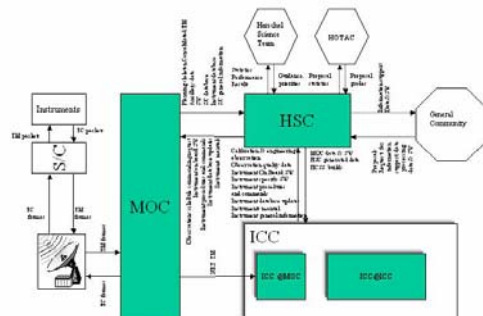
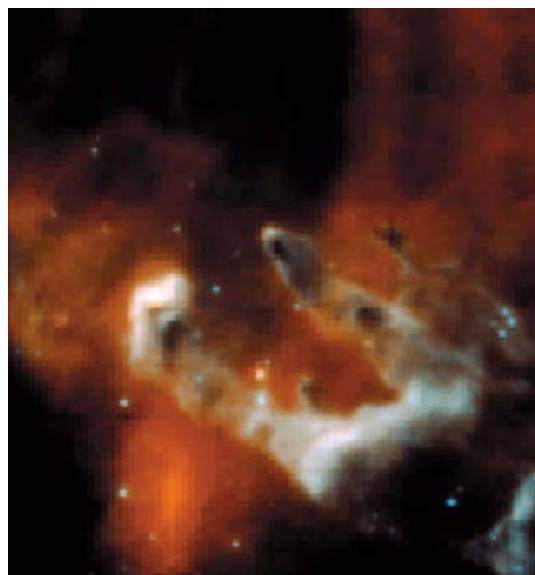





## HERSCHEL SPACE OBSERVATORY OBSERVING PROGRAMMES



Ref: Herschel/HSC/DOC/0369

Date: 1 June 2004

Issue: 1.1

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## DOCUMENT STATUS SHEET

<b>Issue</b>	<b>Revision</b>	<b>Date</b>	<b>Status and reason for change</b>
0	1	16 May 2003	Initial draft produced after the Key Projects meeting of a subset of the Herschel Science Team, held in ESTEC on 2 May 2003.
0	2	15 Jun 2003	More - but still not fully - complete draft for discussion in HerschelST#15.
0	3	8 Jan 2004	Draft for submission to the AWG. Based on discussions in HerschelST#15; presentation, discussion, and feedback from AWG#116; and subsequent discussions and agreements in HerschelST#16.
1	0	9 Jan 2004	Submitted to AWG for AWG#117.
1	1	1 Jun 2004	Comments by AWG#117 taken into account, as discussed and agreed in HerschelST#17 and #18, and loop closed with the AWG Chair and Secretary.




**HSC**

Herschel Space Observatory  
Observing Programmes


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# 1 INTRODUCTION

## 1.1 Scope of Document

The purpose of the present work is to document the elaboration performed on the (then *FIRST*) ‘Science Management Plan’ (SMP = [Ref.1]) regarding the *Herschel Space Observatory* observing programmes by the ‘Herschel Science Team’ (HerschelST), as agreed in its meeting #16 held on 13-14 October 2003 [Ref.2], and subsequently iterated with the ESA ‘Astronomy Working Group’ (AWG) as discussed below.

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 provides the ‘rules of the road’ regarding all aspects of the *Herschel* observing programmes, including types of observing programmes, guaranteed time, and data rights. In particular 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.

While the SMP sets the rules at the top level, it is not detailed enough to be used as the (sole) source for implementing these rules in practice. Elaboration, and sometimes interpretation, are necessary. On the subject of observing programmes the HerschelST has undertaken this task.

The activity started with an attempt to involve and consult with the future user community. ‘The Promise of the Herschel Space Observatory’ meeting, held in Toledo on 12-15 December 2000 [Ref.3], was organised for this purpose and attended by approximately 200 astronomers from all over the world - while in addition Roger Bonnet (ESA Director of Science at the time) renamed *FIRST* to *Herschel*. Based on the input generated by the Toledo meeting lively discussions in several meetings of the HerschelST followed. This led up to preliminary agreements in a dedicated meeting of a subset the HerschelST held on 2 May 2003 [Ref.4]. These agreements were endorsed, subject to various comments, by the full HerschelST in its subsequent meeting #15 held on 16-17 June 2003 [Ref.5]. The PS then presented the scheme to the AWG in its meeting #116 held on 9 October 2003 [Ref.6] which generated feedback from the AWG [Ref.7]. This feedback was discussed and addressed in HerschelST mtg#16, as documented in v1.0 of this document and presented in AWG mtg#117 [Ref.8] on 15 January 2004 which generated feedback [Ref.9]. This feedback was discussed in HerschelST#17 [Ref.10] and #18 [Ref.11], and after consultation with the AWG chair has led to the present version v1.1 of this document.

The present document has been written to fulfill the following tasks:

- to record the agreements regarding the *Herschel* observing programmes as reached by the Herschel Science Team,
- to serve as the source document for approval by the relevant ESA advisory body, the Astronomy Working Group,

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- after receiving approval, to in effect supersede the Science Management Plan in the areas addressed, and thus
- to serve as a source document for providing information about *Herschel* observing programmes to potential *Herschel* users and the scientific community in general.

In section 2 the agreed observing programme scheme is described, while in section 3 the in-orbit mission phases for carrying out the adopted observing programme are briefly described.

It should 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 which will be provided as part of the calls for observing proposals that will be issued as ‘Announcements of Opportunity’ (AOs).

It also has to be stated that, as outlined in this section, the scheme described is the result of a long process accommodating conflicting interests and the rules imposed by the SMP; by necessity therefore it is a compromise. The present scheme has, however, been found acceptable by all members of the HerschelST.


This document has been prepared and issued on behalf of the Herschel Science Team by the custodian, Göran Pilbratt, Herschel Project Scientist.

## 1.2 References


- Ref.1: FIRST Science Management Plan (SMP); ESA/SPC(97)22, rev.1 = FIRST/FSC/DOC/0019; available online at <http://www.rssd.esa.int/Herschel/Publ/1997/smp-spc2-clean.pdf>
- Ref.2: Herschel Science Team mtg#16 minutes; Herschel/HSC/MOM/0365
- Ref.3: Proc. Symposium ‘The Promise of the Herschel Space Observatory’; ESA SP-460; available online at [http://www.rssd.esa.int/Herschel/Publ/2001/toledo\\_confprocs.html](http://www.rssd.esa.int/Herschel/Publ/2001/toledo_confprocs.html)
- Ref.4: Herschel Science Team ‘Key Progs special’ mtg minutes; Herschel/HSC/MOM/0320
- Ref.5: Herschel Science Team mtg#15 minutes; Herschel/HSC/MOM/0333
- Ref.6: Herschel Project Scientist presentation to AWG#116
- Ref.7: Resolution by the AWG mtg#116 concerning Herschel observing programmes; ASTRO(2003)14
- Ref.8: Herschel Project Scientist presentation to AWG#117
- Ref.9: Resolution by the AWG mtg#117 concerning Herschel observing programmes; ASTRO(2004)4
- Ref.10: Herschel Science Team mtg#17 minutes; Herschel/HSC/MOM/0376
- Ref.11: Herschel Science Team mtg#18 minutes; Herschel/HSC/MOM/0402
- Ref.12: Herschel Science Implementation Requirements Document (SIRD); SCI-PT-03646

## 1.3 Acronyms

ACMS	Attitude Control and Measurement System
AO	Announcement of Opportunity
AOT	Astronomical Observation Template
AWG	(ESA) Astronomy Working Group
DT	Discretionary Time
DTCP	Daily TeleCommunication Period

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ESA	European Space Agency
FIRST	Far InfraRed and Submillimetre Telescope
GT	Guaranteed Time
HCSS	Herschel Common Science System
HerschelST	Herschel Science Team
HK	HouseKeeping
HOSS	Herschel Optical System Scientist
HOTAC	Herschel Observing Time Allocation Committee
HSC	Herschel Science Centre
ICC	Instrument Control Centre
IRAS	InfraRed Astronomical Satellite
ISO	Infrared Space Observatory
KP	Key Project
L2	2nd Lissajous point (in Earth-Sun system)
LEOP	Launch and Early Operations Phase
MOC	Mission Operations Centre
MS	Mission Scientist
OT	Open Time
PI	Principal Investigator
PR	Public Relations
PS	Project Scientist
PV	Performance Verification
SIRD	Science Implementation Requirements Document = [Ref.12]
SMP	(then FIRST) Science Management Plan = [Ref.1]
SPC	(ESA) Science Programme Committee
ToO	Target of Opportunity
TM	TeleMetry

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## 2 HERSCHEL OBSERVING PROGRAMMES

### 2.1 Introduction

To build, operate, and exploit a major facility such as *Herschel* is a substantial investment of public funds that provides for astronomical observing capabilities never before available to the scientific community. It follows that all aspects of the *Herschel* mission must be optimised to maximising the return on the investment within existing constraints.

The top level consideration is that all use of spacecraft 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 should be looked at from the point of view of ‘is this the most productive way of spending this amount of helium?’. This means making 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 this time in the best possible manner.

This document is restricted to dealing with the use of 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 the various players involved.


### 2.2 Herschel specific considerations

#### 2.2.1 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  $\mu\text{m}$  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 imposes very stringent timescales on

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the successful processing of *Herschel* data in a timely manner.

### 2.2.2 Introduction of ‘Key Projects’

The SMP (section 5.1.2) anticipates 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’. The SMP leaves open what is meant by a ‘substantial fraction’ but requires GT holders to spend at least 50% of their GT in KPs, and foresees collaborations between GT holders and the community at large to form. However, it is emphasized that it is not necessary to be a GT holder to propose and lead a KP.

The SMP further states that it ‘will be the responsibility of the PS, supported by the HerschelST, to devise and implement a suitable strategy’ for carrying out these programmes as well as follow-up observations ‘while at the same time optimising the whole observing programme’. The SMP anticipates these programmes to be scheduled early in the operational life of the mission to enable follow-up observations by *Herschel* itself within its lifetime limitation, leading to a ‘phased approach’.

The SMP foresees ‘a separate initial call’ for observing proposals for KPs at an early stage to be followed by a call for ‘normal’ observing programmes only when the KPs ‘have been established’.

### 2.2.3 Coordination of observing programs

The 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.

### 2.2.4 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 3.3) of the mission. Only observations using validated AOTs will be released for scheduling (cf. section 3.3.2).

### 2.2.5 Time available

*Herschel* will be operated in a large Lissajous orbit around the second Lagrangian 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, as is 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

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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 allowing for 14% engineering/calibration observation time, gives 939 schedulable days providing 19,723 schedulable hours.

## 2.3 Observing time

For the purpose of estimates it is useful to approximate the available *Herschel* schedulable observation time with ~1,000 days or ~20,000 hours. This time will be divided (SMP section 5.1.1) into two categories:

- 'Guaranteed Time' (GT), and
- 'Open Time' (OT) .

### 2.3.1 Guaranteed time


#### 2.3.1.1 Amount of guaranteed time

As prescribed in the SMP the GT 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.

#### 2.3.1.2 Sharing of guaranteed time

The GT is shared between the 'Principal Investigator' (PI) consortia, the 'Herschel Science Centre' (HSC), the 'Mission Scientists' (MSs), and the 'Herschel Optical System Scientist' (HOSS). The HOSS was not considered at the time of the SMP and her share of the observing time is not included in the 32% cited above; cf. below. The sharing of the GT is as follows:

- Each PI owns 30% of the GT. The SMP does not prescribe how the PI should manage this time within the consortium.
- The Herschel Science Centre owns 7% of the GT. The SMP does not prescribe how this time should be managed within the HSC.
- The five MSs combined own 3% of the GT. It is not explicitly stated in the SMP but tacitly assumed that they each own 1/5 of this time.
- The HOSS owns an amount of GT equal to that of a MS. However, this time does not come from the GT as defined in the SMP, but is taken from the 'Discretionary Time' (DT), cf. section 2.3.2.2 below.

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The SMP states that it would be ‘preferable’ for the GT to constitute a larger than average fraction of the total observing time early during the mission.

## 2.3.2 Open time

### 2.3.2.1 ‘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).

### 2.3.2.2 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 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.

### 2.3.2.3 Targets of Opportunity

The SMP considers two distinct 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 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.

## 2.4 Observing programmes and awarding observing time

### 2.4.1 Generalities

The HerschelST has elaborated on the ‘rules of the road’ provided by the SMP, and has agreed on a scheme which is consistent with these rules, interpreted as recorded in the present document. As required by the SMP 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.

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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.

## 2.4.2 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.

## 2.4.3 ‘Key Project’ programmes

The concept of ‘Key Projects’ as foreseen in the SMP is regarded of very high importance by the HerschelST. The HerschelST has addressed the implementation of the KPs at length, and traded off different ways of implementing these. As required by the SMP there will be a separate initial call for KPs upfront ahead of the calls for the regular GT and OT programmes.

### 2.4.3.1 Definition of KPs

The KP concept was initially introduced to make sure that there was a mechanism to ensure that ‘unusually’ large programmes requiring a great deal of observing time could be proposed, selected, and observed. This need, pre-identified in the SMP 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.

### 2.4.3.2 Data reduction

Since the KPs will involve particularly large amounts of observing time, much of which 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:

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- 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.

In order to ensure that this happens, the HerschelST finds it appropriate and fair to make an additional demand (not discussed in the SMP) of the KP time owners related to data processing. The call for KPs should 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.

### 2.4.3.3 Awarding Key Project time

As required by the SMP the call for Key Projects 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.

Furthermore, the SMP requires GT owners to spend at least 50% of their GT on KPs. However, the SMP does not make a difference between the different GT owners, some of whom own only limited amounts of GT. In the interest of scientific efficiency the HerschelST has agreed that that the 50% rule should only apply to the major GT owners i.e. to each of the three PI consortia (who together own 90% of the GT). As a matter of illustration, if 60% of the total GT were to be used for KPs this would amount to 192 days. As discussed in section 2.2.2 the SMP expected 'a substantial fraction' of the total mission time to be used for KPs. The HerschelST assumes 40% of the OT (272 days) to be allocated to the OT KP AO.

The Cycle KP call is foreseen to be issued 2 years before the foreseen launch date (L-24 months). 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 2.4.7.

### 2.4.4 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 2.4.7.

### 2.4.5 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 about how 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. The second call, OT2,

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will be issued well into the in-orbit mission. For a timeline see section 2.4.7.

### 2.4.6 Illustration of possible time awarding per cycle

The time awarded in the three AO cycles described above are summarised below. 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 60% 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 the these, again this is for illustration only.

- Cycle KP with a duration of ~ 45% of the routine science operations period, or ~ 16 months.
  - GT 'Key Project' programmes: fraction  $f_{KP}$  (assumed 60%) of GT = 192 days
  - OT 'Key Project' programmes: 40% of OT = 272 days
- Cycle 1 with a duration of ~ 27% of the routine science operations period, or ~ 10 months.
  - GT1 programmes: max half of remaining GT = 0-64 days
  - OT1 programmes: 30% of OT = 204 days
- Cycle 2 with a duration of ~ 27% of the routine science operations period, or ~ 10 months.
  - GT2 programmes: remainder of GT = 64-128 days
  - OT2 programmes: 30% of OT = 204 days

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.


### 2.4.7 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 (L is the *Herschel* launch date):

- L - 24 months: Issue AO for 'Cycle KP' proposals
- L - 21 months: Submission deadline for GT KP proposals
- L - 18 months: Selection and announcement of GT KP programmes

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- L - 15 months: Submission deadline for OT KP proposals
- L - 12 months: Selection and announcement of OT KP programmes
- L - 12 months: Issue AO for 'Cycle 1' GT proposals
  - L - 9 months: Submission deadline for GT1 proposals
  - L - 6 months: Selection and announcement of GT1 programmes
- L: *Herschel* launch followed by in-orbit operations (cf. section 3)
- L + 5 months: Science demonstration workshop followed by optimisation 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 in the SMP, 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 2.2.4), the appearance of 'generic' ToOs (cf. section 2.3.2.3) etc.

The timeline is subject to optimisation 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 Catalogue.

## 2.5 Data products

It is pointed out in the SMP (section 5.2) that 'data products in the traditional sense' are neither generated nor delivered to the observers. The strategy adopted was to, through the HSC, offer observers the best and most up-to-date means and support required to generate the desired data products on their own.

The SMP charges the HSC with the responsibility of providing the observers with access to their data and to the necessary software for data processing. However, the provision of the software itself is the responsi-

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bility of the respective Instrument Control Centre (ICC) as laid down in [Ref.12] (= the SIRD) in the Announcement of Opportunity (AO) for the *Herschel* science payload.

The current plan is that the HSC, after ingestion of the raw telemetry from the MOC, will systematically run all data through a standard processing sequence ('pipeline') in order to ascertain the quality of the data, and to generate a starting point for further processing.

The SMP puts no formal obligation on the original data owner to process and publish his/her data, nor to put anything back into the archive. Clearly data owners are assumed (in their own interest) to plan at least to process and publish their data. However, for KPs the HerschelST considers it unacceptable that a large observing programme - most likely of great interest also for the general community e.g. for follow-up - could even run the risk of not being processed in a timely manner, hence the introduction of a special data processing selection criterion for awarding KP observing time (cf. section 2.4.3.2).

## 2.6 Data rights policy

The data rights policy adopted (SMP section 5.3) 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 proprietary time given in the SMP varied in the range 1-2 years depending on when in the mission the observation was performed.

The HerschelST agrees with comments provided, e.g. by members of the AWG, that the SMP scheme is overly complicated, and that the length of the proprietary time could reduce the scientific return of the *Herschel* mission. Consequently, in the spirit of the overall goal of maximising scientific return and impact of the *Herschel* mission the HerschelST has decided (all GT owners are represented in the HerschelST) that the proprietary time be reduced, basically halved [Ref.2]:


- 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. 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.

[Comment: This decision will need to be revisited for refinement; as it stands some observations will become public before others taken earlier, a 'bridging' scheme will be needed. Neither the Herschel PS nor the HOTAC Chair may have a vested interest in the programme they are deciding over.]

In addition it was decided that:

- 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 'budgetted' to the relevant GT programme.

[Comment: The details of the mechanism will have to be worked out.]

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### 3 IN-ORBIT MISSION PHASES

As discussed in section 2.2.5 the overall *Herschel* in-orbit mission comprises 3.5 years, 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 follows 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 2.

#### 3.1 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 checkout 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.

#### 3.2 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 verifi-

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cation of the spacecraft/instrument interface. The spacecraft performance verification is seen as an extension of the spacecraft commissioning 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.

### 3.3 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.

#### 3.3.1 Instrument commissioning

The instrument commissioning includes initial switch-on and functional checkout. During checkout, 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 team at the corresponding ICCs will perform further detailed analysis of these data. Instrument checkout shall verify that the basic functions required to support science operations are available.

Instrument commissioning and checkout 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.


#### 3.3.2 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/optimisation 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

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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.

### 3.4 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 2.4.7).

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.

### 3.5 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 prede-

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financed 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.

### 3.6 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 that these people get 'trained on the job'. If necessary observations that allow validation/optimisation 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.