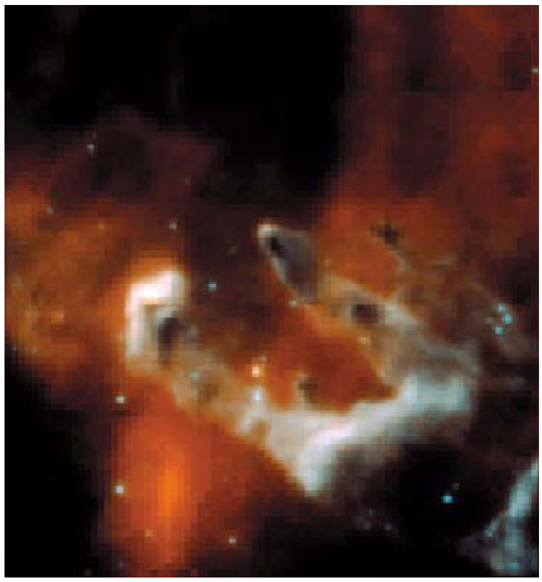
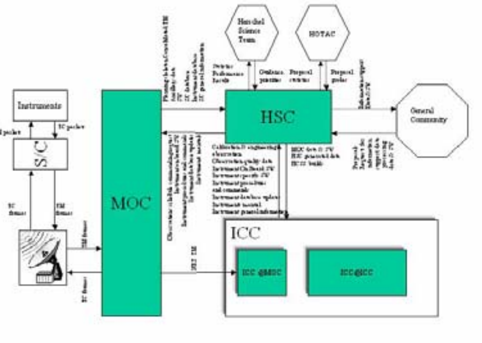
HERSCHEL

Herschel Space Observatory





Science Management Plan

DOCUMENT STATUS SHEET

Issue	Revision	Date	Status and reason for change
0	1	14 Mar 1997	Initial draft.
0	2	14 Apr 1997	Draft submitted to the AWG.
1	0	14 May 1997	**ESA/SPC(97)22**. Submitted to the SPC after incorporation of AWG comments.
1	1	20 Aug 1997	**ESA/SPC(97)22, rev.1**. Resubmitted to the SPC after incorporation of the requested modifications. **Approved**. Part of the AO for Principal Investigators and Mission Scientists issued on 3 Sep 1997.
1	2	Mar 2005	Not issued. Identical in content to issue 1.1, with new cover page and addition of status sheet (this page). Transferred from LaTeX to Framemaker, starting point for issue 2.
2	0	12 Apr 2005	Submitted to the AWG. The background and updating philosophy is described in section 1.2. The following sections (current issue is 'new', issue 1.1 is 'old') have been replaced and/or renamed: New 1.1 is old 1 renamed, **new 1.2 has been added**. New 2, 3, 4, and appendix A are the same as old 2, 3, 4, and appendix A, except for updated cross-references. **New 5.1-5.4 replace old 5.1, new 5.5 replaces old 5.2, new 5.6 replaces old 5.3**, new 5.7 is old 5.4 renamed, but with FIRST updated to Herschel. **New 6 has been added**. The table of contents and list of acronyms (appendix B) have been updated. In case of contradictions between an updated section and an unchanged one, the updated prevails.
2	1	22 Apr 2005	Submitted to the SPC after incorporating AWG comments: boldface penultimate paragraph in sec. 1.2 addition of last paragraph in sec. 5.4.2

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1 Scope

1.1 SMP issue 1997

The 'Far Infra-Red and Submillimetre Telescope' (FIRST) mission is one the four 'cornerstone' missions in the in the ESA 'Horizon 2000' long term science plan (cf. ESA SP-1070, December 1984). It was selected for implementation as 'Cornerstone 4' (CS4) by the Science Programme Committee (SPC) in its November 1993 meeting. A description of the scientific objectives, reference model payload, spacecraft and system design, and science operations and overall management for the selected mission was published as ESA SCI(93)6 in September 1993.

In the meantime virtually all aspects of the FIRST mission have been optimised resulting in a technically different cheaper mission, which is summarised in the present document. The science objectives have also been reassessed taking all foreseen complementary ground-, air-, and space-based observing facilities into account, in order to ensure that the precious FIRST time is allocated to areas where its capabilities are unique and its scientific impact will be the most profound.

The aim of this document, the 'FIRST Science Management Plan' (SMP), ESA/SPC(97)22, is to outline the 'current' FIRST mission, from approval of the SMP up to and including the post-operational phase with special emphasis on science operations, external involvement, and science (data) management.

In section 2 an overview of the FIRST mission as presently defined - including scientific objectives, scientific payload, spacecraft and mission, and community participation - is given. The science management and the novel manner in which the science operations are proposed to be implemented are described in section 3. Section 4 describes the schedule and manner of how to involve external participation in the FIRST programme through the issue of a Announcement of Opportunity (further details of this process are given in appendix A. The structure of the observing programme and the data products are described in section 5.

1.2 SMP issue 2005

The emphasis of the scope of the 'Science Management Plan' (SMP) is different in 2005 compared to in 1997. The SMP sets the framework approved by the ESA 'Science Programme Committee' (SPC), it is binding for everyone involved in the implementation and exploitation of the *Herschel* mission.

The SMP was originally written to be part of the initial 'Announcement of Opportunity' (AO) for 'Principal Investigators' (PIs) and 'Mission Scientists' (MSs), issued on 3 Sep 1997. At the time its main purpose was to supply information about *Herschel*, and to lay down the conditions for external participation in the form of becoming/being a PI or a MS, leading to their selection in 1998.

Subsequently, on 2 Apr 2001 an additional AO was issued, for participation in the form of becoming the 'Herschel Optical System Scientist' (HOSS). This was done without updating the SMP, and the conditions were given in the AO itself. The HOSS was appointed in 2001, and is a full member of the 'Herschel Science Team' (HerschelST), and has 'Guaranteed Time' (GT).

At the present time the first AO for *Herschel* observing time is being prepared. The SMP provides the 'rules of the road' regarding all aspects of the *Herschel* observing programmes, including types of observing programmes, guaranteed time, and data rights. However, SMP was not detailed enough to be used as the (sole) source for implementing these rules in practice, elaboration, and sometimes interpretation, are necessary. The SMP charges the 'Herschel Project Scientist' (PS) to manage the scientific programme, and, advised by the HerschelST and the 'Herschel Observing Time Allocation Committee' (HOTAC), to formulate and implement a strategy to maximise the scientific return.

On the subject of observing programmes and data rights the PS/HerschelST have undertaken this task, in consultation with the 'Astronomy Working Group' (AWG). In addition, general developments have lead to changes in the scope and implementation of data processing and science data products to be sought; this has financial implications for the 'Herschel Science Centre' (HSC). These two reasons have necessitated an update of the SMP, in order to seek re-approval by the SPC.

The guiding principle in updating the SMP, in order not only to save time and effort for everyone involved but also for maximum clarity, has been to minimise changes. Since the subject matter addressed was contained in only three subsections (5.1-5.3) in 1997 SMP, the decision was taken only to update these (there is no longer a need e.g. to describe *Herschel* or its instruments - this information is nowadays publicly available elsewhere). **Exactly what has been updated is described in the document status sheet (page ii)**.

It should also be noted that the present document addresses the scheme at the level of detail for its intended purpose, clearly there are aspects such as e.g. the definition of duplicate observations, instrument modes, data products, etc. that will need further development, and others e.g. timing that will require fine tuning; this information will be provided as part of the relevant AOs.

This document has been prepared and issued by its custodian, Göran Pilbratt, *Herschel* PS.

2 FIRST mission overview

2.1 Introduction

The ‘Far Infra-Red and Submillimetre Telescope’ (FIRST) is a multi-user ‘observatory type’ mission which targets the far infrared and submillimetre part of the electromagnetic spectrum, covering approximately the wavelength range 85-600 μm. It was selected by the Science Programme Committee (SPC) in its November 1993 meeting for implementation as Cornerstone 4 (CS4), subject to a ‘reconfirmation’ to take place at a later date. The key scientific topics to be addressed by FIRST will cover subjects as diverse as galaxy formation in the early universe, interstellar medium physics - including large- and small-scale star formation - in our own and external galaxies, and cometary and planetary (satellite) atmospheres. The science objectives are further described below in section 2.2.

ESA is responsible for the overall FIRST project; it will procure the satellite with the exception of its scientific instruments; it is also responsible for testing and validation, for mission design, launch, and all real-time interaction with the satellite during orbital operations. The scientific instruments will be provided by Principal Investigators (PIs), representing instrument-building consortia, to be selected in response to an Announcement of Opportunity (AO) to be issued (cf. section 4). The reference model payload is further described in section 2.3 and the spacecraft in section 2.4.

The current schedule, which includes preliminary approval of the Science Management Plan (SMP, this document) by the SPC in its June 1997 meeting, leading to final SMP approval in September 1997 and instrument selection in June 1998 by the SPC, assumes a FIRST launch in late year 2005 (cf. table 1 for an overall project schedule) by a dedicated Ariane 5 into a direct transfer trajectory into a large Lissajous orbit around the Lagrangian point L2 in the Earth-Sun system. Its distance from the Earth in this orbit will vary in the range 1.2-1.8 million km. FIRST will conduct scientific operations for nominally 22 (TBC) hours per day, while the remaining 2 hours will be used for sending the recorded data back to Earth. In the L2 orbit the predicted cryostat lifetime of FIRST is 4.5 years. The science operations are described in section 3, and observation programmes and data products in section 5.

2.2 Scientific objectives

The FIRST wavelength region of the spectrum, 85-600 μm, bridges the gap between what can be observed from current and future groundbased and airborne (e.g. SOFIA) facilities, and that of other space missions (e.g. ISO, SWAS, Odin, WIRE, SIRTF, and IRIS). Black-bodies with temperatures between 5 and 50 K peak in the FIRST wavelength range, and gases with temperatures between 10 and a few hundred K emit their brightest molecular and atomic emission lines here. Broadband thermal radiation from small dust grains is the most common continuum emission process in this band. These conditions are widespread everywhere from within our own solar system to the most distant reaches of the Universe !

The science objectives of FIRST have been constantly discussed and reviewed since first formulated, most notably in a number of major symposia including in Segovia, 1986 (proceedings published as ESA SP-260 in August 1986), Liège, 1990 (ESA SP-314, December 1990), and Grenoble, 1997 (ESA SP-401, to be published autumn 1997), and additionally in a special 'hearing' with invited experts organised by the FIRST Science Advisory Group (SAG) in September 1996.

Observation time from a space platform is particularly precious. The outcome of the assessments made in the 'hearing' of the existing multitude of potential observational objectives is that the key scientific topics to be addressed by FIRST include (but are not necessarily limited to):

- 150-500 μm deep broadband surveys and related research. The main goal of research in this area will be a detailed investigation of the formation and evolution of galaxy bulges and elliptical galaxies in the first third of the present age of the Universe. Furthermore, the possibility of discovery of new classes of objects is great.
- Follow-up spectroscopy of especially interesting program objects discovered in the survey. The far infrared/submillimetre band contains the brightest cooling lines of interstellar gas which give very important information on the physical processes and energy production mechanisms (e.g. AGN vs. star formation) in galaxies.
- Detailed studies of the physics and chemistry of the interstellar medium in galaxies, both locally in our own Galaxy, as well as in external galaxies, including objects at high redshift. This includes implicitly the important question of how stars form out of molecular clouds in various environments.
- Observational astrochemistry (of gas and dust) as a quantitative tool for investigating the physical and chemical processes involved in star formation and early stellar evolution (e.g. cloud collapse, freeze out, disk formation, dust coagulation, and planetesimal formation).
- Detailed high resolution spectroscopy of a number of comets, high resolution molecular spectroscopy of the cool outer planets, and searches for Kuiper-belt objects.

From past experience it is also clear that the 'discovery potential' is significant when a new capability is being exploited for the first time. Observations have never been performed in space in the 'prime band' of FIRST, thus FIRST will be breaking new ground since a space facility is essential in this wavelength regime !

2.3 Scientific payload

In order to address its scientific objectives FIRST will need instruments for high and medium resolution spectroscopy, imaging and photometry. The model payload as presently defined has evolved to consist of three instruments and has been used to define requirements, interfaces, operation and performance of the spacecraft for study purposes. The model payload comprises:

- A heterodyne instrument, referred to as the 'HET'. It performs high to very high resolution spectroscopy in approximately the 500-1200 GHz (250-600 μm) range. It is a multichannel SIS mixer receiver with solid state local oscillators and ('hybrid') digital autocorrelator and/or acousto-optical spectrometers. The SIS mixers need to be operated at a temperature of 4.5 K or lower, preferably at around 2 K.

- An incoherent photoconductor instrument, referred to as the 'PHOC'. It performs imaging line spectroscopy and photometry in the 85-200 µm range using a 25x16 stressed 'bulk' Ge:Ga photoconductive detector array and an image slicer in combination with a long-slit grating spectrometer. The photoconductors need to be cooled to around 1.7 K.
- An incoherent bolometer instrument, referred to as the 'BOL'. It performs imaging photometry in the 200-600 µm range, simultaneously covering the same field in three bands, and in addition, spectroscopy in the 200-350 µm range, using bolometer detector arrays. The bolometers have an operating temperature of around 0.2 K.

The model payload is being optimised with respect to the identified key science topics, and for minimising technical complexity and risk, cost, operational effort, and at the same time complying with the spacecraft constraints.

2.4 Spacecraft and mission description

The mission selected for implementation as CS4, i.e. the concept in circa 1993, was based on the outcome of an industrial study performed in 1992-93. The spacecraft employed a payload module (PLM) with a 3 m diameter Cassegrain telescope inside a sunshade and a science payload 4.5 K environment created by mechanical cryo-coolers, and a service module (SVM) providing the necessary infrastructure.

Since then two different spacecraft concepts have been studied. On the one hand, the design of the cryocooler spacecraft has been refined, taking the current increased technical maturity and performance of the coolers into account. On the other hand, a 'wet' cryostat concept based on the (now well proven) ISO cryostat technology has been studied. For both concepts it has been investigated whether the (re-)use of the XMM SVM could be advantageous.

Following an extensive scientific and technical evaluation and trade off of the study results, including risk, choice of orbit, and cost, made by the project, and following the SAG recommendation in favour of the cryostat concept and L2 orbit, **it has been decided to implement the FIRST mission with a cryostat spacecraft, and to conduct in-orbit operations from an orbit around the Lagrangian point L2 in the Sun-Earth system**.

The spacecraft (cf. figure 2.4) will consist of three parts: the Telescope Assembly (TA) comprising the telescope inside its sunshade, the Payload Module (PLM) with the cryogenically cooled focal plane science instruments, and the Service Module (SVM) which will also accomodate the 'ambient' temperature payload electronics.

The telescope will be a 3.5 m (TBC) main reflector diameter Cassegrain (or Ritchey-Chrétien) telescope inside a fixed sunshade. The telescope will have a total wavefront error (WFE) of less than 10 µm (with a goal of 6 µm - corresponding to 'diffraction-limited' operation at 150 µm (goal 85 µm - in orbit, a very low emissivity, and an operational temperature in the range 70-80 K (TBC). The PLM will employ a superfluid liquid helium cryostat based on ISO technology for focal plane science instrument cooling. The calculated cryostat lifetime in the L2 orbit is 4.5 years. Using a dedicated Ariane 5 launcher, FIRST can be launched directly into an L2 orbit transfer trajectory. There exists a near midday launch window of about 45 mins duration which is open throughout the year - except for a two week period around each of the two equinoxes and a couple of days per month (to avoid the Moon) - and a virtually eclipse free orbit for the entire mission duration can be selected.

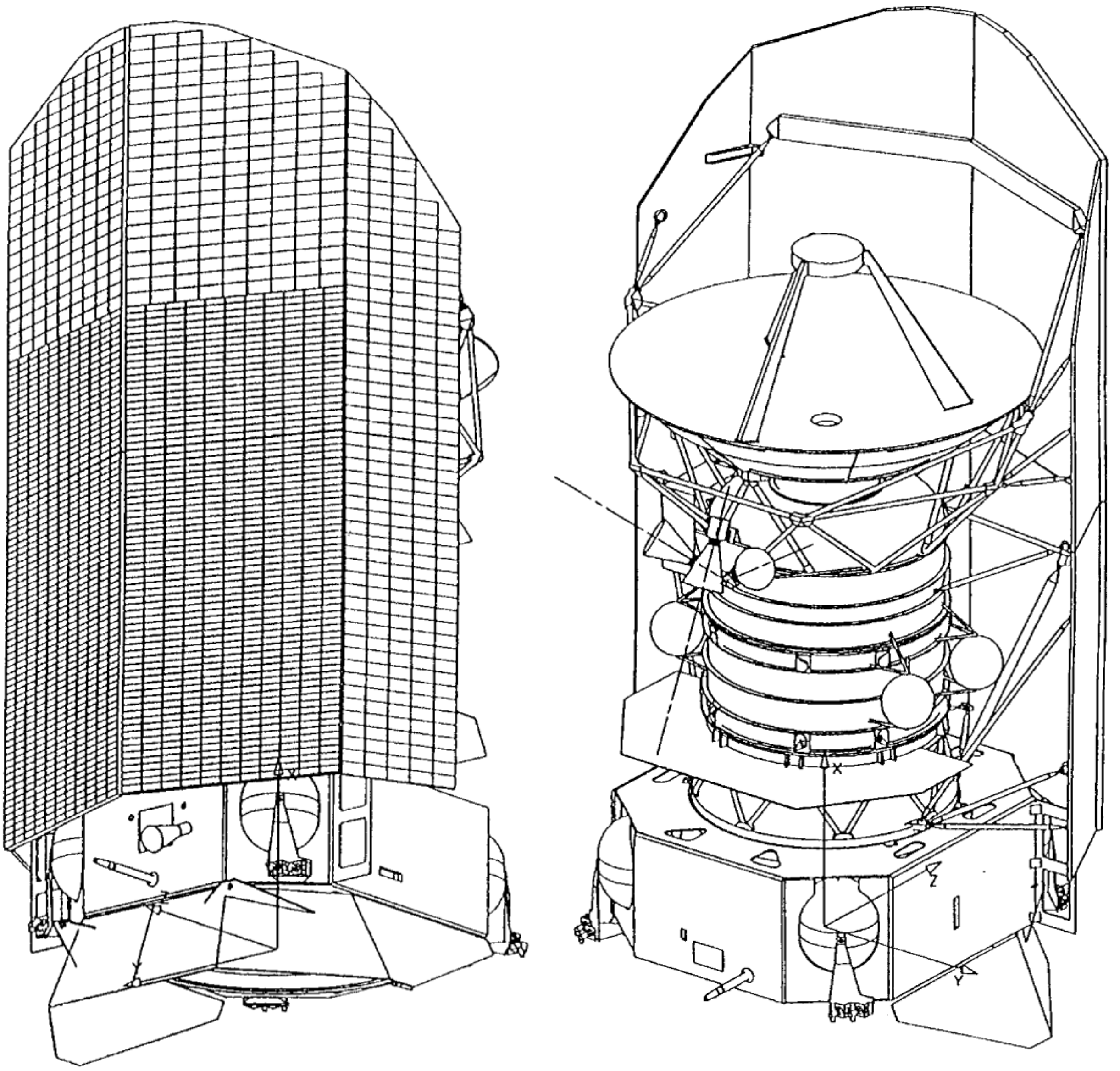

Figure 1: The FIRST spacecraft based on the ISO cryostat

Two views of the FIRST cryostat spacecraft in the flight configuration optimised for a large Lissajous orbit around L2. The satellite has a total height of 8.05 m, a maximum width of 4.43,m, and a launch mass of 4159 kg including all specified margins and a 98 kg launcher adapter. A 3.5 m diameter main reflector with the tripod supporting the sub-reflector is protected by an open sunshade/sunshield structure. The payload is housed inside the cryostat which contains 2560 l of superfluid helium at 1.7 K, giving a predicted cryostat lifetime of 4.5 years in the L2 orbit. Mounted on the outside of the cryostat vacuum vessel payload units (^{3}He and ^{4}He bottles and the local oscillator unit) and the three startrackers in a skewed configuration are visible.

In the orbit around L2 scientific operations are planned to be conducted 22 (TBC) hours per day, while 2 hours per day are allocated for data downlink by repointing the spacecraft to the Earth and using the 32 m antenna of the ESA groundstation in Perth, Australia. The science operations will be conducted using a ‘decentralised’ ground segment concept which is further described in section 3.

2.5 Participation of the scientific community

The general scientific community will be invited to participate in the FIRST mission in several ways:

- by providing science instruments and their associated ICCs, through an Announcement of Opportunity (AO) process
- by becoming Mission Scientists (MSs), through an Announcement of Opportunity (AO) process
- by becoming observers, through submission of observing proposals in response to calls for observing proposals to be issued
- by accessing data in the FIRST database after the proprietary period of time has expired
- by accessing ‘final’ data products in the FIRST database after completion of the post-operational phase

3 Science management and operations

3.1 Overview

FIRST has been conceived as a multi-user observatory, with instruments provided by Principal Investigators, and it will be open to the general international astronomical community. Throughout the entire operational lifetime of the FIRST mission, the observation time will be shared between guaranteed and open time (cf. section 5.1). The guaranteed time will be defined by the guaranteed time holders. The open time will be allocated to the general community on the basis of calls for observing proposals. The formation of large observer collaborations collectively addressing key scientific topics will be actively encouraged. The proposals will be evaluated and selected by a time allocation committee on the basis of scientific merit and technical feasibility.

All scientific data (cf. section 5.2) will be archived and made available to the general astronomical community after a proprietary period (cf. section 5.3) of time has elapsed, together with software tools to produce ‘standard’ data products, and to interactively further process the data. The ‘end product’ of the mission will be derived in the post-operational phase and will consist of:

- the ‘raw’ data products
- the ‘final’ software tools
- data reduced with the ‘final’ software tools to ‘final standard’ data products
- various documentation and manuals

The ESA Director of Scientific Programmes (D/Sci) has the overall responsibility for all aspects of the FIRST mission. A FIRST Project Scientist (PS) will be nominated with the responsibility to manage the FIRST scientific programme. A FIRST Project Manager (PM) will be appointed to manage the project during the development phase of the mission, up to and including successful completion of the satellite - including its scientific payload - commissioning. At this point the responsibility will be assumed by the ESA Space Science Department (SSD).

The scientific operations of FIRST will be conducted in a novel ‘decentralised’ manner. The proposed ground segment concept (cf. section 3.3) comprises five elements:

- a FIRST Science Centre (FSC), provided by ESA (cf. section 3.3.2),
- three dedicated Instrument Control Centres (ICCs), one for each instrument, provided by the respective PI (cf. section 3.3.3),
- a Mission Operations Centre (MOC), provided by ESA (cf. section 3.3.4).

The ground segment elements will be united by dedicated computer links into a coherent science ground segment. These computer links are part of the FIRST Integrated Network and Data Archive System (FINDAS, cf. section 3.3.2) for which the FSC is responsible. The FSC acts as the single-point interface to the science community and outside world in general.

Responsibility for the design, manufacture, testing, and performance validation of the scientific instruments rests with the respective PI. For each science instrument there will be a ICC, whose design, implementation, and operation is the responsibility of the corresponding PI. Each ICC will be responsible for the operation of its instrument, and also for the provision of calibration and data reduction tools for all data generated.

The execution of all in-orbit operations will be the responsibility of the MOC. The responsibility for the design, implementation, and operation of the MOC, rests with ESOC.

The FIRST Ground Segment Advisory Group (FGSAG) will consist of the PS and of representatives of the FSC, ICCs, MOC, and - in the development phase - of the FIRST project. It monitors the progress of the development of the ground segment elements, their operation, as well as providing analysis at system level in view of the overall mission and science ground segment objectives. It advises and reports to the FIRST PM during the development phase, and to the PS during the operational phase. The management of the whole science ground segment is shown in figure 2.

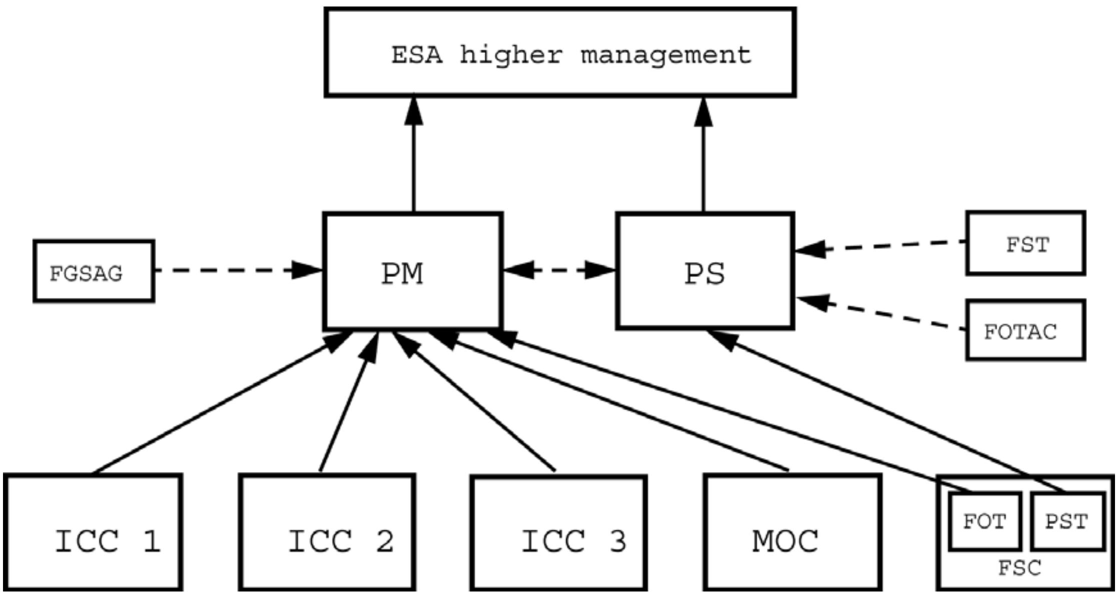

Figure 2: The FIRST ground segment

A management diagram of the FIRST ground segment during the development phase. Solid arrows denote formal (not necessarily hierarchical) links, dashed arrows advisory links. For the ICCs, which (unlike the MOC and FSC) are PI responsibilities, there are formal links to the PM through agreements between the PIs and ESA. The FGSAG consists of representatives of all the ground segment elements, and of the PS and the project; it advises the PM in the development phase, and later, in the operational phase, the PS.

3.2 Science management

3.2.1 Project Scientist (PS)

The FIRST Project Scientist (PS) has the responsibility to manage the FIRST scientific programme, to safeguard the scientific interests, and to maximise the scientific return of the FIRST mission during all its phases. The PS will lead a team (the PST) which, advised by the FIRST Science Team (FST, cf. section 3.2.2) and the FIRST Observing Time Allocation Committee (FOTAC, cf. section 3.2.3), will be responsible for formulating and implementing strategy to fulfill these responsibilities. The PS will act as the Chairman of the FST and as such coordinate its activities (cf. below section 3.2.2).

The PS represents the interests of the scientific community for the whole duration of the project and will be ESA's interface to the external scientific community, including the instrument/ICC PI consortia and the MSs, for all scientific matters.

Within ESA, he will liaise with the Project Manager (PM) and the project team in the development phase, and will coordinate all scientific issues with the PM and the project team. In particular, the PS will advise the FIRST project payload manager on technical matters when they affect scientific performance. During the development and operational phases, the PS will monitor the state of implementation and readiness of the instruments, their scientific capabilities, and their operations and data processing infrastructure which will be provided by the corresponding ICCs and the FSC. After the completion of the in-orbit operations the PS will manage the transition into the post-operational phase.

3.2.2 FIRST Science Team (FST)

The FIRST Science Team (FST) will be formed after selection of PIs and MSs has taken place through the AO process, and will remain in place until the end of the post-operational phase. Its membership will include:

- the ESA Project Scientist (PS) as its Chairman,
- the payload instrument/ICC Principal Investigators (PIs),
- the payload instrument/ICC Co-PIs,
- the FIRST Science Centre Operations Manager (FOM),
- the Mission Scientists (MSs),
- a representative of the FIRST Project, usually the payload manager.

The overall objective of the FST is to safeguard the scientific interests of the FIRST mission. It fulfills this task by giving advice, it has no executive power. The MSs should represent the interests of the astronomical community 'at large', they must be independant of the PI teams and must not be affiliated with any institute having a major role in any PI consortium.

In general, the members of the FST will be expected to monitor and advise on all aspects of FIRST which affect its scientific performance. In particular, they will participate in major project reviews, and perform specific tasks as needed during the development and operation phases. The FST will be responsible for:

- acting as a focus for the interest of the scientific community in FIRST
- assisting the PS in maximising the scientific return of FIRST within its boundary conditions
- reviewing the scientific goals of FIRST at regular intervals in the light of recent results, while considering the technical requirements of the spacecraft
- monitoring and advising on the scientific aspects of the development of the instruments and the ground segment elements
- advising on the formulation and optimisation of the observation programme and the calibration strategy
- recommending updates or changes to the observing plan during the operational phase
- monitoring and reviewing the analysis of the data, and the quality of the data products, especially from the point of view of a 'general' observer
- defining data rights and publication policy following the established guidelines (cf. section 5.3)
- monitoring the transition to and advising on the organization of the post-operational phase
- promoting public awareness and appreciation of the FIRST mission, and supporting ESA in its public relations efforts (cf. section 5.4)

The FST will mainly rely on the technical support of the PIs and the FSC and their teams for the fulfillment of its functions. Ad-hoc experts will be invited to attend FST meetings as the need arises. The specific number and expertise of these experts will vary during the development of the mission to reflect the current needs of the FST.

The members of the FST, with the exception of the MSs, will have to provide their own funding to support their activities, and in particular will pay their travel and other expenses in connection with attending meetings of the FST. ESA does pay these costs for the MSs, and for any experts it may choose to invite to these meetings.

The PS may charge external scientific consultant(s)/expert(s) to conduct independent reviews of any of the activities which normally fall under the responsibility of the FST, the PIs, or the FSC. Such experts may be drawn from ESA's Astronomy Working Group (AWG) to whom a report should be submitted.

3.2.3 FIRST Observing Time Allocation Committee (FOTAC)

One single international scientific FIRST Observing Time Allocation Committee (FOTAC) will be established by ESA sufficiently early before launch. The composition of the FOTAC will be arranged such that conflicts of interests with proposers will be avoided. It will be based on scientific excellence. After consultation with the AWG, the members of this committee shall be appointed by the ESA Director of Scientific Programmes for an initial period of 4 years.

The function of the FOTAC will be to assess observing proposals made by the science community at large (for the 'open' time, cf. section 5.1). In particular, the FOTAC will:

- establish criteria for 'open' time observing proposal selection,

- review and categorize proposals on scientific merit, technical feasibility, and priority in light of the scientific objectives of FIRST,
- recommend to ESA the assignment of observing time.

The time allocation process performed by the FOTAC will be supported by the FSC. The FSC will be responsible for preparing the call(s) for observing proposals for FIRST observing time, supplying all the relevant technical documentation (users manuals, instrument performance descriptions, instrumental constraints, etc.). The FSC will also receive the proposals and assess their technical feasibility prior to FOTAC meetings. The FSC will also provide status reports on payload state-of-health, various statistics on science instrument utilisation, consumables, reports on the conduct of operations etc. These reports will be made available to the FOTAC prior to the assessments of the proposals.

When attending meetings hosted by ESA, FOTAC members from ESA member states will have their travel expenses and per diem paid by ESA.

3.3 Science ground segment

3.3.1 Basis

FIRST has been conceived as a multi-user observatory, and it will be open to the general international astronomical community. This means that the science ground segment needs to be designed to this effect, including providing an interface for the community at large to keep abreast with FIRST developments as they happen - especially with regard to its predicted scientific capabilities and schedule for the planned calls for observing proposals - and to provide user support.

In order to implement an efficient science ground segment clear and logical divisions of responsibility with clearly defined deliveries and interfaces must be established; expertise must be utilised efficiently; operability and data reduction must be key drivers for the design, ground test, characterisation, and calibration; and commonality between the various instruments and between the ground and flight operational environments should be enforced.

The FIRST science operations concept as outlined in the overview (cf. section 3.1) has been designed with the objective to minimise the total overall operations effort (and thus cost) within the constraints given. It is regarded the most efficient concept technically in that:

- the expertise of all involved is utilised in a maximum and optimum way with clear predefined areas of responsiblity and interfaces,
- it is designed to give strong incentives to the PIs to develop their instruments with operations and data processing requirements addressed from the very beginning, expected to lead to instruments which are less complex to operate and ground testing programs designed with data reduction in mind,
- guidelines for instrument design and operational environments will be given in the Announcement of Opportunity (AO) to ensure the required level of commonality,
- it minimises overheads and needs of dedicated infrastructure.

In times of fast computer links and teleconference facilities the physical separation between the building blocks of the ground segment is considered not to be a noteworthy disadvantage.

3.3.2 FIRST Science Centre (FSC)

The FIRST Science Centre (FSC) is the single-point interface to the ‘outside’ world - including not only the general scientific community but also the press and general public - for contacting the FIRST observatory. It will be located at a suitable location in an ESA member state, e.g. at Vilspa.

In the broadest sense the FSC has two fundamental tasks:

- The FSC should make sure that the scientific productivity and impact of the FIRST mission is maximised within the given constraints. This is the responsibility of a scientific team directly led by the Project Scientist (the PST), supported by the FIRST Science Team (FST) and the FIRST Observing Time Allocation Committee (FOTAC) as described in section 3.2.1.
- The FSC is responsible for a number of functional tasks, including the responsibility for the development and maintenance of FINDAS. These tasks are the responsibility of the FSC Operations Team (FOT) which is led by the FSC Operations Manager (FOM).

The FSC will be responsible for all ‘observatory’ aspects of the mission. The PS supported by the PST and the FOTAC, will define and implement the scientific mission strategy, and will be responsible for:

- providing community support throughout all mission phases, acting as single-point input (requests, proposals) output (information, data, software) interface and ‘central helpdesk’,
- performing cross-calibration, between FIRST instruments, and between FIRST and other facilities.

The FOM is responsible for performing a number of functional duties, including:

- designing, implementing, and maintaining FINDAS,
- providing, through FINDAS, access to FIRST data, software, and information throughout all mission phases for legitimate users,
- handling of proposals and providing corresponding support to the FOTAC,
- generating and maintaining the mission database,
- scientific mission planning.

As a consequence the FSC needs staff with hands-on experience of the FIRST instruments and their associated software. They need to be recruited well in advance of the start of in-orbit operations. These staff will work with the PIs/ICCs during the development phase, particularly with regard to user handbooks (instruments and data/software), instrument calibration, and data reduction and processing. They must (be given the opportunity to) go through all the phases of using FIRST as general users by proposing, observing and reducing their own data as part of the guaranteed time for the FSC.

FINDAS is the ‘nerve centre’ of the FIRST ground segment. It contains all information relevant to the project within a database system, i.e. data (test and flight), software, manuals and other miscellaneous information. It provides configuration control of all its components and ensures that everything accepted into (and exported out of) the database is traceable. At the same time it controls access in order to allow legitimate users - obviously there will be different types of users who will have different access restrictions - to perform allowed operations.

The responsibility for the design, implementation, and operation of the FSC rests with ESA.

3.3.3 Instrument Control Centres (ICCs)

The ICCs are responsible for the succesful operation of their respective instruments, and for making possible the processing of the resulting data. Each ICC performs tasks dedicated to their particular instrument; the responsibilities include:

- the monitoring of instrument development and testing,
- the provision of instrument simulators for inclusion into the satellite simulator, and of 'time estimators',
- the production of instrument manuals,
- the maintenance of the instrument onboard software which has been generated and validated by the instrument teams,
- the generation and maintenance of flight control procedures,
- the generation and maintenance of all ground software and procedures needed for operating the instruments, and for performing monitoring and trend analysis,
- the provision of all software and procedures required for error correction, calibration, and generally for the scientific processing of the data from the instruments, including interactive analysis tools and scripts ('recipes', command files) allowing the generation of 'standard' data products.

The responsibility for the design, implementation, and operation of the ICCs rests with the corresponding PIs.

3.3.4 Mission Operations Centre (MOC)

The MOC is responsible for all realtime operations of the satellite i.e. the spacecraft as well as the science instruments. The satellite will perform science operations for 22 (TBC) out of every 24 hours, the remaining time being used for repointing the spacecraft telemetry antenna towards the Earth and transmitting the data stored during the observations.

The responsibilities of the MOC include:

- Generating all commands to be uplinked to the satellite based on input from the FSC, the ICCs and its own subsystems. All commands will be time tagged, uplinked in advance, and stored onboard the satellite for later execution.
- Receiving, recording for safekeeping, and delivering telemetry to FINDAS ensuring access to instrument and housekeeping data in near realtime after reception.

- Insuring the health and safety of the satellite and all its subsystems, including that of the science instruments.

The responsibility for the design, implementation, and operation of the MOC rests with ESA/ESOC.

4 Programme participation

4.1 Introduction and programme schedule

It will be possible to participate in the FIRST programme by gaining either ‘guaranteed’ or ‘open’ observing time (cf. section 5.1.1). Guaranteed time will be granted to the selected respondees to the FIRST Announcement of Opportunity (AO), who will undertake to provide ESA with additional elements of the FIRST programme not funded by ESA. Open time will be granted on the basis of proposals for observing time.

In this section further information about the participation in the FIRST programme through responding to the AO is given; while information about the participation of the scientific community in the open observing programme is given in section 5.1. The overall schedule for the FIRST programme is given in table 1.

Approval of Science Management Plan by SPC	Jun/Sep 1997
Issue of the Announcement of Opportunity (AO)	Sep 1997
Selection of PIs and MSs by SPC	Jun 1998
Issue ITT for Phase B/CD	Mar 1999
Phase B/CD	Apr 2000 - Jul 2005
Instrument QM deliveries	Apr 2002
Software deliveries to be included	TBD
Issue of ‘Call for observing proposals for key programmes’	TBD
Definition of ‘guaranteed time and key observing programmes’	TBD
Issue of ‘Call for observing proposals’	TBD
Instrument FM deliveries	Jan 2004
Flight acceptance review	Jul 2005
Launch	Dec 2005
Nominal end of in-orbit operations (assuming 4.5 years cryostat liftime)	Jun 2010
Nominal end of post-operations (formal end of the FIRST mission)	Sep 2013
‘Historical’ archive phase	Sep 2013-

Table 1: FIRST overall programme schedule (TBC).

At the time of issue of the ITT all interfaces between instruments and the spacecraft, as well as within the ground segment must be defined and agreed upon. Software ‘deliveries’ are made by declaring software operational and making *it available for general use through FINDAS. The flight acceptance review encompasses the entire system, i.e. the spacecraft and the complete focal plane instruments as well as the complete ground segment. The predicted cryostat lifetime in L2 is 4.5 years (TBC). The post-operational phase has a duration of 3.25 years, at its conclusion the 'formal' end of the FIRST mission will have been reached. It consists of a run-down phase (3 months), a mission consolidation phase (6 months), an 'active' data archive phase (2 years), and an 'archive consolidation' phase (6 months) when 'final' data products will be produced. In line with the policy given in ESA/SPC(92)14, the resulting 'historical' archive will be maintained 'indefinitely' by ESA/SSD for the benefit of the whole science community.*

4.2 Announcement of Opportunity (AO)

The Announcement of Opportunity (AO) will be issued after approval of the Science Management Plan (cf. table 1). The AO will be open to response from scientific groups within the ESA member states, and in the United States of America (via NASA) in accordance with the ESA/NASA agreement on the principle of reciprocity. After release of the AO, ESA will hold a briefing meeting for interested parties.

By issuing the FIRST Announcement of Opportunity (AO), ESA will invite the scientific community to participate in the FIRST programme by:

- becoming Principal Investigators (PIs) by providing complete focal plane science instruments and their corresponding Instrument Control Centres (ICCs)
- becoming Mission Scientists (MSs)

During the AO process individuals will be able to submit proposals in more than one category. However, success for an individual as a PI, or Co-PI, will automatically remove his/her candidature for a MS position.

The specific elements of the proposals will be detailed in the AO, but will in general include (where appropriate for each catagory) scientific aspects (including a description of the proposed guaranteed time scientific programme), technical aspects (related to the instrument development and operation, including instrument ground calibration and detector characteristics), data processing aspects (related to the development and support of the data processing structure), and management and schedule aspects.

The Announcement of Opportunity (AO) for FIRST will be composed of:

- the Announcement of Opportunity itself
- the Science Management Plan (SMP, i.e. this document)
- a draft Instrument Interface Document (IID), part A, to be completed in phase B of the project
- a draft Instrument Interface Document (IID), part B, for each focal plane instrument, to be completed by the instrument consortia
- a draft Ground Segment Interface Document (GSID)
- a draft FIRST Operations Interface Requirements Document (FOIRD)
- the Public Relations Plan (PRP)

Details on the selection procedure, the proposal evaluation criteria, and the formal agreements between

ESA and the selected consortia are given in appendix A.

A detailed schedule for the AO process is given in table 2.

Call for Letters of Intent	11 Apr 1997
Letters of Intent due	23 May 1997
Issue of the Announcement of Opportunity (AO)	30 Sep 1997
Questions for briefing due	21 Nov 1997
General briefing meeting	1 Dec 1997
Appoint evaluation committee	12 Feb 1998
Proposals due	16 Feb 1998
Evaluation phase	Feb - May 1998
Preliminary recommendation by evaluation committee	Mar 1998
Clarification and optimisation meetings	Mar - Apr 1998
Final recommendation by evaluation committee	29 Apr 1998
AWG/SSAC review	May 1998
SPC selection	Jun 1998

Table 2: Detailed schedule for the FIRST AO cycle.

4.3 Instrument/ICC Principal Investigators (PIs)

The three focal plane instruments and their associated Instrument Control Centres (ICCs) will be provided by instrument consortia led by Principal Investigators (PIs), selected via the Announcement of Opportunity (AO). Each consortium will be expected to satisfy the following conditions (cf. appendix A.2 for a more detailed description of the formal responsibilities of the PIs):

- it will be led by a single Principal Investigator (PI), who, on behalf of the entire consortium (possibly including a Co-PI as well as Co-Is) will act as interface to ESA and will be a member of the FST
- it will be committed to design, develop, manufacture, test, characterise, and calibrate an instrument according to a model philosophy and schedule agreed with ESA
- it will implement and operate an ICC according to an agreement with ESA regarding responsibilities, deliveries, and schedule
- it will establish a well specified and identified management structure, e.g. with an experienced Technical/Engineering Manager (responsible for instrument technical development) and an ICC Manager (responsible for the development and operation of the ICC) under the responsiblity of the PI
- it will have adequate control over all aspects of its undertaking, including financial, technical, and human resources

The consortia are encouraged to involve additional associates who could contribute actively to specific scientific and technical aspects of the mission throughout its development, operational, and exploitation phases.

Considering the potential size and sophistication of the science instruments, as well as the responsibility for each PI to provide a dedicated ICC, and the likely involvement of a large scientific community through international collaborations, it is planned - pending final instrument selection following the AO process - that the selected PI for each instrument shall nominate one scientist who is an active member of the PI team and who, if appropriate, represents a major participating country other than the one providing financial support for the PI. This nominated scientist, called the Co-PI, will be a member of the FST and shall actively support his/her PI in fulfilling all FST related tasks.

4.4 Mission Scientists (MSs)

The role of the Mission Scientists (MSs) is, while acting as full members of the FIRST Science Team (FST), to provide input independently of the PI instrument/ICC consortia and FSC. In particular (for formal responsibilities cf. appendix A3) the following specific tasks shall be covered by each MS:

- to monitor the progress of instrument development with emphasis on system level aspects in view of the overall mission objectives and instrument complementarity
- to provide independent advice on science operations, and in particular on instrument calibration, operational modes, and data reduction software
- to review, advise, and assist on optimising the observing programme based on the scientific objectives of FIRST

They shall be scientists with a high international reputation in astrophysics, and specifically in one or more of the fields of distant galaxies/galaxy formation/cosmology, interstellar medium physics/astrochemistry/star formation, and/or cometary/planetary (satellite) atmospheric physics.

They shall be capable of making personal contributions to the FIRST programme during both development and operational phases. It is planned to appoint a total of three MSs. They shall have different experience/competence profiles, so that it becomes appropriate and natural that they concentrate their effort on separate tasks, e.g. possible specialisations being for a MS each to concentrate on:

- instrument hardware design, fabrication, ground testing and in-orbit verification, with special emphasis on functional reliability and scientific performance,
- science data calibration and processing, with special emphasis on the quality, timeliness, and userfriendliness of the ICC-developed software supplied to the FSC, and the support offered by the FSC to the community,
- the composition, structure, and execution of the ‘key’ programs, and in particular, of the survey programs.

In the case that not all tasks are fully covered and/or new tasks and new areas of independent expert advice require attention during the course of the programme, the number of appointed MSs may be increased by the ESA D/Sci according to standard procedures.

5 Observing time and science data products

5.1 Introduction

The top level consideration is that all use of observatory time must be dictated by considerations of scientific productivity. ***Herschel* is a strictly 'consumables limited' mission: when the available helium cryogen has been exhausted the observatory will no longer function.**

The boiling off of helium starts already on the launch pad! Consequently any use of spacecraft time (for a short description of the various mission phases see section 6) should be looked at from the point of view of: 'Is this the most productive way of spending this amount of helium?'

It follows that the objective is **to make the maximum amount of spacecraft time available for scheduling of scientific observations,** subject to the constraints set by observatory maintenance including calibration and engineering needs, and **to use the available observing time in the best manner possible with the overall objective to maximise the science return and its impact,** while at the same time recognising the legitimate interests of all involved.

5.2 Herschel specific considerations

5.2.1 Science case and timing

Herschel will offer observing capabilities never realised before. The fact that *Herschel* will bring far infrared and submillimetre observatory capabilities for observations longward of 200 µm into space for the first time has another important consequence, which can easily be seen by making a comparison with the *ISO* situation.

When the *ISO* observing programmes were being planned by the various future observers the data resulting from the all sky survey performed by *IRAS*, in its four photometric bands all within the *ISO* spectral coverage, were available. With *ISO* one could thus plan to build on the *IRAS* observations when extending the coverage in phase-space offered by the much more powerful *ISO* capabilities.

Simply put, except for the shortest wavelengths *Herschel* has no *IRAS* equivalent, thus at least to a certain degree it will need to be its own pathfinder. The fact that ***Herschel* observers will want to build on and follow-up their own observations forces scheduling of observations expected to generate follow-up observations early in the mission.** Consequently and importantly, **it therefore also imposes very stringent timescales on the successful processing of *Herschel* data in a timely manner.**

5.2.2 Introduction of 'Key Projects'

It is anticipated that given the scientific objectives of the mission 'Key Projects' (KPs) in the form of large spatial and spectral surveys will constitute very important elements of the observing programme, requiring a substantial fraction of the available time of the overall mission, and that (some of) these programmes will be scheduled early in the operational life of the mission to enable follow-up observations by *Herschel* itself within its lifetime limitation.

There will be a separate initial call for observing proposals for KPs at an early stage, to be followed by a call for 'regular' observing programmes only when the KPs have been established.

5.2.3 Coordination of observing programs

The 'Herschel Science Team' (HerschelST) has the opinion that large coordinated observing programmes, or groups or combinations of 'connected' smaller programmes, will generally - exceptions proving this are expected - provide a higher science return than a number of disconnected smaller programmes requiring the same amount of observing time. This view is not restricted to the KPs only - which by their nature will be large and coordinated - and will be reflected in the AOs for proposals that will be issued.

5.2.4 Observing modes and AOTs

The *Herschel* satellite and instruments will offer a restricted number of ways they can be used by the observer; this will be done in the form of providing a number of 'Astronomical Observation Templates' (AOTs) for the users. The AOTs will have to be tested and validated during the 'Performance Verification' (PV) phase (cf. section 6.3) of the mission. Only observations using validated AOTs will be released for scheduling (cf. section 6.3.2).

5.2.5 Time available

Herschel will be operated in a large Lissajous orbit around the second Langrangian point (L2) in the Sun/Earth system. This point is located 1.5 million km antisunwards from the Earth, the distance to *Herschel* will vary in the range 1.2-1.8 million km. A cryostat lifetime of 3.5 years is a system requirement to ensure the provision of 3 years of routine scientific operations.

In principle *Herschel* will be operated 24 hours/day subject to the relevant Sun and Earth constraints set by thermal, power, and communication requirements. *Herschel* will normally be in autonomous operation mode. During routine operations the ground station contact is nominally 3 hours per day; this is the so-called 'Daily TeleCommunication Period' (DTCP). During the DTCP schedules are uplinked and data are downlinked, and in addition the 'Mission Operations Centre' (MOC) performs various maintenance activities. It may or may not be possible to (at least partly) use the DTCP for performing observations, but in this case only subject to all the (notably pointing and the operation of the onboard transponder) restrictions imposed by the primary use of the DTCP. The remaining nominally 21 hours per day are available for the scheduling of scientific operations.

It is recognised upfront that some of the available science time will have to be allocated to engineering and calibration observations. The actual time required will have to be borne out by experience during in-orbit operations; here as an assumption the *ISO* number of ~14% (for *ISO* 1 revolution out of every 7) is taken as a guideline.

The remainder is the *Herschel* observing time available for the scheduling of astronomy observations. Assuming routine scientific operations for 3 years, and nominally allowing for 14% engineering/calibration observation time, gives 939 schedulable days providing 19,723 schedulable hours.

5.3 Observing time

For the purpose of estimates it is sometimes useful to approximate the available *Herschel* schedulable observation time with ~1,000 days or ~20,000 hours. This time will be divided into two categories:

- ‘Guaranteed Time’ (GT), and
- ‘Open Time’ (OT).

5.3.1 Guaranteed time

5.3.1.1 Amount of guaranteed time

The GT to be shared between the ‘Principal Investigator’ (PI) consortia, the ‘Herschel Science Centre’ (HSC), and the ‘Mission Scientists’ (MSs) amounts to 32% of the total available observing time, the remaining 68% of the observing time constitutes the OT. The GT is owned by the GT holders.

The ‘Herschel Optical System Scientist’ (HOSS) was not considered at the time of the original issue of the SMP (for the purpose of selection of PIs and MSs, cf. section 1.2). When it was decided to add the HOSS it was decided that the incumbent should have the same amount of GT as a MS, but that this time should be taken from the ‘Discretionary Time’ (DT, cf. section 5.3.2.2), since it was considered unfair to decrease the amount of GT for the ‘original’ GT holders.

5.3.1.2 Sharing of guaranteed time

The GT is shared between as follows:

- Each PI owns 30% of the GT. It is the responsibility of each PI to manage this time within the respective consortium.
- The Herschel Science Centre owns 7% of the GT. It is the responsibility of the PS to manage this time within the HSC.
- The five MSs combined own 3% of the GT. It is assumed that they each own 1/5 of this time, they each manage their own time.
- The HOSS owns an amount of GT equal to that of a MS.

It would be preferable for the GT to constitute a larger than average fraction of the total observing time early during the mission.

5.3.2 Open time

5.3.2.1 'General' open time

The OT is to be awarded to the general astronomical community, including the GT owners, through a standard competitive proposal procedure. The proposals will be judged for scientific merit by an independent time allocation committee, the 'Herschel Observing Time Allocation Committee' (HOTAC). Depending on the amount of observing time applied for in relation to the amount of time available (the oversubscription factor) and the quality of the proposal, it may or may not be awarded a high enough grade to be likely to be scheduled for observing. The not rejected proposals will be screened for technical feasibility by HSC staff.

A small fraction of the OT will be allocated to 'Discretionary Time' (DT) and to 'Targets of Opportunity' (ToO).

5.3.2.2 Discretionary time

DT can be awarded to proposals made at any time. It is limited to a maximum of 4% of the OT, and can only be awarded to proposals proposing observations which could not have been foreseen at the time of the regular calls. The DT is awarded in consultation between the PS and the HOTAC chair. A fraction of the DT has already been allocated to provide for the HOSS GT (cf. section 5.3.1).

5.3.2.3 Targets of Opportunity

A distinction is made between two different forms of ToOs. There is an important difference in how to apply for time for these two categories.

Generic ToOs are objects (e.g. supernovae and newly discovered comets) which are 'known' and expected but cannot be predicted in advance as to where and when they will be available for observation. Observing proposals for generic ToOs should be submitted in response to the regular calls for proposals.

Serendipitous ToOs are the remaining ToOs, and these proposals will be treated as proposals for DT.

5.4 Observing programmes and observing time awarding

5.4.1 Generalities

There will be three kinds of *Herschel* observing programmes:

- 'Key Project' (KP) programmes, these can consist of either GT or OT,
- 'Guaranteed Time' (GT) programmes, and
- 'Open Time' (OT) programmes, including DT programmes and ToOs.

All observing proposals for all programmes (including GT programmes) will be required to go through the HOTAC. While the GT belongs to the GT owners in the sense that they are guaranteed a certain amount of observing time, all use of time will have to be approved by the HOTAC as scientifically justified use of *Herschel* time.

5.4.2 Calls for observing proposals (AOs)

Three cycles of calls for observing proposals - 'Announcement of Opportunities' (AOs) - are planned to be issued:

- there will be one AO for Key Project programmes only - 'Cycle KP'
- there will be two AOs calls for GT and OT regular programmes - 'Cycle 1' and 'Cycle 2'

Each cycle will be subdivided in two parts, in the first instance the GT (in the respective cycle) will be awarded, followed by the OT, as described in more detail below. Depending on the actual lifetime of the mission - which will only be known some time into the mission - a fourth cycle could be considered.

In avoiding and resolving duplications of observations, observations awarded in each cycle shall have priority over the following cycle(s), and the GT observations in a particular cycle shall have priority over the OT observations in the same cycle.

5.4.3 'Key Project' programmes

The concept of 'Key Projects' is regarded of very high importance. There will be a separate initial call for KPs upfront ahead of the calls for the regular GT and OT programmes.

5.4.3.1 Definition of KPs

The KP concept has been introduced to make sure that there is a mechanism to ensure that 'unusually' large programmes requiring a great deal of observing time can be proposed, selected, and observed. This need relates to the science objectives of *Herschel*, in combination with the absence of a precursor mission for a large fraction of the *Herschel* spectral region.

To be defined as a 'Key Project' an observing programme must have the following characteristics:

- exploit unique *Herschel* capabilities to address (an) important scientific issue(s) in a comprehensive manner,
- require a large amount of observing time to be used in a uniform and coherent fashion, and
- produce a resulting well characterised dataset of high archival value.

Paraphrasing what has already been stated regarding the use of the limited helium supply it is clear that the scientific motivation for an observing programme needing a particularly large amount of observing time has to be particularly high and well motivated. The size of a KP is foreseen to be in the range 100-1000 hours of observing time, with the median size expected to be in the lower part of this range, however, there is no formal upper limit.

5.4.3.2 Data reduction

Since the KPs will involve particularly large amounts of observing time, much of it spent early in the mission and is likely to generate the need for follow-up observations, it is recognised that there are clear and legitimate science return interests for everyone, including the community at large, that:

- the data generated by these observations are reduced in a timely fashion, and

- the resulting data products and the tools developed to produce them are made public.

The call for KPs will therefore ask for a demonstration of the ability and a commitment to perform data reduction, and to making data products (at a 'publishable' level of quality) and related tools publicly available through the 'Herschel Common Science System' (HCSS) at the end of the proprietary period. This should be a key criterion in the selection of the KP investigators.

5.4.3.3 Awarding Key Project time

The call for KPs will be the initial *Herschel* call for observing proposals; it will be open to the entire community. The awarding of observing time will have two parts however; first GT KPs will be awarded, subsequently followed by the awarding of OT KPs.

It is required that the major GT owners (the PI consortia) spend at least 50% of their GT on KPs. 40% of the OT will be reserved for the OT KP call.

The Cycle KP call is planned to be issued approximately 1.5-2 years before the foreseen launch date. The GT KPs will be selected and announced before the OT KPs. All KPs, both GT and OT, will be selected and announced before the Cycle 1 call is issued. For a timeline see section 5.4.7.

5.4.4 Guaranteed time programmes

The guaranteed time (GT) will be awarded in two separate AO cycles. If a given GT holder has been awarded GT KP for a fraction f_{KP} of the available GT (where f_{KP} is greater or equal to 50%) the maximum amount of GT available in the first GT call ('GT1') is half the remaining GT i.e. max $(1-f_{KP})/2$. The remainder of the GT will be awarded in the second call for GT ('GT2').

The first call, GT1, will be issued when all KPs (GT and OT) have been selected and announced i.e. 1 year before the launch, the selected programmes will be announced 6 months before the launch. The second call, GT2, will be issued well into the in-orbit mission. For a timeline see section 5.4.7.

5.4.5 Open time programmes

Like the GT, the open time (OT) will be awarded in two separate calls. With 40% of the OT having been allocated to the cycle KP and splitting the remaining OT evenly between cycles 1 and 2, 30% of the OT will be available in each of the two cycles.

The first call, OT1, will be issued in connection with a workshop taking stock of what has been learned regarding the operation and capabilities of the *Herschel* observatory. This workshop will be held at the conclusion of the science demonstration phase approximately 5 months after launch (cf. section 6.4). The second call, OT2, will be issued well into the in-orbit mission. For a timeline see section 5.4.7.

5.4.6 Illustration of possible time awarding per cycle

The **possible time awarded in the three AO cycles** described above are summarised below, **given certain assumptions**. For illustration 1,000 days is used as the length of the routine science operations period.

As indicated the duration of the time awarded in Cycle KP assumes that 85% of the GT is spent here, and the indicated durations of Cycles 1 and 2 in addition assume that half of the remaining GT is spent in each of these; again this is for illustration purposes only.

- Cycle KP with a duration of ~ 54% of the routine science operations period, or ~ 19 months.
  - GT ‘Key Project’ programmes: fraction f_{KP} (assumed 85%) of GT = 272 days
  - OT ‘Key Project’ programmes: 40% of OT = 272 days
- Cycle 1 with a duration of ~ 23% of the routine science operations period, or ~ 8.5 months.
  - GT1 programmes: half of remaining GT = 24 days
  - OT1 programmes: 30% of OT = 204 days
- Cycle 2 with a duration of ~ 23% of the routine science operations period, or ~ 8.5 months.
  - GT2 programmes: remainder of GT = 24 days
  - OT2 programmes: 30% of OT = 204 days

As already alluded to the introduction of a Cycle 3 could be contemplated in the event that the predicted lifetime of the mission significantly exceeds the assumed 3 year operational lifetime.

5.4.7 Timeline for AO cycles

There are conflicting arguments for when to issue the AOs. Generally for ‘pure’ scientific reasons the later the AOs are issued the better, enabling the use of the latest information in the context of a particular scientific field or problem. Likewise, the later an AO is issued, the more will be known regarding predicted instrument/observatory performance - however, at all times before actual in-orbit operations this information is likely to be incomplete.

There are also arguments for not waiting too late with the issue of AOs. Obviously there is an operational limit, it takes a certain time to process an AO cycle, and it is necessary to have observations available for scheduling when needed. In addition and in particular for the ‘Key Project’ AO cycle, time will be required by the various consortia to set themselves up and to organise themselves.

Based on analysis of other observatory missions an AO cycle time of 6 months has been adopted, and the following tentative timeline has been agreed:

- K: Issue AO for ‘Cycle KP’ proposals
  - K +3 months: Submission deadline for GT KP proposals
  - K + 6 months: Selection and announcement of GT KP programmes
  - K + 9 months: Submission deadline for OT KP proposals
  - K + 12 months: Selection and announcement of OT KP programmes
- K + 12 months: Issue AO for ‘Cycle 1’ GT proposals
  - K + 15 months: Submission deadline for GT1 proposals
  - K + 18 months: Selection and announcement of GT1 programmes

- L: *Herschel* launch followed by in-orbit operations (cf. section 6)
- L + 5 months: Science demonstration workshop followed by optimization of selected observing programmes and update of AO information
- L + 6 months: Issue AO for ‘Cycle 1’ OT proposals
  - L + 9 months: Submission deadline for OT1 proposals
  - L + 12 months: Selection and announcement of OT1 programmes
- L + 18 months: Issue AO for ‘Cycle 2’ proposals
  - L + 21 months: Submission deadline for GT2 proposals
  - L + 24 months: Selection and announcement of GT2 programmes
  - L + 27 months: Submission deadline for OT2 proposals
  - L + 30 months: Selection and announcement of OT2 programmes
- L + 42 months: End of nominal *Herschel* mission

This timeline fulfils the objective of KP selection before regular programmes. It also allows primarily KP and GT programmes to be scheduled early in the mission as foreseen, enabling follow-up as appropriate of KPs and training of the HSC staff - by performing their own observations and data reduction from end-to-end - before large numbers of OT observers will require assistance.

The timeline addresses the awarding of time, not necessarily the scheduling of the selected observations. However, it is assumed that the majority of the time awarded in a given cycle will be observed before observations selected in a subsequent cycle will be scheduled. This is subject, however, to e.g. sky visibility and other constraints including e.g. the validation of AOTs (cf. section 5.2.4), the appearance of ‘generic’ ToOs (cf. section 5.3.2.3) etc.

This timeline is **for illustration only** and **is subject to optimization as appropriate for achieving the overall goal of maximising scientific return and impact of *Herschel***, in particular wrt the amount of *Herschel* data available in the public domain and the availability of the *Planck* Early Release Compact Source Catalogue.

5.5 Data products and deliverables

5.5.1 Starting point

Herschel must offer its users, the astronomical community, the means (observing opportunities, data, products, software, and support) to do science. The concept on how to fulfil this task has evolved considerably since the ‘Science Management Plan’ (SMP) was approved by the SPC in 1997.

At the time, it was considered sufficient to provide astronomers with raw data and software tools to carry out the data processing, no ‘data products’ were to be generated and delivered. The strategy adopted was to offer the means for the individual observer to generate any desired product him/herself, if needed with support from the HSC. This also meant that the *Herschel* archive was not to be populated (except with raw data) until in the post-operations phase, severely restricting the usefulness of *Herschel* data for the wider community.

5.5.2 Paradigm evolution

However, in the last years, the expectations of the astronomical community on what to expect from observatories and their data processing systems, data products, and archives have evolved; what was once considered acceptable is no longer considered palatable. Furthermore, the importance of archives in astronomy has increased, on the tacit assumption that they are populated (or appear to be - it is an important technicality subject to optimization whether products are actually produced and stored, or produced in real time) with scientifically useful products, and there is - at the very least - an implicit requirement that all ESA astronomy archives must be suitable for access by ‘Virtual Observatory’ (VO) tools, i.e. they must be ‘VO compliant’.

5.5.3 Current plan

Following intensive discussions between ESA and the PI teams, the current position is that systematic pipeline processing of all data must be carried out and that an integrated easy-to-use, well tested and distributable ‘Data Processing’ (DP) ‘Interactive Analysis’ (IA) system, as an extension of the ‘Herschel Common Science System’ (HCSS), will be made available to the community.

In particular, the DP system shall provide tools to interactively reduce the data and a framework to automatically generate scientific data products. These data products will be VO compliant and be used to populate the archive making it directly usable for science by the wider community. In addition, quality data for each observation must be generated to support archive users in the assessment of a scientific product and to guide them in the level of interactive analysis that is required for its scientific publication. To ensure consistency, the system that automatically generates the data products should be a subset of the IA system.

Experience from previous missions shows that there may be long delays before the know-how and the data processing tools available at the instrument centres are available to the general community. This situation can be drastically improved by implementing the ‘Instrument Calibration’ and ‘Trend Analysis’ systems as part of the general DP system. If all tools for data reduction and analysis are implemented in the same environment, the transition for their distribution to the general astronomer will be easier, quicker, and smoother. An important additional advantage is that the system will be better tested and will be more robust when it is distributed to the community, because it has been extensively used by the instrument specialist and calibration scientists already from the instrument tests in the laboratory. An important implication of this approach is that the software development must be front loaded.

A fundamental aspect of the *Herschel* data processing is the intention that the IA package shall be distributed free of charge to the astronomical community. This implies that the system must be easily installed and well documented, it must be portable to run on common computer platforms, and must be license free. Since the astronomer will perceive and use *Herschel* as an observatory, commonality across the three instruments is an important asset. In particular, commonality is expected in the general interactive analysis framework, in the ‘look and feel’ of the user interface, in the scripting language, in non-instrument specific data analysis tools, and in the structure and definition of the data products. Commonality is also fundamental to share and optimise the use of the available resources, to simplify maintenance, and to enable the provision of the best possible user support by the HSC.

The *Herschel* DP system shall not be considered in isolation, but in the context of other archives and data analysis tools available to the astronomical community. As mentioned, final *Herschel* data products must be VO compliant. The system must also provide hooks to allow the user to use other data analysis packages, i.e. it shall provide the means to export data out of the system at various processing stages. The incorporation of external packages in the Herschel DP system cannot be ruled out, but the main requirements of the system in terms of portability, license free or data reduction history traceability should not be violated.

An implementation plan has been drawn up, based not only on current *Herschel* knowledge but also on previous experience within ESA and the instrument teams on developing IA systems. Development will be carried out in a similar manner to the successful HCSS activity and will be front-loaded so that the system can be extensively used by instrument specialists during instrument development. This will ensure that a robust system is available for general users by the end of the performance verification phase.

5.6 Data rights policy

The data rights policy gives the data owners a certain proprietary time, and after this time has elapsed the entire scientific community has equal access to the data, including any generated products.

The original (SMP 1997) scheme was criticised e.g. by members of the AWG as overly complicated, and that the length of the proprietary times should be reduced to optimise the scientific return of the *Herschel* mission. In the spirit of the overall goal of maximising scientific return and impact of the *Herschel* mission the proprietary times have been reduced:

- All observations (GT and OT, KP and non-KP) observed in the first year of the routine phase will have proprietary times of 12 months, while for all observations observed later, the proprietary time will be 6 months, with a simple ‘bridging scheme’. The proprietary time applies to each observation individually, counted from the day when the data are available to the initial data owner. However, a scheme will be put in place whereby the *Herschel* PS and the HOTAC Chair in consultation can grant additional proprietary time to certain large programmes, in order to prevent the release of improperly or inhomogeneously calibrated or processed data.

Neither the Herschel PS nor the HOTAC Chair may have a vested interest in the programme they are deciding over. Furthermore:

- All non-routine phase observations (i.e. observations taken during e.g. PV and Science Demonstration phases, and calibration and engineering observations throughout the mission) will have no proprietary time, with exception of observations being identical to existing GT programmes which can be ‘protected’ if the time used is ‘budgeted’ to the relevant GT programme.

5.7 Public Relations (PR)

ESA will be responsible for planning and carrying out Public Relations (PR) activities related to all aspects of the *Herschel* programme and the results thereof. A general outline of PR activities will be included in the AO in the form of a Public Relations Plan (PRP). The PRP and guidelines for its implementation will be part of the agreements between ESA and the selected PIs and MSs.

The active cooperation of all scientists involved in the *Herschel* mission is essential for the success of the related PR activities. For this purpose, the Project Scientist will initiate and identify opportunities for publishing project-related progress reports and scientific results. PR materials suitable for release to the public will be provided by the members of the HerschelST upon their own initiative or upon request from the PS at any time during the development, operational and post-operational phases of the mission. Indeed, as noted in appendix A, the PIs of the instrument/ICC consortia have the obligation to supply ESA with such materials. The exact nature of these materials, if not specified in the PR Plan, is to be defined at the appropriate time.

6 In-orbit mission phases

The overall *Herschel* in-orbit mission comprises a minimum of 3.5 years (as set by the cryostat lifetime requirement, cf. section 5.1), providing a 'routine science operations' phase duration of 3 years.

The instruments will be tested, characterised, and calibrated at instrument level before delivery, and verification of their proper functioning will be performed at system (satellite) level after integration, before and after environmental qualification. However, fully accurate scientific performance knowledge will only be obtained by in-orbit operation.

Below follow short descriptions of the objectives and activities performed in the various mission phases, leading up to the routine science operations phase. This section is meant to be for reference only and to provide additional background for section 5.

6.1 Launch and early operations phase

Herschel will be launched (together with *Planck*) by an Ariane 5 launcher into a transfer orbit towards a large Lissajous orbit around the L2 point. The final top-up of the *Herschel* superfluid liquid helium tank will take place 4 days before the launch. *Herschel* will separate from the launcher about half an hour after launch, followed by *Planck,* they will then proceed independently to their respective orbits.

The 'launch and early operations phase' (LEOP) will comprise approximately the first two weeks of the mission. The LEOP operations will be centred on the check-out of the spacecraft subsystems, the acquisition of the 'attitude control and measurement system' (ACMS) nominal mode, and the performing of transfer trajectory corrections for a proper orbit insertion around L2.

During LEOP the spacecraft will be transmitting only 'housekeeping' (HK), and the payload will not produce any 'telemetry' (TM). The LEOP is considered to last until the 3rd trajectory correction (scheduled for day 12) has been made, thereafter the transfer phase begins. During the transfer towards L2 the spacecraft commissioning followed by the spacecraft and science payload 'performance verification' (PV) phases will take place.

6.2 Spacecraft commissioning phase

The spacecraft commissioning (and performance verification) phase commences immediately after the end of the LEOP. It is to some extent intertwined with the science payload commissioning and PV phase, the boundary between the two phases is not absolute. Nominally, the (science payload) PV phase starts at the end of the (spacecraft) commissioning and PV phase.

The spacecraft commissioning includes a complete check-out of spacecraft functions and verification of all subsystems performance, ensuring that the satellite can be operated safely in ‘autonomy’ mode, and verification of the spacecraft/instrument interface. The spacecraft performance verification is seen as an extension of the spacecraft commissioning and addresses in particular ACMS and ACMS sensor calibration. The nominal duration of this phase is 2 weeks, the cumulative time since launch at the end is thus 4 weeks.

6.3 Science payload performance verification phase

The instrument (commissioning and) performance verification (PV) phase nominally commences after the conclusion of that of the spacecraft. However, in practice they will to some extent overlap in time.

6.3.1 Instrument commissioning

The instrument commissioning includes initial switch-on and functional check-out. During check-out, a subset of the test procedures used in ground tests will be repeated to confirm that the instruments have survived the launch.

Instrument HK parameters will be monitored by the MOC and the ‘Instrument Control Centre’ (ICC) teams co-located at the MOC will analyse the data in order to establish the status of their instruments. The instrument operations teams at the corresponding ICCs will perform further detailed analysis of these data. Instrument check-out shall verify that the basic functions required to support science operations are available.

Instrument commissioning and check-out does not require a specific target or pointing, in fact it does not even require the cryostat lid to be open. The nominal duration of this phase is 2 weeks, the cumulative time since launch at the end is thus 6 weeks, which corresponds to when the telescope temperature will be approaching its operational temperature and the cryostat cover can be opened.

6.3.2 Instrument performance verification

The instrument performance verification includes all activities necessary to validate and/or optimise instrument operational and calibration parameters so that the identified instrument operating ‘modes’ (offered to the users in the form of AOTs) can be used for scheduling ‘real’ observations. In particular the PV phase includes:

- Instrument performance determination and calibration.
- Instrument focal plane geometry calibration.
- ACMS to instrument calibrations
- Verification/optimization of instrument operations including the verification and tuning of the AOTs and associated instrument command sequences.

Due to the complexity of the instruments this phase will be considerably longer than the preceding ones. It will be carried out according to an instrument PV plan generated by the HSC with participation of the instrument teams.

The objective is that at the end of the PV phase all spacecraft and instrument nominal configurations have been established and all tunable spacecraft and instrument parameters have been set to their optimal operating values. Thus, at the end of the PV phase all instrument AOTs should be scientifically validated and ready to be used for the routine scheduling of observations.

In the real world unexpected problems/issues will probably occur, but all planning and preparation should be directed towards obtaining full PV completion. It is clear that the telescope temperature will be somewhat elevated and slowly decreasing throughout this phase, and the sky accessibility will be somewhat more restricted compared to around L2 (larger angle between Earth and Sun), and depending on the exact launch date the observability of various calibration sources will vary.

After the initial PV phase described above periodic calibrations/re-calibrations of both spacecraft and instruments are expected to be required during the routine phase. The extent and frequency of these operations will be established in the course of the PV phase. The corresponding calibration operations will be carried out as normal routine phase operations thereafter.

A first determination of the remaining helium mass in the main tank is planned to take place. The nominal duration of this phase is 2 months, the cumulative time since launch at the end is thus about 3.5 months.

6.4 Science demonstration phase

Assuming that the PV phase has been successfully completed the operation of *Herschel* should now be ‘routine phase’ like. The objective of the science demonstration phase is threefold:

- There is a need to demonstrate to (potential) observers in the astronomical community what the actual scientific capabilities of the observatory are; i.e. demonstrate what *Herschel* can do, and also state what it cannot. In this sense this phase can be seen as the ‘crowning’ of the PV phase activities.
- Conversely, a second objective of the science demonstration phase is to learn what we can learn about the universe from observations performed successfully from a technical point of view; thus to demonstrate that identified science objectives can be addressed with the actual performance of the observatory.
- This phase was originally motivated and introduced by a need to produce ‘pretty pictures’ for communications purposes, which remains one of the objectives.

A very important activity connected to this phase is the organisation of a workshop. In this workshop the actual performance of *Herschel* will be demonstrated and explained, enabling already selected observations to be optimised before being scheduled in the routine phase. In addition, the information for proposing can be updated to reflect actual - rather than predicted - performance ahead of the issue the OT part of the ‘Cycle 1’ AO (cf. section 5.4).

The nominal duration of this phase is 2.5 months (there is a trade-off with the duration of the PV phase), the cumulative time since launch at the end is thus about 6 months - the foreseen start of the routine science operations phase.

6.5 Early failure protection observations

It is foreseen to identify a limited set of observations that every effort should be made to execute in the event that the lifetime of the mission for some unforeseen reason is much less than expected. These predefined observations would then be scheduled upfront in order to provide the maximum science return given the circumstances.

Such a scenario could be due to a technical problem of some sort, e.g. a leak or an unwanted thermal conductance. Depending on the severity of the problem, most likely only a limited PV phase would be executed restricted to dealing with the instrument modes necessary to execute the observations identified for this phase.

6.6 Routine science operations phase

The routine science operations phase will commence after the conclusion of the science demonstration phase. Initially, the observing schedule will be entirely dominated by ‘Key Project’ (GT and OT) and GT programmes.

The programmes scheduled early should be those that most likely will require follow-up *Herschel* observations, but it is also of importance that a number of smaller regular GT observation programmes involving the community support staff get observed so that these people get ‘trained on the job’. If necessary observations that allow validation/optimization of remaining non-validated AOTs and improved calibration also warrant early scheduling.

The nominal duration of this phase is 3 years, the cumulative time since launch at the end is thus 3.5 years, which is the specified cryostat lifetime. Should spacecraft and other constraints allow, the duration of this phase will be extended for as long as is possible; also the durations mentioned of all other phases are subject to optimization.

Appendix A: Announcement of Opportunity (AO)

A.1 Selection procedure

Proposals for instrument/ICC PIs and MSs will be examined by an evaluation committee appointed by ESA's Director of Scientific Programmes on the advice of the Astronomy Working Group (AWG). The ESA FIRST Project will assess the instrument/ICC proposals against technical, managerial, programmatic, and financial criteria, to assist the evaluation committee in the selection of proposals. Attention will be paid to establish an efficient and effective management scheme of the selected PI teams and their contractors. The financial criteria will include both the assurance of adequate funding for the proposal and the impact upon ESA on accepting that proposal. After taking into account all these aspects, the Project will put forward a preliminary science payload proposal, possibly with options, for consideration by the appointed evaluation committee. Both the scientific and technical assessment processes may include meetings with the proposers individually and/or collectively to clarify details and to discuss areas of overlap and complementarity. During and as a result of these meetings, the proposals may be modified in order to optimise the instrumentation to satisfy the global needs of the mission. In parallel, negotiations with funding agencies will be conducted and the management scheme will be reviewed.

At the end of the evaluation phase, and after confirmation of the funding and endorsement by the relevant national authorities, the evaluation committee will recommend both a final payload complement and a data processing strategy to the advisory bodies of ESA. Based on the advice of the AWG and the Space Science Advisory Committee (SSAC), a recommendation will be presented by the Executive to the SPC for approval. The selected proposals will be announced following approval by the ESA SPC. Following selection, ESA will confirm participation of instrument/ICC PIs (and their possible Co-PIs and Co-Is) and MSs. The schedule for proposal evaluation and selection is shown in table 2, section 4.2.

A.2 Evaluation criteria and responsibilities of instrument/ICC PI consortia

A.2.1 Responsibilities

The proposals for the FIRST instruments/ICCs shall be made bearing in mind the scientific and operational objectives of the FIRST programme and the current programme definition and constraints. The instrument complement will be optimised to accomplish the overall scientific aims of the mission. As a result, proposals may need to be amended after submission, in joint discussions between ESA and the proposer(s). The baseline proposed instruments must comply with the technical requirements contained in the AO documents. However, if proposers feel that a greatly improved scientific return may be obtained with a mature and proven instrument concept by relaxing one or more of these constraints, they may identify this as an option in their proposal, justifying it in the scientific section and explaining it in the technical section. The PI shall establish an efficient management scheme especially in the case where many institutes are providing sub-assemblies, sub-systems, or tasks. Details of the management structure will be agreed after selection through the establishment of the Instrument Implementation Agreement and the Instrument Interface Documents.

The proposal must demonstrate that the PI has adequate control over all aspects of the programme, including direct access to adequate financial resources, and to technical and human resources through his management structure, so that his/her responsibilities can be met. Principal Investigators are at all times responsible for the funding arrangements of the instruments, the ICCs, and the management thereof. In this context, use of ESA facilities - other than those facilities associated with spacecraft assembly, integration and verification - by investigators will be on a cost reimbursement basis.

The responsibilities shall include, but are not necessarily limited to, the following:

Management

- Take full responsibility for the instrument and data processing programmes at all times and retain full authority within the consortium over all aspects related to procurement and execution of the programmes. In this context the PI shall be able to make commitments and decisions on behalf of all other participants in the consortium.
- Establish an efficient and effective managerial scheme which will be valid for all aspects of the instrument and data processing programmes.
- Define the role and responsibilities of the Co-Primary Investigator (Co-PI).
- Define the role and responsibilities of each Co-Investigator (Co-I).
- Identify (by name) key team members responsible for science management, technical management, technical interfacing, data processing management, and operational management.
- Organise the effort, assign tasks and guide other members of the team of investigators.
- Provide the formal managerial interface of the instrument/ICC to the ESA Project Office and support ESA management requirements (e.g. status reports, progress reviews, programme reviews, change procedures, product assurance etc.) as defined in the IID.

Scientific

- Attend meetings of the FST and supporting groups as appropriate, to report on the development of the instrument and data processing programmes, and to take a full and active part in the work of the FST.
- Ensure adequate calibration analysis of all parts of the instrument both on ground and also in orbit.
- Support the FSC in the definition of the science operations.
- Participate in the definition of the observing plan.
- Exploit the scientific results of the mission.

- Support ESA on Public Relations activities related to FIRST, in particular by providing materials appropriate for release to the press or participation in ESA media events on request from the PS, in accordance with the Public Relations Plan.

Instrument Hardware

- Define the functional requirements of the instrument and its ancillary equipment (e.g. ground support equipment).
- Ensure the development, construction, testing and delivery of the instrument. This shall be in accordance with the standards, technical and programmatic requirements outlined in the AO including its Annexes and subsequently reflected in the approved IID.
- Ensure adequate test and calibration of all parts of the instrument both on ground and in orbit.
- Ensure that the design and construction of the instrumentation, and its development test and calibration programmes are appropriate to the objectives and lifetime of the mission, and reflect properly the environmental and interface constraints under which the instrumentation must operate. It is essential from technical, programmatic and cost viewpoints that a representative example of the flight instruments be developed, tested, and calibrated early in the programme to demonstrate their scientific performance, their flight worthiness from an engineering viewpoint and their ability to provide a valid scientific return for the lifetime of the mission. Only then will the commitment be taken by ESA to fly the instruments.
- Ensure that all required hardware for the data processing activities is available within the scheduled times defined in the IID.
- Ensure that all procured hardware is compliant with ESA requirements as defined in the IID, through participation in technical working groups and control boards as requested (e.g. cleanliness control board) and to ensure that the hardware allows system level performance compatibility to be maintained.
- Provide overall documentation during the project as defined in the IID.

Instrument Software

- Ensure the development, testing, validation, and documentation of all instrument specific software (e.g. necessary for the control, monitoring, testing, simulation, operation, calibration, and data reduction/analysis etc.) in accordance with procedures and schedules as defined in the IID.
- Ensure the delivery as required of such instrument specific software and its documentation including user manuals to ESOC in accordance with procedures and schedules as defined in the IID.
- Support the instrument specific software integration and operation activities at the MOC, in particular during payload commissioning phases.
- Ensure the development, testing, validation, documentation and delivery of on-board software, and software required during instrument system level tests in the real-time or off-line mode including auxiliary software (instrument EGSE and interfaces) as defined in the IID.
- Ensure the development, testing, validation, and documentation of software required both for daily and long-term data processing activities.

- Maintain and update all software for the duration of the mission including all data processing activities and a post-operations (archiving) phase.

ICC Hardware

- Define the functional requirements of the ICC computers and its main and peripheral units (processing units, terminals, data storage devices and media, output devices etc.).
- Ensure that all data processing and analysis devices including storage devices/media and output devices that are required for the full functionality of the ICC are available within the times scheduled.
- Ensure that the functionality of the ICC is appropriate to the objectives and lifetime of the mission, and reflects properly the interface constraints under which the ICC must operate.
- Provide overall documentation during the project as defined.

ICC Software

- Ensure the development, testing, validation, and documentation of all ICC specific software in accordance with procedures and schedules as defined, and with the Ground Segment Interface Document (GSID).
- Ensure that all software (including instrument specific software provided by instrument teams) is tested and integrated into the ICC data analysis system.
- Ensure full operation of all software tasks.
- Ensure that all created software is maintained, updated, re-validated, and well documented.
- Provide instrument teams (on their request) with off-line raw data to allow study and analysis of their instrument performance.

Product Assurance

- Provide product assurance functions which are compliant with the requirements of the Product Assurance Requirements Document (PARD).

Operations

Operational phases include pre-launch activities (e.g. instrument software design and development, instrument calibrations), the actual operational phase and post-operational phases. The PI will be responsible to:

- Support all instrument operational phases by providing the necessary hardware, software, information (technical data), manpower and/or expertise (training) to the MOC. In particular, the PI must support pre-launch instrument operations (e.g. instrument calibration analysis and simulation), the in-orbit operational phase, and the post-operational phase, by providing the necessary functional support, including resources and manpower of the ICC. The level of support shall be defined and agreed with the ESA Project Office.
- Support operations through his expertise including resolution of anomalies and malfunctions of the instrument including recalibrations etc. as required.

- Recognise during all operational phases the occurrence of transient and/or anomalous events and inform the Project Scientist and the FST.
- Support the archiving phase.

Financial

- Ensure (through his Co-PI and Co-Is, if necessary) that adequate funding is available at the required time(s) for all aspects of the instrument and its support, and for the development and operation of the ICC.

Relation with Scientific Users Community

- Make the scientific data processing and other software available to the science community through FINDAS in accordance with agreed procedures and schedules.

A.2.2 Evaluation criteria

The selection criteria for individual proposals will include the following (not in order of importance):

- Merit of specific scientific objectives of proposed instrument.
- Scientific compatibility with global mission objectives of FIRST.
- Ability of proposed instrumentation to satisfy its scientific objectives.
- Technical feasibility of proposed instrumentation.
- Reliability and space qualification of proposed instrumentation (especially previous space heritage of detectors and other sub-systems).
- Development status of proposed instrumentation.
- Technical compatibility with available spacecraft resources and mission constraints.
- Operational constraints and complexity.
- Ability of proposed data processing concept to satisfy the operational and scientific objectives of the mission.
- Adequacy of proposed computational hardware configuration.
- Competence and experience of the team in all relevant areas (e.g. scientific, space technology, proposed techniques, software development and technology, numerical analysis etc.).
- Adequacy of proposed management scheme (including organigramme, project manager(s), roles of Co-PI, Co-Is etc.) to ensure a timely execution of instrument and data processing structure development, and associated tasks including post launch support.
- Adequacy of resources specifically assigned to interfacing to the telescope, the other selected instruments, and the spacecraft.
- Adequacy of human resources and institutional support to ensure a timely execution of instrument and data processing structure development, and associated tasks.

- Previous experience of key people (PI, Technical/Engineering and ICC Managers) in managing a space instrumentation programme, in scientific operations and large data processing programmes.
- Credibility of costing of proposed development programme.
- Compliance with all applicable management, reporting and product assurance requirements and standards.
- Financial impact upon ESA of proposed instrumentation.
- Assurance of adequate funding for proposed instrumentation.
- Willingness to comply with ESA's policy in regard to Public Relations activities as defined in this Science Management Plan, and in particular acceptance of and adherence to the Public Relations Plan.

For the overall integrated complement of the payload for FIRST, the selection criteria will include:

- Results of the evaluation of the individual proposals on the basis of the evaluation criteria listed above.
- Overall scientific merit of the complete payload with respect to meeting the FIRST scientific objectives.
- Experience of the PI(s), their e.g. technical and ICC managers, and their teams.
- Technical compatibility with available spacecraft resources and mission constraints.
- Compatibility with programme constraints.
- Assurance of adequate funding.
- Compliance with the PR plan.

A.2.3 Agreements with ESA

After selection, an Instrument Interface Document (IID) will be established for each instrument. A draft IID (parts A and B) will be contained in the AO package. This IID defines the FIRST technical and programmatic requirements (including management and control procedures), specifies in detail the interface information applicable to each instrument and specifies the planning applicable to each instrument. The IID becomes the formal interface control document and formal reference for all progress reporting, and it shall be placed under formal configuration and change control once agreed and signed off by the parties involved. Adherence to the PR plan is also part of the formal agreement with ESA.

A.2.4 Monitoring of development/performance

ESA will monitor the progress of the design, development and verification of the scientific instruments and the implementation of the ICCs. The PIs will have to demonstrate to ESA in regular reports and during formal reviews compliance with the scientific mission goals, the spacecraft system constraints, the spacecraft interfaces and the programme schedule as defined in the mutually agreed Instrument Interface Document. The scientific performance will be monitored by the ESA Project Scientist who may draw on the support of the FST as a whole. The technical and programmatic compliance will be monitored by the ESA FIRST

Payload Manager.

A.3 Evaluation criteria and responsibilities of MSs

A.3.1 Responsibilities

The roles and tasks of the Mission Scientists (MS) have been described in section 4.4. Their formal responsibilities are given below. In general, the MSs are expected to:

- attend all meetings of the FST and to take a full and active part in its work, covering the tasks described in section 4.4,
- participate in the major reviews of the FIRST programme,
- establish and maintain close contact - through the Project Scientist - with the development of the FIRST programme,
- provide a report to the AWG, on a yearly basis, on the fulfilment of their appointed tasks.

A.3.2 Evaluation criteria

The Mission Scientist proposals will be evaluated and reviewed by the AWG with support from the Project and - where appropriate - by additional scientists. The SSAC will make recommendations to the ESA Executive. The ESA Director of Scientific Programmes will appoint the Mission Scientists for a fixed (renewable) period of 3 years. The selection procedure will be arranged to eliminate conflicts of interest.

The following criteria will be used in assessing the individual proposals:

- Full experience of proposer in one or more areas as particularly specified in section 4.4.
- Merit of proposed general contribution to FIRST.
- Stated availability of time.

Appendix B: Acronyms

ACMS	Attitude Control and Measurement System
AO	Announcement of Opportunity
AOT	Astronomical Observation Template
AWG	(ESA) Astronomy Working Group
BOL	Bolometer instrument (in FIRST model payload)
Co-I	Co-Investigator
Co-PI	Co-Principal Investigator
CS4	Cornerstone 4 (in Horizon 2000, i.e. FIRST)
DP	Data Processing (system)
D/Sci	(ESA) Director of Scientific Programmes
DT	Discretionary Time
DTCP	Daily TeleCommunication Period
ESA	European Space Agency
ESOC	(ESA) European Space Operations Centre
FGSAG	FIRST Ground Segment Advisory Group
FINDAS	FIRST Integrated Network Data and Archiving System
FIRST	Far Infra-Red and Submillimetre Telescope
FM	Flight Model
FOIRD	FIRST Operations Interface Requirements Document
FOM	FSC Operations Manager
FOT	FSC Operations Team
FOTAC	FIRST Observing Time Allocation Committee
FSC	FIRST Science Centre
FST	FIRST Science Team
GSID	Ground Segment Interface Document
GT	Guaranteed Time
HCSS	Herschel Common Science System
HerschelST	Herschel Science Team
HET	Heterodyne instrument (in FIRST model payload)
HK	HouseKeeping
HOTAC	Herschel Observing Time Allocation Committee
HOSS	Herschel Optical System Scientist
HSC	Herschel Science Centre

IA	Interactive Analysis
ICC	Instrument Control Centre
IIA	Instrument Implementation Agreement
IID	Instrument Interface Document
IRAS	InfraRed Astronomy Satellite
ISO	(ESA) Infrared Space Observatory
ITT	Invitation to Tender
KP	Key Project/Programme
L2	L2 Lagrangian point of the Earth-Sun System
LEOP	Launch and Early Operations Phase
MOC	Mission Operations Centre
MS	Mission Scientist
NASA	(US) National Aeronautics and Space Administration
OT	Open Time
PHOC	Photoconductor instrument (in FIRST model payload)
PI	Principal Investigator
PLM	Payload Module
PM	Project Manager
PR	Public Relations
PRP	Public Relations Plan
PS	Project Scientist
PST	Project Scientist Team
PV	Performance Verification
QM	Qualification Model
SAG	(FIRST) Science Advisory Group
SIRTF	(NASA) Space Infra-Red Telescope Facility
SIS	Superconductor-Insulator-Superconductor
SMP	Science Management Plan
SOFIA	(NASA/DARA) Stratospheric Observatory For Infrared Astronomy
SPC	(ESA) Science Programme Committee
SSAC	(ESA) Space Science Advisory Committee
SSD	(ESA) Space Science Department
SVM	Service Module
SWAS	(NASA) Submillimeter Wave Astronomy Satellite
TBC	To Be Confirmed
TBD	To Be Defined
TM	TeleMetry
ToO	Target of Opportunity
XMM	(ESA) X-ray Multi-Mirror observatory