Close-Approach Trajectory Phase
The close-approach trajectory starts at ATP. Lines-of-sight to landmarks and on-ground radiometric measurements will be used to estimate the spacecraft's relative position and velocity, and the comet's absolute position, attitude, angular velocity, and gravitational constant.

A very good estimate of the comet's kinematics and gravitational constant should be available at the end of this phase, which is the Orbit Insertion Point (OIP). At the OIP the spacecraft will be injected onto a hyperbolic arc to the comet, at a typical distance of 60 comet radii and with a velocity of some cm/s relative to the comet, depending on the comet's size and density.

Transition to Global-Mapping Phase
The transition to global mapping starts at the OIP. Rosetta will follow a hyperbolic arc until it is about 25 comet radii from the target, where a capture manoeuvre will close the orbit. The plane of motion, defined by the spin-axis and Sun directions, will be rotated slightly to avoid solar eclipses and Earth occultations.

Global-Mapping Phase
This preliminary survey of the comet's surface should map at least 80% of the sunlit areas, from polar orbits around the comet at heights of between 5 and 25 nucleus radii. The semi-major axis of the mapping orbit will be chosen as a function of the comet's gravity and spin rate, taking into account the following constraints:
– coverage without gaps
– safety considerations (no impact on nucleus)
– volume of data for real-time transmission
– maximum time to complete surface mapping
– optimum resolution and viewing angle to surface normal, and
– continuous communications to Earth.

The orbital period will usually be greater than the comet's spin period and horizontal swaths will cover the nucleus surface as it is presented. Ideally, all of the Orbiter payload instruments will be operating and the scientific data gathered will be buffered in the onboard memory ready for transmission to the ground station.

During this global-mapping phase, the nucleus' shape, surface properties, kinematics and gravitational characteristics will be derived using optical landmark observations. Based on these mapping and remote-observation data, some five areas (500 m x 500 m) will be selected for close observation.

Close-Observation Phase
Manoeuvre strategies will be designed for sequences of close-observation orbits, flying within 1 nucleus radius of selected surface points. Constraints to be taken into account include:
– uninterrupted communications
– continuous illumination of solar arrays
– safety constraints (no nucleus encounter in case of manoeuvre failure)
– avoidance of debris, dust and gas jets

– adequate illumination of target area, and angle between viewing direction and local surface normal less than 30 degrees.

This phase is expected to last about 30 days and, based on the data collected, it will then be decided to which site the Surface Science Package (SSP) will be delivered. A transition phase to the initial conditions for SSP delivery will then be implemented.

Surface-Science Package Delivery Phase
Surface-Science Package Delivery will take place from an eccentric orbit (pericentre altitude as low as possible, e.g. 1 km) with a pericentre passage near the desired landing site. The time and direction of SSP separation will be chosen such that the package arrives with minimum vertical and horizontal velocities relative to the local (rotating) surface. An ejection mechanism will separate the SSP from the spacecraft with a maximum relative velocity of 1.5 m/s.

Relay-Orbit Phase
After delivery of the SSP, the spacecraft will be injected into the most suitable orbit for receiving the SSP's data and relaying it to Earth. Commanding of the Package may also be required.

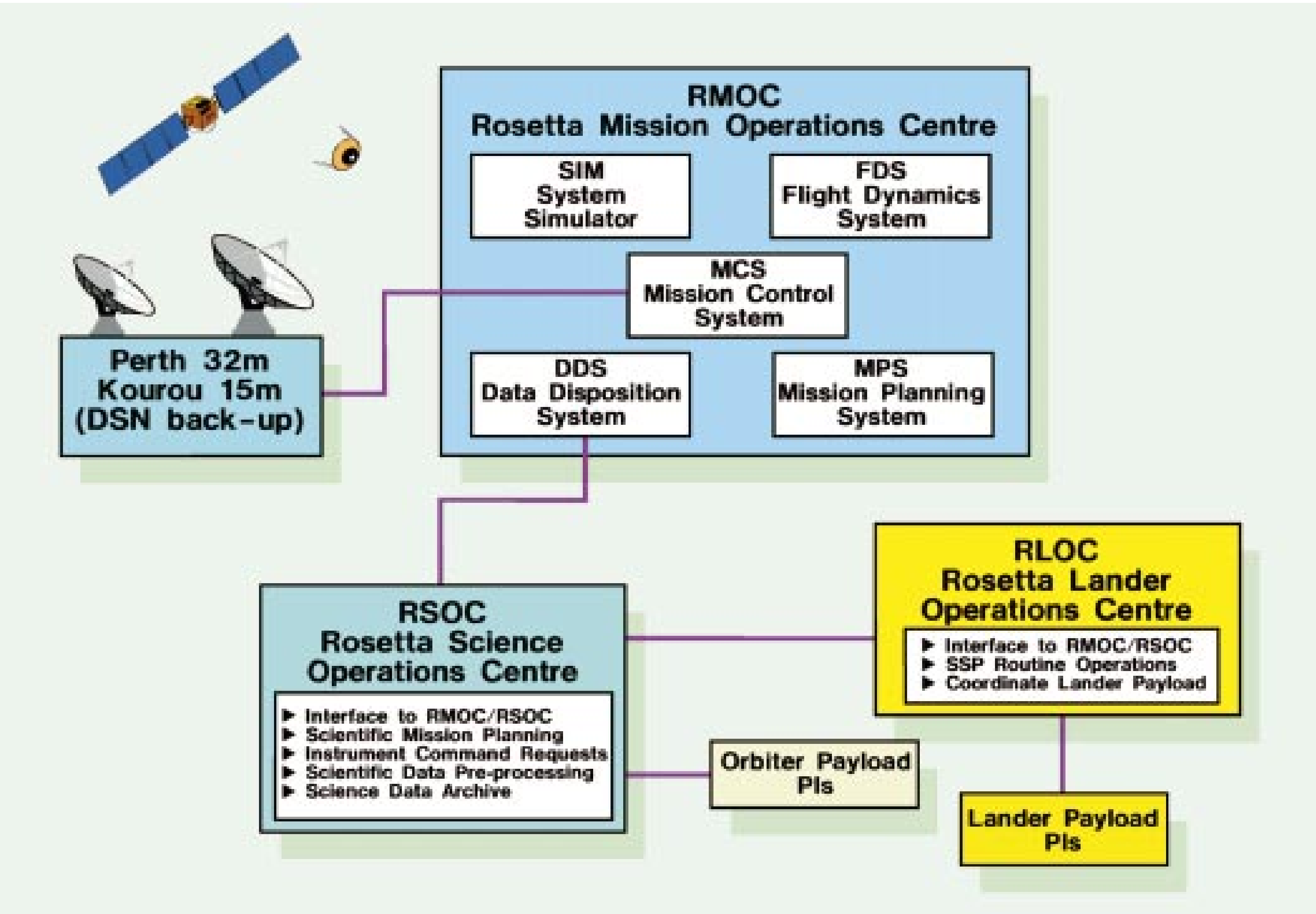
Extended-Monitoring Phase (through perihelion)
After the completion of the SSP-related activities, the spacecraft will spend at least 200 days in orbit in the vicinity of the comet until perihelion passage. The objective of this phase is to monitor the nucleus (active regions), dust and gas jets, and to analyse gas, dust and plasma in the inner coma from the onset of activity until its peak.

The orbital design and mission planning for this phase will depend the scientific results already obtained from of the previous observations and safety considerations associated with the activity pattern of the comet. Extended monitoring of various regions in the vicinity of the nucleus could be performed with successive hyperbolic flyby's following petal-like trajectories.

Run Down (end of mission)
The mission nominally ends at the perihelion pass around day 3800, unless a mission extension is agreed if the spacecraft should survive the cometary environment unscathed!

Mission operations
Throughout its long and demanding mission, Rosetta will be operated and controlled from

Figure 5. The Rosetta ground segment



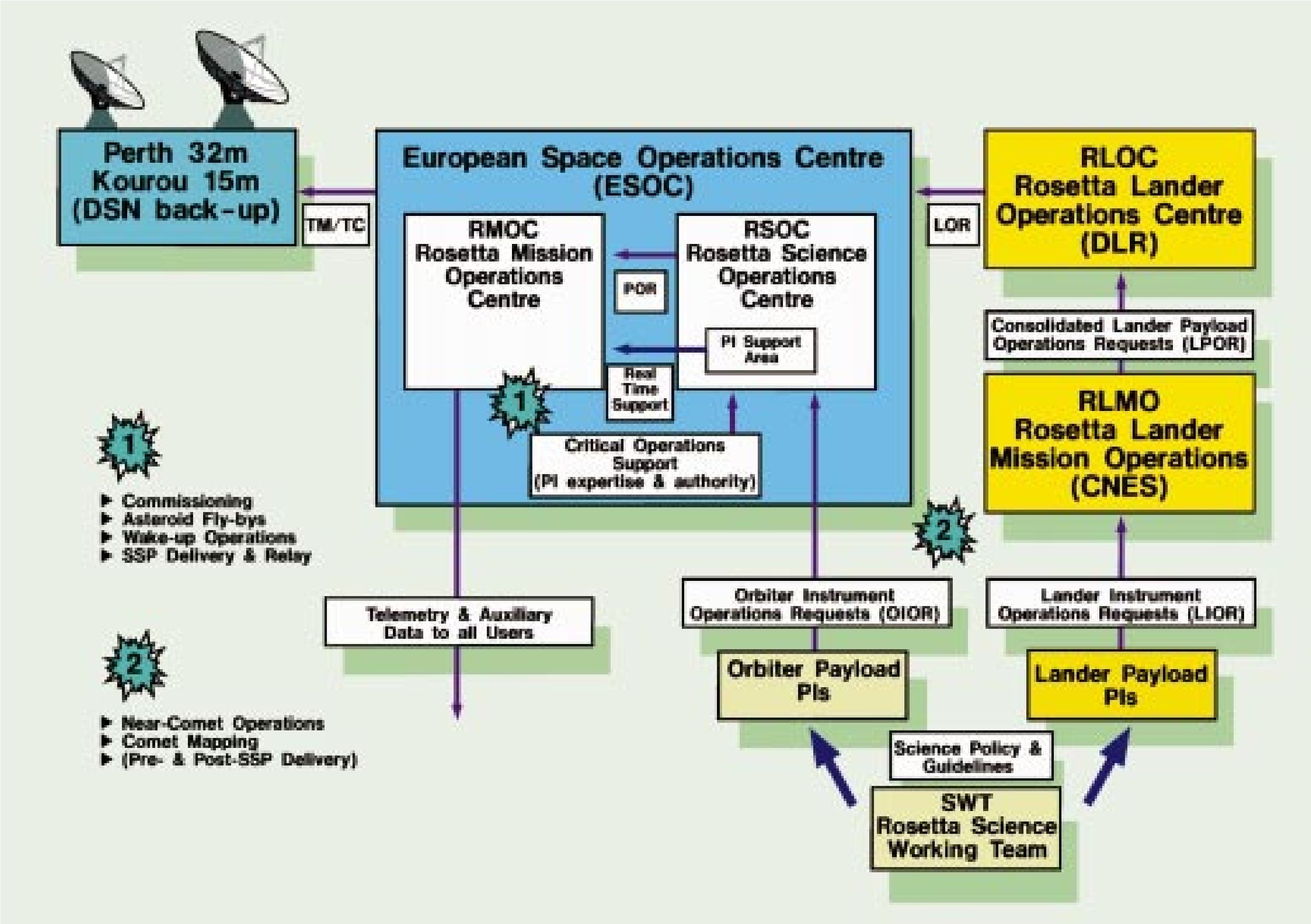


Figure 6. Schematic of Rosetta payload operations

the European Space Operations Centre (ESOC), in Darmstadt, Germany (Fig. 5). The main ground station for the mission will be the new 32-metre Deep-Space Antenna to be built near Perth, in Western Australia. The NASA Deep-Space Network will be used as a back-up during critical mission phases.

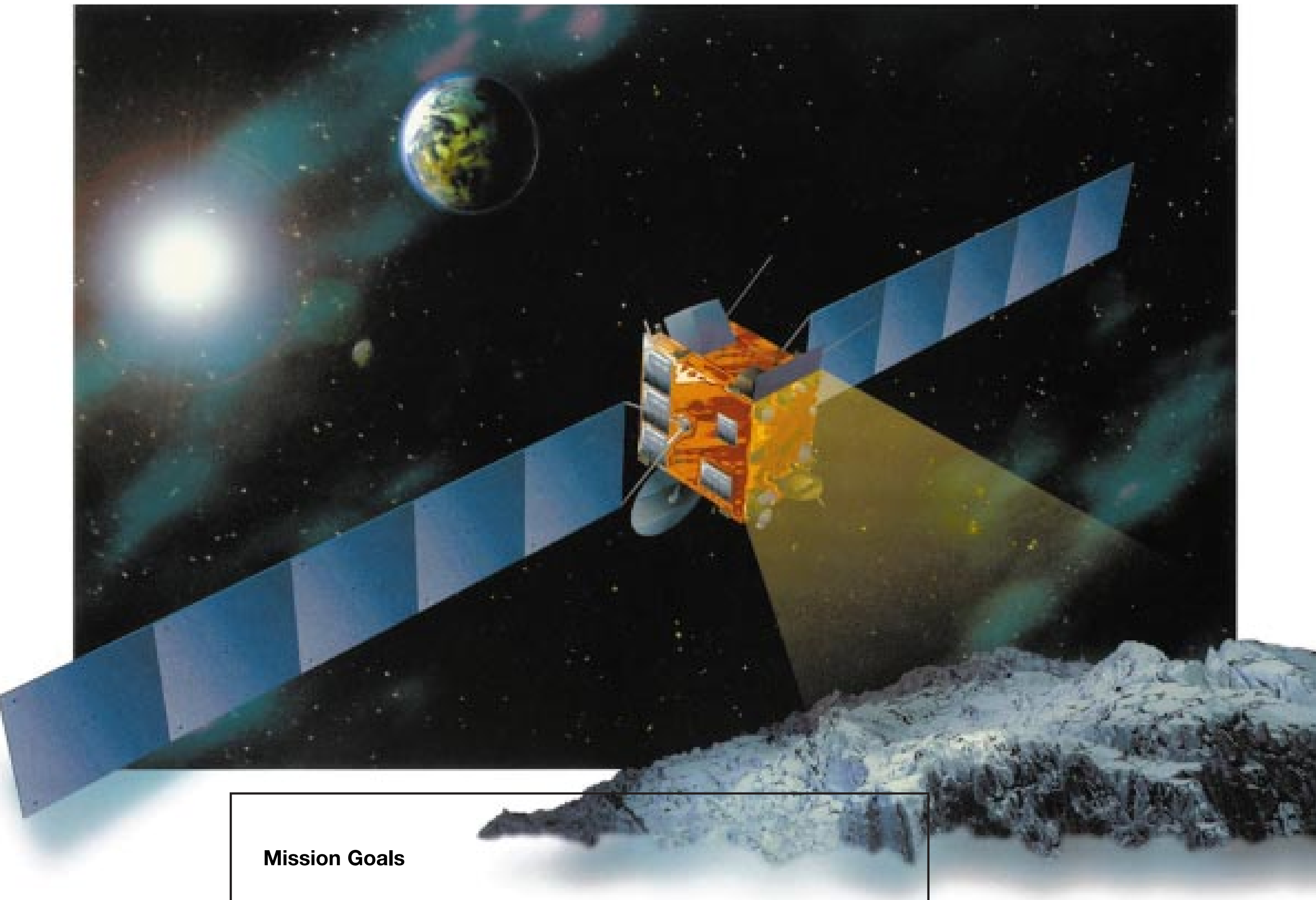
During the payload-checkout periods, the asteroid flybys and the near-comet phases of the mission, the Rosetta Science Operations Centre (RSOC) will be co-located with the Mission Operations Centre (RMOC) at ESOC in Darmstadt. A schematic of the mission and science operations facilities is shown in Figure 6.

Conclusion

Rosetta promises to be one of the most exciting planetary missions currently in preparation. It will provide unprecedented access to the original material of the proto-solar nebula and will help us to acquire a real understanding of how comets work.

The recent magnificent displays in our skies of Comets Hyakutake and Hale-Bopp have demonstrated yet again the intriguing mysteries associated with these objects, and fuelled enthusiasm in the scientific community for this novel mission opportunity.

The Project successfully passed its first milestone on 19 December, with the successful completion of the System Requirements Review. The Prime Contractor for Rosetta, selected early in 1977, is DASA-Dornier System of Germany. Responsibilities for the Platform and Avionics have been assigned to Matra Marconi Space UK and Matra Marconi Space France, respectively. Alenia Spazio of Italy is to be responsible for Rosetta's Assembly, Integration and Testing (AIT). esa



Mission Goals

The prime scientific objective of the mission as defined by the Rosetta Science Team is to study the origin of comets, the relationship between cometary and interstellar material, and its implications with regard to the origin of the Solar System. The measurements to be made in support of this objective are:

- Global characterisation of the nucleus, determination of dynamic properties, surface morphology and composition
- Determination of the chemical, mineralogical and isotopic compositions of volatiles and refractories in a cometary nucleus
- Determination of the physical properties and interrelation of volatiles and refractories in a cometary nucleus
- Study of the development of cometary activity and the processes in the surface layer of the nucleus and the inner coma (dust/gas interaction)
- Global characterisation of asteroids, including the determination of dynamic properties, surface morphology and composition.