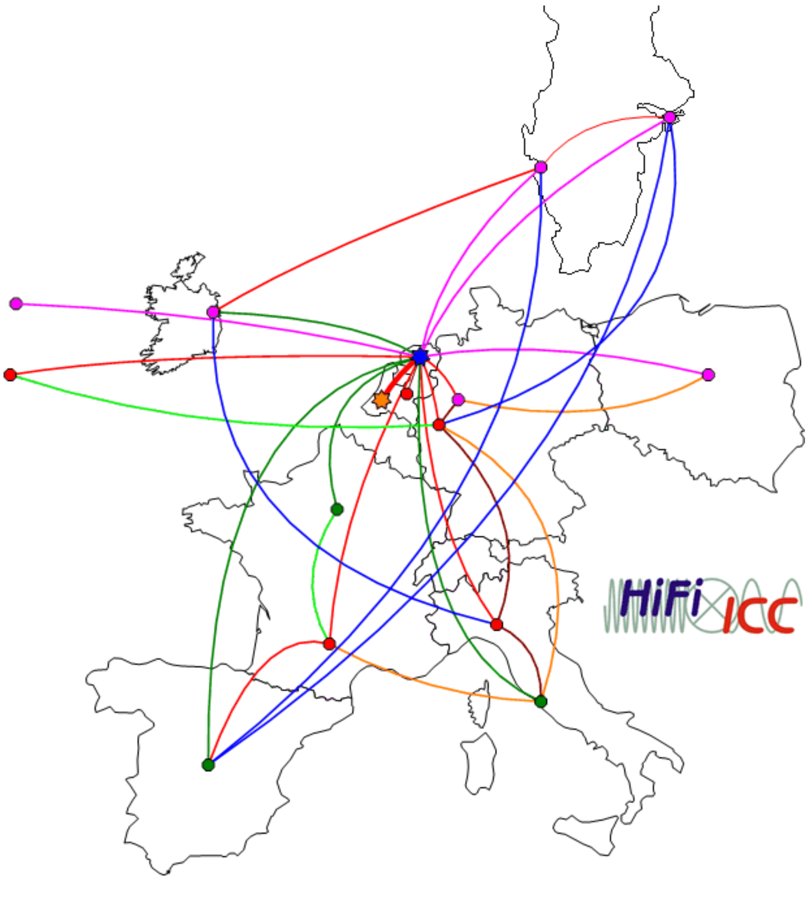
Science Implementation Plan for the *HIFI* ICC

Issue 1.2 of 21/12/04, by Peter Roelfsema



Abstract

This document contains the *HIFI* response to the HERSCHEL SIRD. It contains a basic description of the HIFI *ICC* and its systems together with the development and management plans.

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Approval page

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Revision history

Version	Date	Changes	Author
DRAFT 0.1	16/02/1998	DRAFT SIP for information with *HIFI* proposal	P. Roelfsema
DRAFT 0.2	12/10/1999	Update for *HIFI* ISVR	P. Roelfsema
DRAFT 0.3	8/11/1999	Update following comments by H. Aarts	P. Roelfsema
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DRAFT 0.96	2/4/2001	Added details in appendix B (resources from consortium members), C (work packages).and D (preliminary ICC development planning)	P. Roelfsema
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Issue 1.2	21/12/2004	Updates for GS review – schedule	P. Roelfsema

Applicable documents

Doc. ref.	Title
AD1	Herschel Science Management Plan
AD2	Herschel Science Implementation Requirements Document – SIRD (PT-03646)
AD3	Herschel Operations Interface Requirements Document - FOIRD (FP-ESC-RS-0001)
AD4	Herschel/PLANCK Ground Segment Interface Document – GSID (PT-04829)
AD5	Guide to applying the ESA Software Engineering Standards (PSS-05-0) to small Software Projects (BSSC-96-2)
AD6	Software Engineering & PA Standards for the HCSS (FIRST/FSC/DOC/0127)
AD7	HCSS Software PA plan (FIRST/FSC/DOC/0161)
AD8	HCSS Software Configuration Management Plan (FIRST/FSC/DOC/0166)

Reference Documents

Doc. ref.	Title
RD1	Herschel Ground Segment Operations Concept (PT-03056)
RD2	Herschel Operations Scenario Document (FIRST/FSC/DOC/0114)
RD3	Herschel Ground Segment Design Description (FIRST/FSC/DOC/0146)
RD4	Herschel Ground Segment Interface Requirements Document (FIRST/FSC/DOC/0117)
RD5	List of Interface Control Documents (FIRST/FSC/DOC/0150)
RD6	HCSS User Requirements Document (FIRST/FSC/DOC/0115)
RD7	HCSS Actor Descriptions (FIRST/FSC/DOC/0157)
RD8	HCSS Use-Cases (FIRST/FSC/DOC/0158)
RD9	HCSS Supplementary Specifications (FIRST/FSC/DOC/0159)
RD10	HIFI ICC product tree (HIFI-ICC-1999-011)
RD11	HIFI ICC Actor Descriptions (HIFI-ICC-TBD)
RD12	HIFI ICC Use-Cases (HIFI-ICC-2004-007)
RD13	HIFI ICC Supplementary Specifications (HIFI-ICC-TBD)
RD14	HIFI calibration plan (LRM-ENS/HIFI/PL/2000-001)
RD15	HIFI Performance Verification plan (HIFI-ICC-2004-009)
RD16	HIFI information via the WWW (HIFI-ICC-TBD)
RD17	Definition of HIFI ICC responsibilities (HIFI-ICC-2000-001)
RD18	HIFI ICC work packages (HIFI-ICC-2000-022)
RD19	HIFI ICC planning (HIFI-ICC-2001-001)
RD20	HIFI ICC hardware specification (HIFI-ICC-2001-002)
RD21	HIFI ICC communications matrix (HIFI-ICC-2001-003)
RD22	HCSS Software Project Management Plan (FIRST/FSC/DOC/0116)
RD23	HCSSMG Terms of Reference (FIRST/FSC/DOC/0143)
RD24	HGSSE Terms of Reference (FIRST/FSC/DOC/0145)
RD25	HSGSSG Terms of Reference
RD26	Herschel Ground Segment Ent-to-End Test Plan (TBD)
RD27	End User Requirements for HIFI Interactive Analysis (HIFI-ICC-2001-004)
RD28	HIFI standard data product specification (HIFI-ICC-2002-002)
RD29	HIFI observing modes description document (HIFI-ICC-2003-008)
RD30	HIFI observing modes definition document (HIFI-ICC-2003-004)
RD31	HIFI observing modes calibration document (HIFI-ICC-2003-010)
RD32	HIFI observing modes implementation document (HIFI-ICC-2003-009)
RD33	HSGSSG Terms of Reference

Glossary

AIPS^{++}	Astronomical Image Processing System (software)
AOT	Astronomical Observation Template
APID	Application Identifier
CA	Calibration Analysis (software)
CAISMI	Centro per l'astronomia infrarossa e lo studio del mezzo interstellare
CC	Configuration Control
CCE	Central Checkout Equipment
CCM	Core Class Model (of HCSS)
CDMS	Command and Data Management System
CESR	Centre d'Etude Spatiale des Rayonnements
CLASS	Astronomical Image Processing System (software)
CSDT	Common System Development Team
CUS	Common Uplink System
C/O	Check Out
EE	End to End (test)
EGSE	Electrical Ground Support Equipment
ESA	European Space Agency
FINDAS	FIRST Integrated Network Data Archive System
FITS	Flexible Image Transport System
FIRST	Far Infra Red and Sub-millimetre Telescope – now christened Herschel
HCSS	Herschel Common Science System
HK	House Keeping
HSC	Herschel Science Centre
FSODG	FIRST Science Operations Definitions Group
GST	Ground Segment Test
HCSSMG	Herschel Common Science System Management Group
HGSAG	Herschel Ground Segment Advisory Group
HGSSE	Herschel Ground Segment System Engineering (group)
HSGSSG	Herschel Science Ground Segment Steering Group (successor to HGSAG)
HIFI	Heterodyne Instrument for the Far Infrared
IA	Interactive Analysis (software)
ICC	Instrument Control Centre
ICD	Interface Control Document
IFSI	Istituto di Fisica dello Spazio Interplanetario
ILT	Instrument Level Test
IFOP	Instrument Flight Operations Procedures
IRAS	InfraRed Astronomical Satellite
ISO	Infrared Space Observatory
IST	Integrated System Test
JPL	Jet Propulsion Laboratory
KAI	Kapteyn Astronomical Institute
KOSMA	Das Kölner Observatorium für Submillimeter Astronomie
LRM/ENS	Laboratoire Radio Millimetrique/Ecole Normale Superieur
MIB	Mission Implementation Base
MOC	Mission Operations Centre
MPS	Mission Planning System
MPIfR	Max Planck Institut für Radioastronomie
OBSW	On Board SoftWare

ODBMS	Object Database Management System
OO	Object Oriented
OTAC	Observation Time Allocation Committee
PACS	Photoconductor Array Camera and Spectrometer (Herschel instrument)
PA/QA	Product Assurance/Quality Assurance
PHS	Proposal Handling System
QCP	Quality Control Pipeline
QLA	Quick Look Assessment (software)
PV	Performance Verification
RTA	Real Time Analysis (software)
RUG	Rijks Universiteit Groningen
SA	Science Analysis (software)
SCOS 2000	Spacecraft Operating System (software)
SET	System Engineering Team (HIFI)
SIP	Science Implementation Plan
SIRD	Science Implementation Requirements Document
SPIRE	Spectral and Photometric Imaging Receiver (Herschel instrument)
SPMP	Software Project Management Plan
SLT	Subsystem Level Test
SOL	Sequenced Observation List
SPG	Standard Product Generation (software)
SRON	Space Research Organisation of the Netherlands
TA	Trend Analysis (software)
TC	Tele Command
TM	Telemetry
TEI	Test Equipment Interface
UML	Unified Modelling Language
URD	User Requirements Document
WBS	Wide Band Spectrometer
WWW	World Wide Web
XML	Extendible Markup Language

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1 Introduction

1.1 Scope

In this document, '*The HIFI ICC Science Implementation Plan*', the development, implementation and operation of the *HIFI* Instrument Control Centre (ICC) are described. It aims to answer the requirements as given in the *'Herschel Science Implementation Requirements Document'* (SIRD, AD2) while following the general operational principles outlined in the *'Herschel Operations Scenario Document'* (RD2).

1.2 The framework of Herschel

Herschel will be a typical observatory type mission. A large number of relatively short observations – durations are expected typically of order one hour – will be carried out using the three different instruments. The observations will be parts of programmes proposed by astronomers from the general astronomical community which have been granted time following peer review. Satellite operations carried out by the teams forming the Herschel ground segment will have to ensure that all proposals are completed with all instruments working in optimal fashion.

1.2.1 The Herschel ground segment

The ICCs constitute three of the five major elements of the Herschel ground segment as described in the *'Herschel Ground Segment Operations Concept and Ground Segment Document*' (RD1). The Herschel ground segment concept is further refined in the *'Herschel Operations Scenario Document'* (RD2) and the *'Hershel Ground Segment Design Description'* (RD3). The other major elements are the Mission Operations Centre (MOC) and the Herschel Science Centre (HSC). For Herschel a novel distributed system for the ground segment is envisaged in which mission operations, science centre and instrument teams are not necessarily at the same location. In this concept the various groups access and transmit data and software through a distributed database system (the *Herschel Common Science System* – HCSS). Because of the distributed nature of Herschel operations the teams can be located where most of the knowledge and facilities appropriate for the task at hand are present. Figure 1 shows the different ground segment components and their interrelations.

1.2.2 *The HIFI* ICC

The *HIFI* ICC is responsible for all *HIFI* related operational issues: designing, planning and implementing *HIFI* engineering and calibration observations, instrument monitoring and calibration, developing and maintaining *HIFI* specific software and procedures, and supporting operations and observatory users. In the ground segment these ICC tasks require regular interactions with the HSC and MOC (see Figure 1 and section 3) for the mission planning and execution of calibration observations. Submission of such observations and retrieval of data is all carried out using the HCSS as a means of communication. Similar interactions occur with HSC and MOC for exchange of software through the HCSS. More details about the ground segment operations can be found in the following sections and in RD1.

2 Prerequisites and assumptions

For the ICC to function properly there are a number of prerequisites. These are described below. The most important prerequisite is the timely availability of the operations and archive system HCSS as it is a central element in the ICC system (see 4.6.1). A second important issue is the adherence to commonality as described in section 2.3.

2.1 Prerequisites

1. The Herschel Common Science system (or its functions) as described in RD3, RD6, RD7, RD8 and RD9 will be implemented according to the timeline as indicated in the HCSS SPMP (RD22).

2.2 General assumptions

1. Herschel is to be launched in 2007
2. Operations will be carried out on a roughly 24 hours basis. There is between 2 and 4 hours ground contact every 24 hours.
3. Operations will be carried out on the basis of a single instrument for a single (or for a few consecutive) Operational Day(s).
4. Early in the development phase high-speed communication links will be available between the ground segment elements as well as between the HIFI consortium institutes contributing to the ICC.
5. All instrument data, i.e. calibration data and science data alike, are accessible for ICC members for calibration use or when evaluating instrument behaviour.
6. SCOS 2000 will be used for RTA during operations and tests.

2.3 Commonality

There are a number of systems that are common (or have common features) to different Herschel instruments or ground segment elements. To decrease the total cost in creating these systems they should be developed jointly. Especially in the ICC software development area, many such possibilities exist.

As a baseline, the *HIFI* ICC will support common development wherever feasible within the constraints given by the consortium on resources and schedule.

2.3.1 ICC – HSC – MOC commonality areas

To date the following systems are considered for common design and/or implementation together with other ICCs, the HSC and/or the MOC:

1. The HCSS structure and facilities (section 4.6.1)
2. Data items to be handled by the HCSS
3. Interactive Analysis and QLA (section 4.6.3.1)
4. The Common Uplink System (section 4.6.2.1)
5. AOT translator (section 4.6.2.2)

For these areas of development the *HIFI* ICC will support the establishment of joint ICC-HSC task teams.

2.3.2 Instrument (hardware) commonality areas

Other areas for commonality with other instruments, related to but outside the scope of the ICC development are:

1. RTA (section 4.6.3.4)
2. A common instrument control philosophy and design
3. A common language and development environment for onboard software

The *HIFI* instrument team is responsible for pursuing these three subjects; the ICC will keep itself informed of developments in the areas.

2.4 Open issues

A number of issues with respect to *HIFI* ICC development and operations remain open at this time. They are addressed in the various sections, and are itemised here for clarity:

1. *HIFI* ICC responsibility and activities vis-à-vis quality control of observatory products
2. *HIFI* ICC responsibility and activities vis-à-vis key projects
3. Availability of EGSE and *HIFI* instrument model for e.g. OBSW tests during operations
4. Level of ESA support for *HIFI* ICC development

3 The Herschel Ground Segment

3.1 The overall operational concept

The Herschel operational concept is described extensively in the *'Herschel Operations Scenario Document'* (RD2). In this section the major elements of this concept are summarised.

In the Herschel ground segment (see Figure 1) the HSC manages the proposal database containing all observations to be executed during the Herschel mission. By monitoring progress of the various proposals and subsequently adjusting scheduling properties the HSC ensures that observations are scheduled such that the scientific aims of the mission are fulfilled. In day-to-day operations the HSC prepares a Sequenced Observation List of science and calibration observations to be conducted within the next scheduling period. A detailed observing schedule is then created by the MOC by interleaving these science observations with the necessary spacecraft operations. The final schedule is subsequently translated into satellite and instrument commands and up linked via the Herschel ground station.

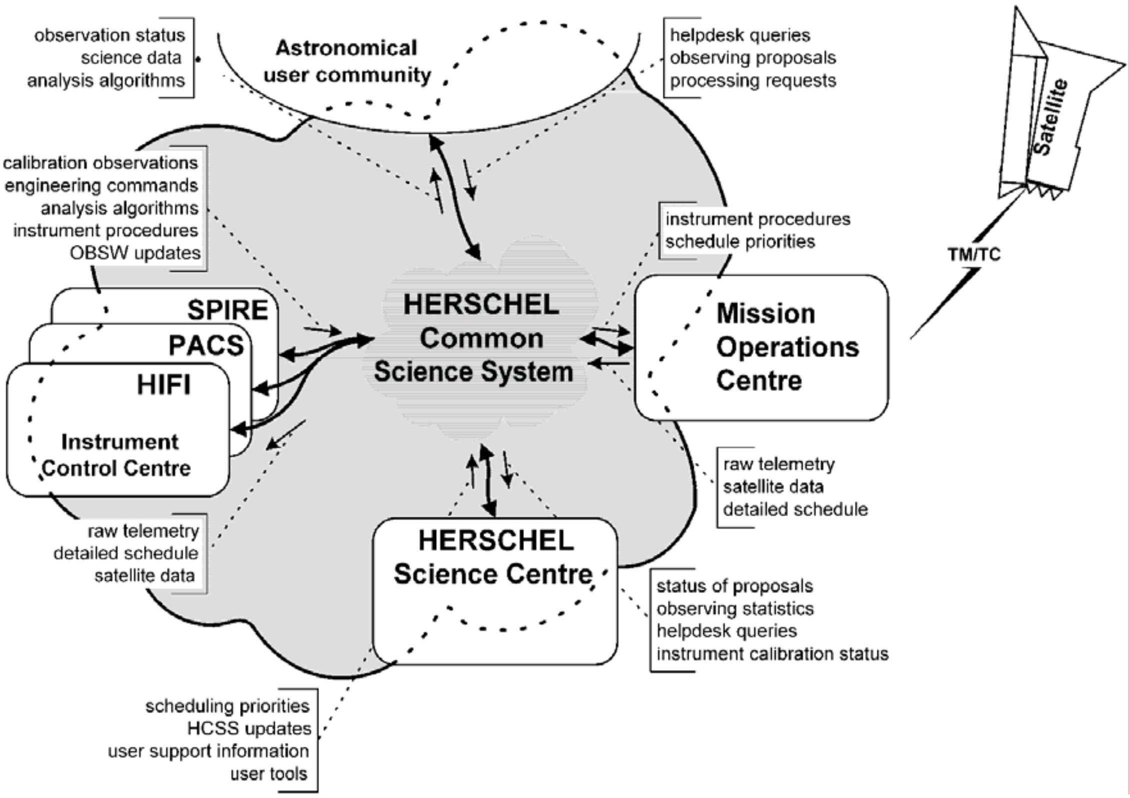

Figure 1. Overview of the Herschel ground segment.

The data stored in the onboard memory is down linked to the ground station and then transmitted to the MOC where it is stored for safekeeping. At the MOC the telemetry is inspected and analysed for possible malfunctions or abnormal operations. When such problems are found they are flagged and appropriate action is taken by the relevant team (ICC, HSC and/or MOC). All spacecraft and instrument telemetry is stored in the Herschel archive system (the HCSS) and thus it becomes accessible for the instrument and science teams for further analysis. After analysis of such a problem when needed the ICC submits (adjusted) operating procedures (e.g. AOT's,) and calibration observations for the following operational period.

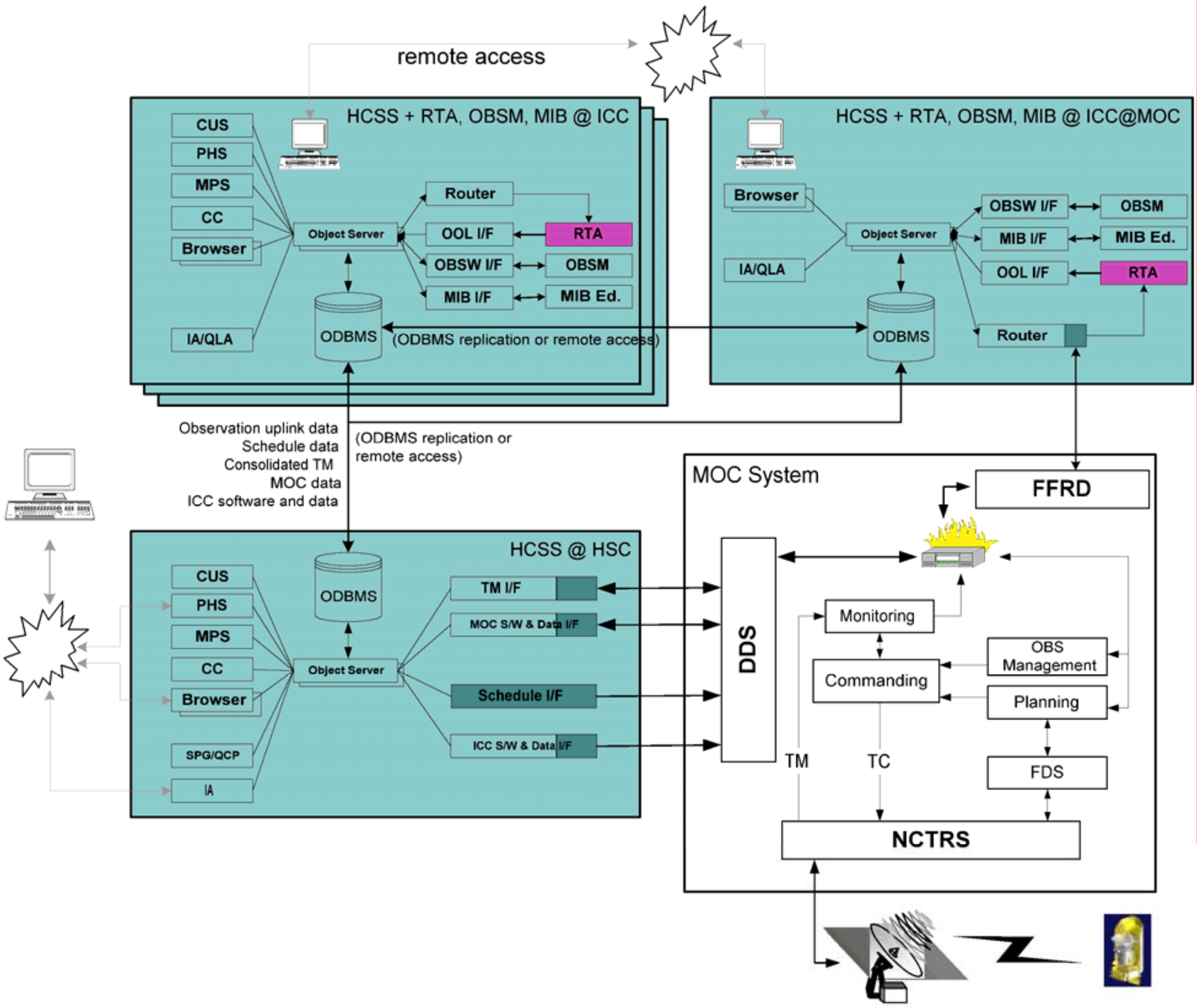

Figure 2. Overall design for the Herschel ground segment in operations (from RD3).

Following this ground segment concept the Herschel Ground Segment System Engineering group (HGSSE) has generated an overall system design *('Herschel ground segement design description'*, RD3). Figure 2 taken from this document shows which systems are expected to be in place for the operations phase of Herschel. Based on the overall system design, requirements on the different interfaces between the ground segment elements have been established (RD4). A dedicated ICD list (RD5) is used to track the different interface control documents pertaining to each of these interfaces. The *HIFI* ICC will be developed such that it is consistent with this design and the relevant interfaces. Where this leads to difficulties the overall system design and or the definition of the interfaces will have to be reviewed.

3.2 Mission phases; the ground segment development timeline

From instrument design through post operations different test and operational periods can be identified. To save on development cost and effort systems will be designed and implemented such that they facilitate smooth transitions between mission phases.

The three main phases are:

- Development.
  In this phase the ground segment and ICC systems are designed, implemented and tested. The development phase in principle ends with launch, however in practice, a number if ICC systems – notably Interactive Analysis and Standard Product Generation – are expected to be further developed after launch. This ICC development phase coincides for a large part with the instrument development phase, but does extend beyond instrument delivery. It includes various instrument tests (SLT, ILT, IST) and ground segment tests (EE).
- Operations.
  This is the phase between Launch and End-Of-Helium during which scientific observations are carried out. It includes instrument check out and performance verification.
- Post operations.
  This phase is geared towards harvesting the data. A large effort will be devoted to consolidating the mission results into some archiving facility, accessible to the astronomical community. The contribution of the instrument groups is expected to be largely in the area of improved calibration.

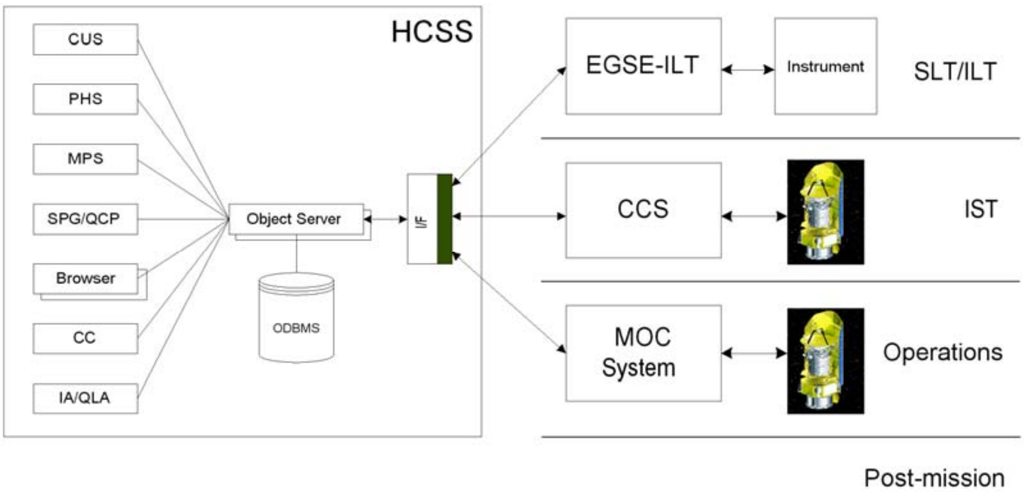

Figure 3: Herschel ground segment systems will be used through all mission phases.

3.2.1 Smooth transitions

Software systems and procedures will be designed such that they can be used in the early test phases as well as during operations (see also Figure 3). Firstly such re-use requires less development work and secondly this will allow ICC personnel to work early on with tools that will be used in the operations phase. A third advantage is that any problems with tools, procedures or even the instrument itself can be discovered early on in the development phase.

One consequence of wanting to design systems, early on, that are useable in all mission phases, is that the initial design will be somewhat more cumbersome, because, already at subsystem test level, operational constraints will have to be taken into account

4 The *HIFI* ICC

As indicated in previous sections the basic design of the *HIFI* ICC largely follows the descriptions given in the documents describing the overall Hershel ground segment (RD2 and RD3). In this section the refinements on this basic design necessary to also incorporate all the *HIFI* specific requirements are outlined. Also the path towards the final *HIFI* ICC implementation is described.

4.1 The main ICC tasks

The main tasks of an ICC are described in the SIRD (AD2, see also appendix E.1). Within the *HIFI* project it has been decide to slightly deviate from that list to better reflect the actual division of activities carried out by the 'instrument consortium' and the ICC proper (see RD17 for details). The most obvious deviation is that the development of the OBSW and the OBSW maintenance facility do not fall under the *HIFI* ICC responsibility.

The remaining tasks can roughly be grouped in three areas:

Managerial and conceptual; plans, documents, procedures

- Make management documents like SIP, WBS and PA/QA plans.
- Gather *HIFI* ICC requirements; ICC use cases, End User Requirements etc.
- Establish *HIFI* calibration plans[1].
- Define *HIFI* AOTs and make observers manual.
- Public outreach and PR

Activities

- Coordinate with HSC/ICC development teams.
- Support HSC with proposal evaluation.
- Provide instrument information to HSC and MOC[1].
- Monitor *HIFI* instrument development.
- Participate in *HIFI* tests and characterisation.
- Determine *HIFI* pre-flight calibration.
- Generate and verify scientific validation procedures.
- Support HSC with follow up on 'helpdesk' questions.
- Support HSC with Quality Control activities (TBC).

Software

- Design and implementation of *HIFI* specific CUS elements, the *HIFI* AOTs, and the *HIFI* time estimator,
- Design and implementation of Interactive Analysis and subsystems like QLA[1].
- Design and implementation of HCSS CCM jointly with HSC, ICCs and MOC,
- Design and implementation of ICC specific parts of the HCSS.
- Design and implementation of the *HIFI* instrument data simulator[1]
- Generate and verify test/calibration procedures[1].

[1] with contributions by the instrument team

Some responsibilities that according to the SIRD fall under the *HIFI* ICC have explicitly been taken over by the *HIFI* instrument team[2]:

- Write the instrument user manual and in flight operational procedures (IFOP)**Error! Bookmark not defined.**.
- Design and implementation of the OBSW and the OBSW maintenance facility.
- Design and implementation of RTA.
- Creation and populating the Mission Implementation Base (MIB, with editor)

These items are seen as deliveries to the ICC, and thus for all the ICC will be involved in the writing of the relevant use case descriptions or URDs.

A number of activities currently are not seen as tasks for the HIFI ICC, one merits explicit mentioning here to stress where the scope of the ICC ends:

- The ICC has no responsibility to support planning and analysis of key-projects

4.2 The basic HIFI ICC set up

4.2.1 A distributed operational ICC

The Herschel ground segment concept already calls for a distributed operational system. For *HIFI* the same applies for the development phase because of the large number of institutes taking part in the *HIFI* consortium (see Figure 4). During development, especially in the earlier phases, the *HIFI* ICC will be distributed over the same institutes that take the lead in the development of the main subsystems/organisational units; management, scientific calibration, focal plane subsystem, back end subsystems, local oscillator subsystem, high frequency unit and instrument control unit. In the development phase similar modes of operation shall be employed (also within the consortium) as envisaged during operations i.e. the HCSS (or HCSS pre-cursors) for data, document and information exchange.

For a successful development an ICC sub-group must consist of (at least several) persons working a significant fraction of their time on *HIFI* ICC issues. For all ICC personnel 50-100% availability must be aimed at, an availability of 20% of their time dedicated for ICC work is considered to be the minimum. If the group is sub-critical in the level of available resources it will not be an effective contributor to the ICC development, and thus such a group cannot be accepted as part of the ICC.

During operations the ICC will be in regular and close contact with other groups within the *HIFI* consortium as well as with ESA. Major decisions will be taken jointly with the original instrument builders. Minor instrument issues will regularly call for contact with the consortium. Software revisions, especially those of systems which are to be used by the general community (e.g. for processing of science data), will have to be verified by a larger community than the ICC itself and thus again the *HIFI* consortium will be asked for assistance. As such the ICC in operations is also very much a distributed organization.

[2] the *HIFI* instrument team here refers to the *HIFI* hardware project responsible for the actual building of the *HIFI* instrument. This team is *not* same as the 'instrument group' that is part of the operational ICC (see Figure 9). The ICC instrument group is a group of instrument specialists who actually work for the ICC.

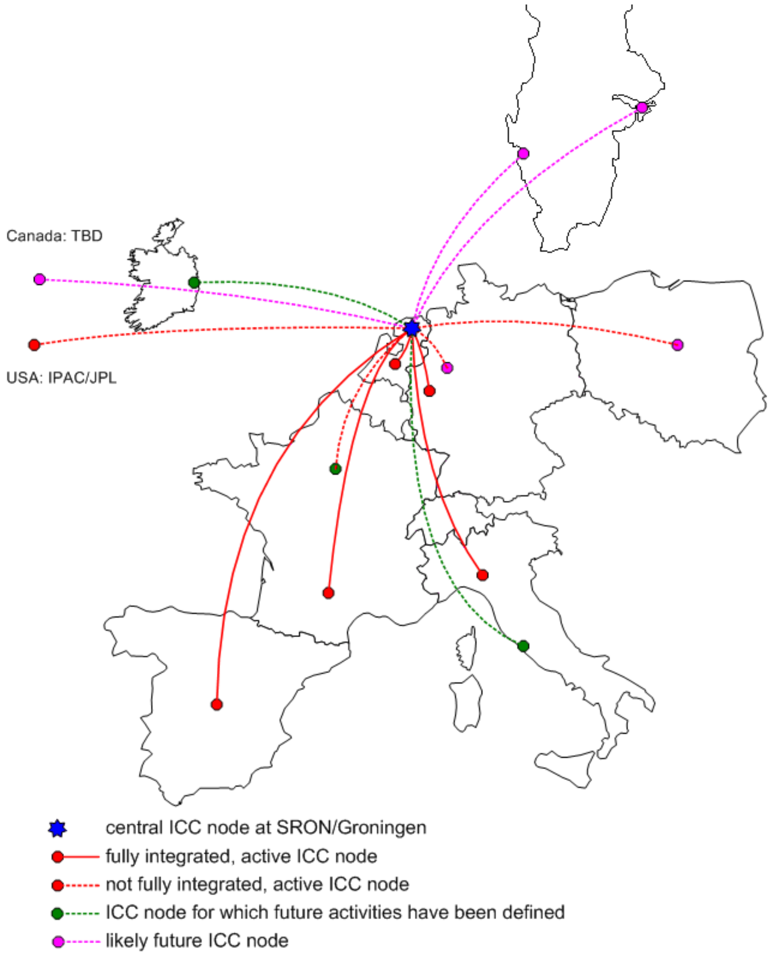

Figure 4. The nodes of the distributed *HIFI* ICC during the development phase

4.2.2 ICC work times

ICC personnel are expected to work only during normal office hours during most phases of the Herschel project: 8 hours per day, 5 days per week. Possibly during the (parts of) operations phase personnel will be asked to be available on call.

Only during the critical mission phases shift work will be introduced. For the CheckOut phase dedicated personnel will be assigned shifts to be able to cover all HIFI operations at all times. During the Performance Verification phase (PV) likely weekend shifts will be introduced, but night shifts are not expected to be required.

4.2.3 Baseline HIFI ICC environment

A typical node in the *HIFI* ICC development (and operational) network will need to provide at least a HCSS node and the appropriate workstations/PCs as required by the tasks assigned to the group.

As for the development environment a number of choices that have been made for HCSS development apply for ICC internal development as well;

- The *HIFI* ICC systems will be designed to be operated under the standard HCSS platform. Currently this is the Red Hat Linux operating system, other operating systems may be supported if the HCSS is also ported to these (at best effort).
- The *HIFI* ICC systems that are interacting with or are part of the HCSS will be implemented in Java and/or Jython
- The *HIFI* ICC systems will be developed using the TogetherJ UML tool

The current baseline development environment for the HIFI ICC development work is defined as listed in Table 1. This definition is largely driven by the common development of the HCSS jointly with HSC and the other ICCs. The details of the ICC hardware setup are specified in RD20.

Item	Version	Note
H/W platforms:		
Intel	Red Hat Linux ES	required for HCSS
Database systems:		
Versant	V6.0.5.3	required for storage of *HIFI* data and for HCSS database functionality development[3]
Development environment		
Java SDK	V1.4.2	required for HCSS
Jython		required for HCSS
Support tools		
TogetherJ	V6.1	For design work and documentation
Documentation standard	MS Word XP	required for all *HIFI* (ICC) documentation
Planning	MS Project 2000	

Table 1: *HIFI* ICC baseline development environment

4.2.4 ICC@MOC set-up

The ICC@MOC will be set up in a manner similar to a standard ICC node. The only peculiarity is that this node is located at the MOC and will have a direct telemetry feed from the MOC operational systems. Connection with the HSC and other ICC nodes will be provide through the public internet.

4.3 Flexibility; building for change

One of the essential qualities of all the *HIFI* ICC systems is flexibility; all the ICC procedures, tools, operational systems as well as the ICC personnel should be able to continuous adapt to the

[3] For the development of HCSS applications (e.g. IA applications) access to a Versant client at SRON will often be sufficient. However when significant amounts of data have to be analysed transferring these back and forth between the central SRON node and another ICC node the transfer overhead may be prohibitive for effective data analysis. In that case a local database, and thus a local Versant licence, will be required.

changes in the operational environment that will undoubtedly occur. Clearly the different mission phases (from test to post operations) all have their own peculiarities in terms of environment and set-up (see the relevant sections for more details). However it is to be expected that also the *HIFI* instrument itself and definitely our understanding of its characteristics will change behaviour as time goes by; the operational procedures and analysis tools will have to be adapted to accommodate such changes. This puts a strong requirement on all procedures and tools to be designed such that they *are* adaptable and that changes can be made on very short timescales – in emergency situations hours rather than days– without upsetting or even disabling other ICC systems. Clearly a highly modular design will facilitate such flexibility.

4.4 ICC work locations

There are four 'locations' or groups to be distinguished at which *HIFI* (ICC) personnel will be working with *HIFI* data.

4.4.1 ICC@ICC

The ICC proper that will be located at SRON during operations. In the development phase it will be distributed over several consortium institutes, headed by the SRON ICC group. The ICC proper will primarily analyse *HIFI* data as stored in HCSS using tools from Interactive Analysis and Calibration Analysis (see sections 4.6.3.1 and 4.6.3.5). When using RTA facilities (section 4.6.3.4) for the analysis, this will be done replaying telemetry from the HCSS through the dedicated RTA playback interface.

4.4.2 ICC@EGSE

This group encompasses the *HIFI* (ICC) personnel monitoring the instrument during tests in one of the *HIFI* consortium Labs. This group interacts directly with the instrument under controlled laboratory conditions and requires immediate feed back possibilities e.g. aborting or changing tests on the basis of e.g. live QLA output. Most, if not all, 'analysis' is done using RTA and QLA.

4.4.3 ICC@CCE

This group is defined as the *HIFI* (ICC TBD) personnel monitoring the instrument during IST at the prime contractor CCS. This is similar to ICC@EGSE, but now at ESA premises and largely under ESA control. They will have no direct instrument commanding capability, but will be able to analyse live telemetry and advice ESA on the progress of tests being executed.

4.4.4 ICC@MOC

The ICC personnel at the MOC during commissioning, early PV phase and for 'emergency' type situations during routine operations. Normally the interaction involves only read out of instrument (HK) parameters using RTA. Feedback, if any, would be given through pre-set procedures executed by MOC personnel at the request of instrument specialists.

4.5 The ICC tools: procedures

A large number of operational tasks of the ICCs will be executed following formal procedures. The ICC development team will identify the requirements for different procedures by analysing the tasks and interactions of the ICC. In the subsequent implementation phase the procedures will be detailed and documented.

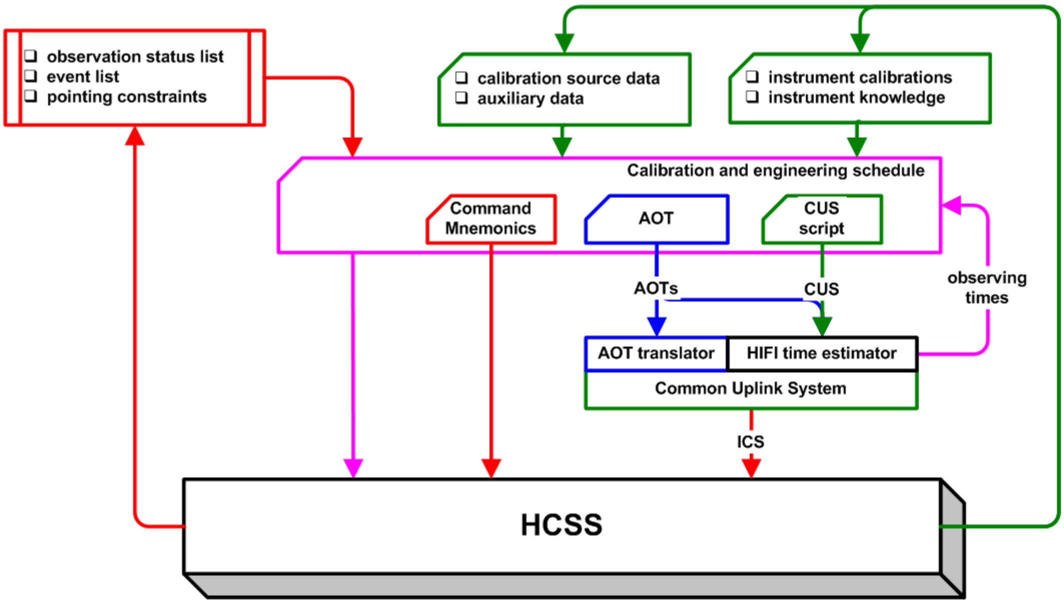

Figure 5: *HIFI* calibration planning data flow

As an example in Figure 5 the flow of information related to *HIFI* calibration measurement sequences is given. The various steps to go through, to plan and implement calibrations, to adjust the calibration strategy etc., will be put together in a series of use cases by the *HIFI* calibration group.

4.6 The ICC tools: software

For ICC work various types of uplink operational software such as an instrument and subsystem simulator, the CUS AOT translator, Common Uplink System and an observation time estimator are needed. For all aspects of inspecting and analysing *HIFI* data, software will have to be developed and maintained. For the downlink systems Interactive Analysis (IA) provides the environment and the basic analysis tools. IA will in actual fact consist of a collection of more or less separate analysis systems: Quick Look Assessment (QLA), Calibration Analysis (CA), Trend Analysis (TA), Standard Product Generation (SPG) and Science Analysis (SA). The Real Time Analysis system (RTA) will be based on SCOS2000.

All of these systems, uplink and downlink alike, will rely heavily on HCSS-provided services (e.g. for data storage and retrieval). The relation between these different systems is indicated in Figure 7 (uplink) and Figure 8 (downlink).

It should be noted that many of the uplink and down link components contain many functions that are common for all instruments onboard Herschel. Thus it will be cost effective to strive for a joint development of (parts of) these software systems (as stated in section 2.3).

All HIFI ICC tools shall be available to *all* nodes in the distributed ICC network. This implies that, firstly all ICC locations need to have a complete ICC software setup, and secondly, that *any* 'local' tools should be included in the general ICC library as soon as they are deemed ready for general ICC use by the developer.

4.6.1 The HCSS – relevant components for the *HIFI* ICC

The *Herschel Common Science System* (HCSS) provides data storage and the infrastructure to run all ground segment systems required by the *HIFI* ICC. A schematic indicating these facilities is shown in Figure 6. A number of the functions implemented as parts of the HCSS (PHS, MPS) are developed by the *Common System Development Team* (CSDT, see 4.12.7) and as such are not pure *HIFI* ICC development tasks. However the ICC will use these functions in various mission phases.

All information pertinent to *HIFI* will be stored in the HCSS. This means that documentation, data as well as software will follow the standard HCSS configuration control mechanism. Thus all this information will be traceable, and its change history will reflect all changes that have been made. The HCSS will be an essential element in the communication between the different groups within the ICC and the *HIFI* consortium (during the development as well as during the operations phase described below). Therefore design of *HIFI* specific data items, especially for items like telemetry packets and data frames that will be used throughout the development phase, must commence (very) early in the ICC development phase.

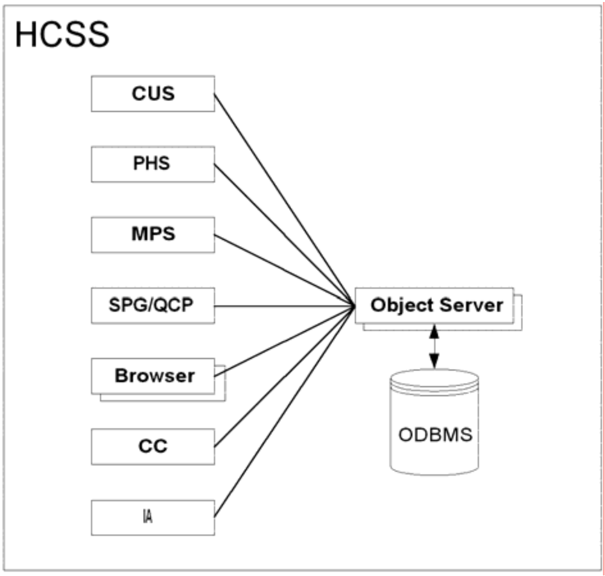

Figure 6. Schematic of an HCSS node and its subsystems.

The relevant HCSS work to be carried out by the *HIFI* ICC development group contains (at least) the following components:

- Definition of storage objects for *HIFI* data (science *and* housekeeping telemetry and SPG data products)
- Definition of storage objects for *HIFI* calibration and characterisation parameters
- Definition of instrument commanding objects for control of the *HIFI* instrument
- Definition of *HIFI* documentation objects
- Definition of ICC interaction objects (action lists, meeting lists etc)

4.6.1.1 The HCSS ODBMS and object browser

The HCSS will be built around an Object Data Base Management System (ODBMS) for data storage and retrieval. Due to its Object Oriented nature the ODBMS can (in principle) treat data and software alike. The system will be used to establish and maintain links between (versions of) software modules and data items and documentation. As a result when retrieving data objects from the system the user automatically has access to all relevant 'context' information; when were these data taken and were there any instrument or satellite problems, with what (version of) software and calibration parameters were these data processed, is there any reason (e.g. quality information) to re process these data etc.

The database component of the HCSS will make data available to the HCSS subsystems through an object server. The use of such a server will allow the *HIFI* ICC to create further subsystems without knowing the details of the underlying object database.

4.6.1.2 CC – Configuration Control

The Configuration Control (CC) component of the HCSS can be used by privileged users to (version) control configurations of data (and software) when stored in the HCSS. The specific use of this component for the *HIFI* ICC will be covered in the framework of *HIFI* PA/QA.
Aside from specific *HIFI* CC it is required that the HCSS will also allow other HCSS users (e.g. scientists analysing their observations) to use the CC component to keep track of their data (see the *HIFI EUR*, RD27).

4.6.1.3 HCSS browser

The object browser component allows users of the system to search the HCSS for any information available in it. This is very much a generic HCSS facility that will likely need tailoring (by inheritance) for *HIFI* specific queries.

4.6.2 Uplink related systems

An overview of the major systems related to uplink that are used by the *HIFI* ICC is given in Figure 7. The different components are described in more detail in the following subsections.

4.6.2.1 CUS – the Common Uplink System

The Common Uplink System as defined in the ground segment design description (RD3) shall be used to build observations out of instrument command mnemonics. For *HIFI* a set of basic instrument command mnemonics (with parameters when relevant) and combinations of these (the so called CUS 'building blocks') to control the instrument and its subsystems shall be defined. The mnemonics will range in functionality from the level of causing simple instrument state changes (switch on/off internal calibrator, set shutter position etc.) to building blocks setting up the instrument and executing full frequency scans with associated calibration measurements. Measurement sequences can be built by chaining a number of these mnemonics in a script. Scripts shall be callable as mnemonics.

The MOC uplink system (SCOS 2000 based) will translate the mnemonics to binary information to be up linked to the instrument memory for execution.

4.6.2.2 Astronomical Observing Template translator

A few Astronomical Observing Templates shall be defined. These will be simple parameterised specifications for standard observing modes of *HIFI,* which are expanded by the AOT translator into a CUS script. The changeable parameters will be chosen such that they reflect the astronomers concept of observing with a heterodyne instrument; central frequency, line transition, total bandwidth, resolution etc.

The translator itself will be a generic HCSS functionality based on the SIRTF observation planning tool SPOT. Thus the *HIFI* ICC will have to provide the translation *rules* from AOT parameters to CUS script, not the translator itself.

The CUS scripts resulting from such a translation will be used by ESA in the Mission Planning System. ESA will be responsible for running the CUS on the Herschel user's observations (also observations proposed by ICCs for calibration purposes) to generate the mission timeline.

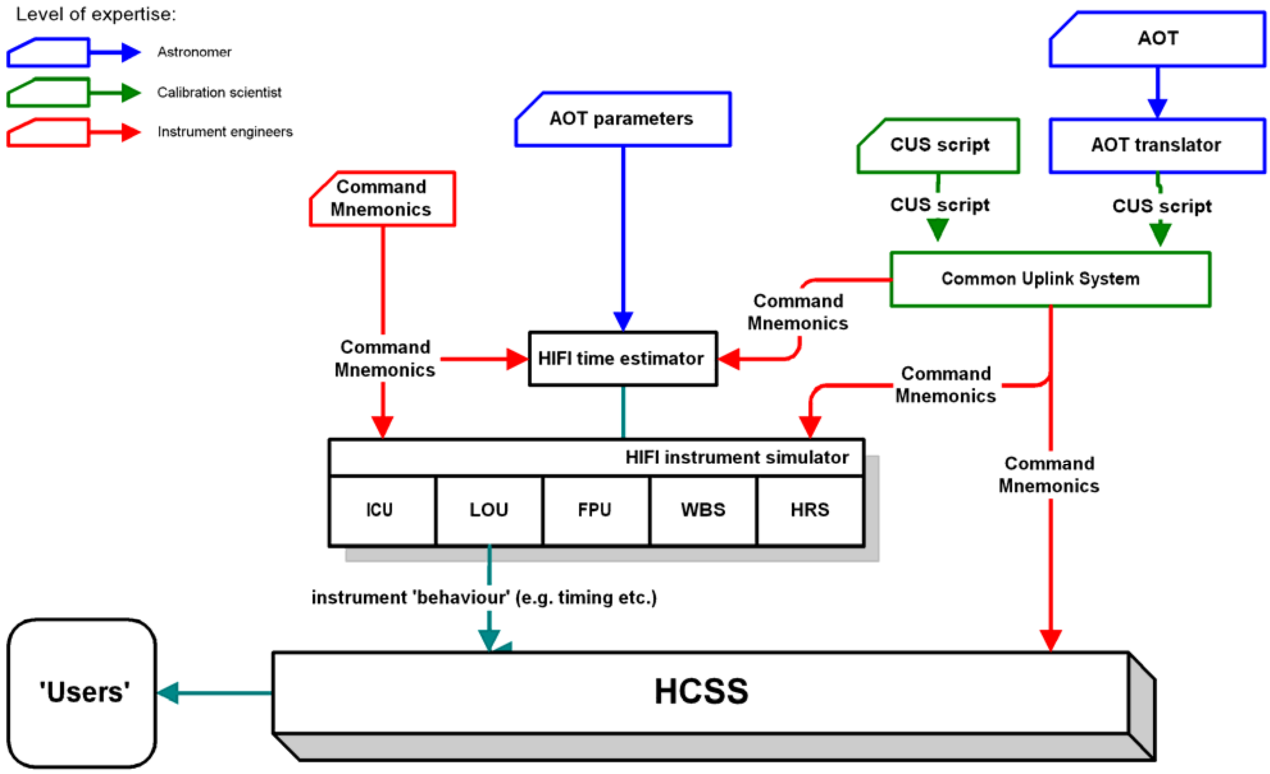

Figure 7. Overview of uplink software systems used by the ICC.

4.6.2.3 The observation time estimator

The main purpose of the observing time estimator is to give users a (good) indication of the time needed to carry out a given observation. In early development phase its main use will be to allow the consortium to give a rough estimate how much time would be spent on e.g. guaranteed projects, to be able to make a properly balanced –both in science and in observing time- *HIFI* core science program and to also establish a prioritisation of the observing modes which are to be supported in flight. Consortium members who have significant understanding of HIFI will carry out this work, thus userfriendlyness of the estimator is less of an issue, while the possibility to explore all types of operational modes is. In later phases when general astronomers need to start preparing their proposals and implementing their programs a more accurate estimator will be needed, which is also more user friendly in the sense that it will cater to astronomers that have less insight in the detailed operations of the *HIFI* instrument.

The observation time estimator will take both AOTs and CUS generated command mnemonics to estimate of the total amount of time to execute the given input measurement specification. In its final implementation the time estimator will be tightly integrated with the CUS, to the extent that it will be a CUS function to calculate the duration based on the exact commanding for a given observation. Because of this tight integration very little dedicated development effort from the *HIFI* ICC itself is needed for this version of the time estimator, once the AOTs have been implemented in the CUS language most work will be done by the as part of the general HCSS development.

Note that in early development phase a time estimator is needed while the CUS and AOT definitions are still far from complete. For use in that period the *HIFI* ICC will develop a very simple calculator.

4.6.2.4 The *HIFI* instrument simulator

A *HIFI* science data simulator will be implemented which will be able simulate the instrument behaviour and to generate science telemetry and HK telemetry relevant for standard analysis representative for the actual *HIFI* instrument. The simulator will be commandable using the tele commands as defined for the *HIFI* instrument. As a result it will be possible to execute operational CUS scripts as well as AOTs on this simulator. The resulting telemetry can be used to verify correct operation of the HIFI Standard Product Generation pipeline as well as the various other Interactive Analysis applications.

The HIFI science data simulator will be based on the KOSMA/WBS simulator framework.

Note that the MOC will require a functional instrument simulator to be used for training of MOC staff responsible for satellite operations. This simulator will mimic instrument behaviour in terms of its HK telemetry, including behaviour under error conditions. The functional instrument simulator will be developed by ESA with inputs from instrument specialists. It is not clear whether this simulator will be useful for ICC work.

4.6.2.5 PHS – the Proposal Handling System

The Proposal Handling System (PHS) as made available to general astronomical users of Herschel will also be used by the ICC to enter new calibration and test observations in the mission data base. PHS will be a standard HSC provide tool and as such the ICC is not involved in the development of this tool other than through specifying user requirements.

4.6.2.6 MPS – the Mission Planning System

The Mission Planning System (MPS) is the system that will be used by the HSC to plan all science observations. Normally the ICC will not use it, but it will be available for the ICCs to be able to plan sets calibration observations, e.g. in the performance verification phase.

4.6.3 Downlink related systems

The major downlink systems used by the *HIFI* ICC are schematically indicated in Figure 8. The different components are described in more detail in the following subsections.

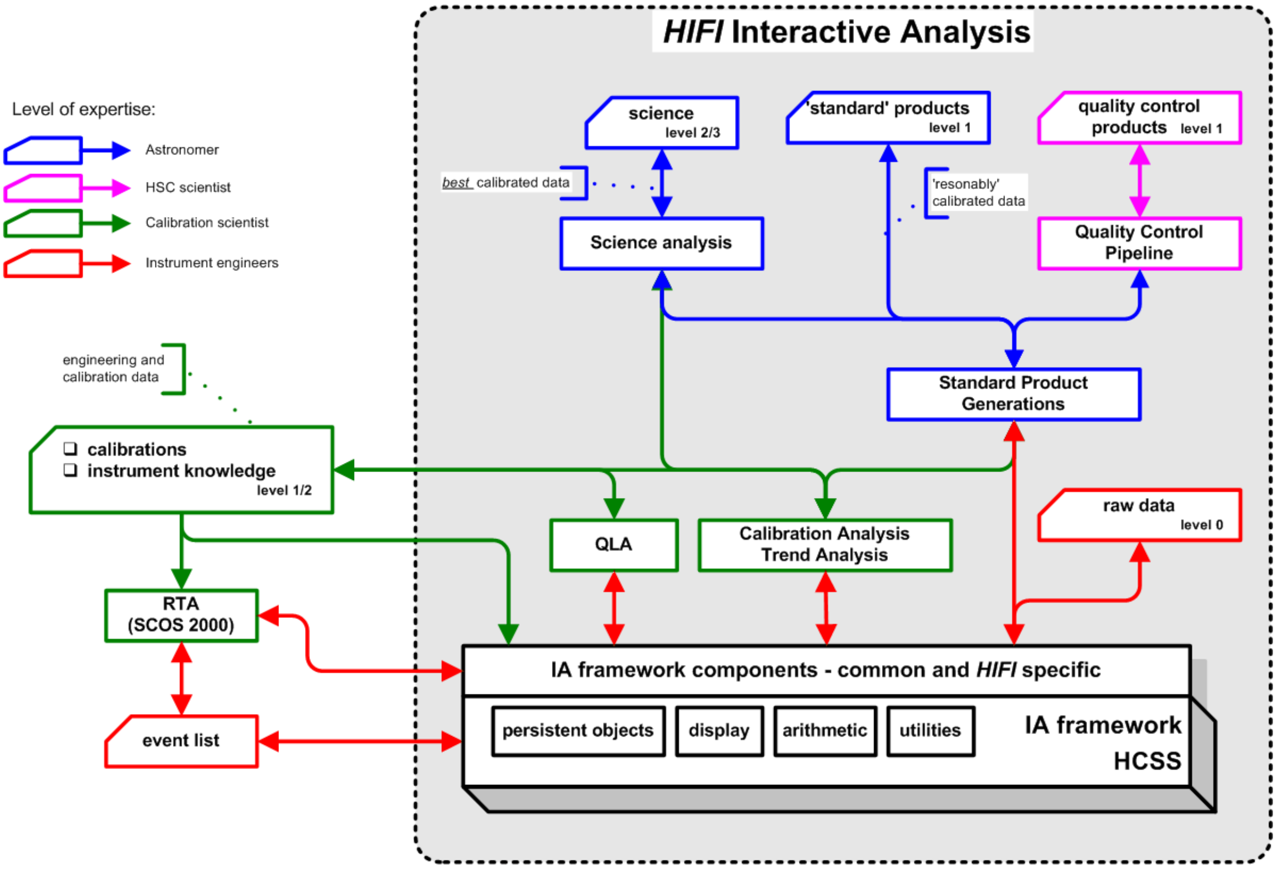

Figure 8. Overview of downlink software systems used by the ICC.

4.6.3.1 *HIFI* data products

For the downlink processing of *HIFI* data four different levels of data products are foreseen. Depending on the level of a data product the processing facilities for the different levels can be fully integrated with or entirely outside of the Herschel ground segment systems, or a combination of the two. It is the goal of the HIFI-ICC to "migrate" a number of the functions/modules developed for level-2 processing into level-1 data processing. The extent of this migration depends on a) the capabilities of the common IA framework concerning import/export and pluggability of external algorithms, and b) on the manpower available for IA development. Secondly *HIFI* aims to achieve a large degree of commonality in the level-2 processing with main-stream S/W of the *HIFI* user community for efficiency but also to provide a service to this community.

The four levels of *HIFI* data products are:

Level-0 data: Raw telemetry data as measured by the instrument, minimally manipulated and put into the mission data base/archive, often sorted and corrected for small errors. Typically, readings are in binary units versus detector pixel number.

Level-1 data: Detector readouts calibrated and converted to physical units, in principle instrument and observatory independent. In principle level-1 data processing can be done without human intervention. For HIFI these are individual spectral scans with detector readings as fluxes versus wavelength. These are HIFI specified standard data products (see RD28) as generated by the Standard Product Generation pipeline (see section

4.6.3.7). Telescope pointing information is given in RA and DEC, the conversion from satellite pointing data to RA and DEC is provided by ESA.

Level-2 data: Further processed level-1 data to such a level that scientific analysis can be performed. Many of the processing steps involved to generate level-2 data require human interaction, based both on instrument understanding as well as understanding of the scientific aims of the observation. Typical HIFI level-2 products are full spectra, maps and data cubes.

Most of the software with the functionalities required for level-2 processing exists already in typical “single dish spectral line” S/W packages, like CLASS and SPECX. Some applications like “side-band de-convolution” will have to be developed by the ICC and added to the level-2 processing environment. Making this software available as well as the overall user friendliness for the general community is at the discretion of ESA.

Level-3 data: These are the publishable science products where level-2 data are used as input. These products are not only from the specific instrument, but are usually combined with theoretical models, other observations, laboratory data, catalogues, etc. The responsibility for this processing resides not with the ICCs, nor with ESA, but with the involved scientific team.

4.6.3.2 IA – *HIFI* Interactive analysis

The *HIFI* Interactive Analysis (IA) can be considered ‘the sum’ of all data reduction systems used by the ICC. It provides the environment that will be used by all ICC calibration and operations specialists both for analysis of instrument data (real time and off line) and for development of calibration and processing algorithms: the various QLA, CA, TA and SPG applications. The proper functioning of IA is of the essence for the ICC. In practice a large number of the functionalities of HIFI IA are generically present in or derived from the common IA framework developed jointly by the ICC’s and HSC as part of the CSDT work.

4.6.3.3 The IA framework

The IA framework will provide all the lowest level IA services such as facilities to select and retrieve data from the HCSS, display facilities, algorithm libraries, utilities to decode *HIFI* telemetry, to perform unit conversions, to perform basic arithmetic on *HIFI* data products etc. Also it will provide facilities allowing users to store results from analysis in the HCSS and to export results (or even raw data) to other data reduction facilities using standard interface formats (e.g. FITS, XML…).

The other major feature provided by the IA framework is the formalism by which IA tasks are put together; the mechanisms to interface with a user, to get data ready for processing, to apply algorithms to those data and to forward the outputs of one process to another. This formalism firstly provides for a very developer friendly way of creating new data reduction processes, and secondly a way to chain existing processes to longer more complex data reduction processes. This formalism will for example be used to chain individual *HIFI* IA modules to create a *HIFI* SPG (see below) ‘pipeline’. As part of the framework also processing history information will be maintained such that for a product stored in the HCSS all processing steps that have been applied can be recovered.

Since IA will be the basis for QLA –one of the systems needed in ILT– its development must start very early in the development phase.

4.6.3.4 RTA – Real Time Analysis

RTA will use the standard interface facilities to retrieve and display (instrument) data from the HCSS. RTA will contain tools to analyse housekeeping data to allow monitoring of the instrument's behaviour. *HIFI* ICC and instrument team members will use it extensively during instrument test and assembly. RTA will be based on the ESA SCOS-2000 system.

During operations this package will be used mainly at the MOC and thus the ICC will have an external maintenance obligation. In this phase changes to this software will be limited to those that are necessary for proper operation at the MOC (following e.g. onboard software changes, changes in hard/soft parameter limits etc.). At the ICC its use will primarily be for troubleshooting and –when needed- to inspect particular housekeeping parameters that cannot be (easily) accessed otherwise.

4.6.3.5 QLA – Quick Look Analysis

The Quick Look Analysis facility comprises of all the functions that are needed to do real time inspection of science telemetry packets. It is mainly needed to support the AIV programme in the various HIFI test campaigns. A second important use of QLA is during instrument commissioning and error recovery operations. The only fundamental difference between QLA and other IA branches is that QLA are required to cope with data arriving in real time beyond that QLA applications are standard IA applications.

The QLA design and implementation priorities will be driven by the AIV needs. To be able to meet the AIV schedule timely specification of the QLA requirements by the *HIFI* AIV team is essential.

4.6.3.6 CA/TA – Calibration Analysis and Trend Analysis software

Calibration Analysis (CA) software consists of a set of tools built in the IA environment. They inherit all standard functionality available there. Each of the calibration analysis tools is designed to analyse a specific (set of) calibration observation(s) to yield a certain (set of) calibration parameter(s). The tools will be prototyped, developed and tested within the IA environment.

Trend Analysis (TA) software will be used to study trends in instrument behaviour based on housekeeping data and science data. Like CA, TA will be designed and tested in IA.

4.6.3.7 SPG – Standard Product Generation software

The Standard Product Generation (SPG) software shall generate a standard (set of) level-1 product(s) for each astronomical observation. Generically for *HIFI* this will be a spectrum calibrated both in frequency and in flux. The standard *HIFI* product will be defined in a dedicated ICD (RD28). Where relevant scans over the same frequency region will be corrected for possible drifts and averaged (re-binned). The definition of 'the standard product' will be an import task to be carried out early in the development phase.

The SPG software will process the raw data as far as is possible without human interaction. Further processing will have to be done using other astronomical analysis tools (e.g. those available in Science Analysis).

The SPG processes will be using IA and/or CA functionality to process data retrieved from HCSS.

4.6.3.8 QCP – Quality Control Pipeline

The Quality Control Pipeline (QCP) is based on IA and SPG components. It is used by the HSC to evaluate the quality of the observations carried out with the *HIFI* instrument. The *HIFI* ICC shall provide and test the basic modules as well as the script to combine them into QCP to HSC.

When QCP is run by the HSC and yields warnings on the quality of certain observations, the HSC will investigate these. In cases where HSC personnel cannot establish the cause for such warnings, further analysis by the *HIFI* ICC as to their cause will be requested. Such investigations by the ICC might subsequently lead to updates in *HIFI* operating procedures or analysis tools.

The *HIFI* ICC will spot check data to verify the general performance of the *HIFI* instrument and the data processing software as well as to assess the general quality of the data products. This intended mainly for instrument health monitoring and for evaluation of the analysis software delivered to the HSC.

The detailed level of support of the *HIFI* ICC for the overall observatory product quality control is still TBD.

4.6.3.9 SA – Science Analysis software

The Science Analysis (SA) software is used to further analyse the products generated in the SPG process or in e.g. CA, RTA and QLA. Results from this analysis should be scientifically useful numbers such as line fluxes, continuum flux densities etc. Also this part of the system should give possibilities for the user to compare *HIFI* data with data from other Herschel instruments as well as from other observatories.

Typical SA tools will be to do line fitting (Gauss, polynomial, Voigt etc.), continuum modelling (Black Body fit, molecular line series), correlation analysis etc. To allow comparison with other non-Herschel (e.g. ISO, IRAS, radio, optical…) data those could be added to the HCSS. Specific search and retrieve capabilities based on basic HCSS functions will be created to find and correlate the appropriate data.

SA will be based on a combination of the available Herschel dedicated systems HCSS, IA, CA and SPG (and thus inheriting all functions already available in these systems) with existing astronomical data reduction packages developed explicitly for analysis of sub millimetre (heterodyne) data like CLASS and AIPS^{++} for functionality not available in the HCSS. These packages should be carefully studied to see which functionalities can be taken over as-is and which functionalities would need to be (re-) coded (or even re-designed) for the inclusion in the Herschel ground segment systems. In any case proper import/export mechanisms in the HCSS are needed to support exchange of level-1 data with these external data reduction systems.

4.6.4 Miscellaneous other systems

4.6.4.1 The Herschel help desk

The HSC will be the front-office for the general astronomer in the sense that all queries with respect to the functioning of the Herschel instruments will initially be dealt with by the HSC. Only in the cases where HSC personnel cannot answer instrument specific queries will the queries be forwarded to the ICC. In that case the ICC will get all information from the user through the help desk facility. Also the answer from the ICC will be fed back to the user using the central Herschel help desk facility.

4.6.4.2 The Mission Implementation Base editor

As described in the ground segment design description (RD3) the instrument database containing the command and telemetry definitions (the Mission Implementation Base – MIB) is changed using a dedicated editor, the MIB editor. The MIB itself is archived and distributed using the HCSS (see RD4).

Changes in command or telemetry definitions are implemented by retrieving the latest MIB version from the HCSS, editing it with the MIB editor to make the desired changes and then storing the new MIB version again in the HCSS. Subsequently the MOC and HSC are notified of the availability of a new MIB for use in the operational system.

The MIB editor is a deliverable from the *HIFI* instrument group to the ICC. In practice the three instrument groups develop the MIB editor jointly.

4.6.4.3 *HIFI* On Board Software maintenance facility

The *HIFI* on board software maintenance facility is used to make changes to the *HIFI* on board software. Like with MIB changes OBSW versions are stored in the HCSS for version control and thus the OBSW maintenance facility will have to be able to store and retrieve the necessary data using the HCSS (see RD3 and RD4).

The OBSW maintenance facility must be directly available at the ICC premises in the period from 6 months (TBC) before launch to 1 year (TBC) after launch. Outside of these periods it must be available such that changes in OBSW can be made within one working week (TBC). During Check Out and PV a possibility to do OBSW maintenance must also be available at the ICC@MOC site.

The on-board software maintenance facility is a deliverable of the *HIFI* instrument project. The ICC will be user of this facility and as such will contribute to its development by specifying the use cases this facility will have to be able to cope with.

4.6.4.4 Test environment for changes in HIFI operational procedures

To date it is not clear what equipment will be available during operations to test changes in the HIFI On Board Software and operational procedures (i.e. AOTs). In principle there are two ways to test such changes:

a) using a hardware set-up. This should contain representative versions of the ICU, both back ends and (at least) the FCU and LCU. Maybe the cryogenic units are also needed, but probably for most updates you would not need those. In this case a full EGSE set-up will be required as well to be able to run the tests.
b) using a software simulator of HIFI. This in practice means we need a platform that can emulate the ICU (i.e. the Virtuoso OS?) in software such that now OBSW images can be run on it. This set-up will also require simulators for the subsystems. Note that simulator here implies simulating the 'functional' behaviour of the (sub)system, it probably need not generate very realistic science data. The timing of the data generated has to be accurate to the level that the proper functioning of the instrument and its satellite interface can be verified. Note that it is unlikely that the functional simulator built by ESA to test MOC procedures is adequate for this purpose. For this software solution a spacecraft and uplink system simulator (usually referred to as mini-MOC) would also be required that would have to be implemented by the *HIFI* ICC as ESA is not planning to provide such a facility.

It is not decided yet what equipment will be available to the *HIFI* ICC to investigate (perceived) *HIFI* hardware trouble. In the ideal world a full copy of the flying *HIFI* instrument... would be available. A combination of QM and spares together to make a test *HIFI* containing representative versions of the ICU and all subsystems is likely achievable. The cryogenic and EGSE parts are required as well, which also means keeping all cryogenic support equipment available.

In the development phase the following questions have to be answered;

1. which is the best option in terms of performance/reliability of test results?

2. which option does *HIFI* take after balancing 1 versus the cost of the various options?
3. who will provide what and specifically if option b) is implemented is the EGSE-instrument simulator interface implemented by *HIFI*, or will HIFI renegotiate with ESA to provide a mini-MOC?

4.7 Science

The performance of *HIFI* and the quality of *HIFI* data and calibration are best evaluated in the context of the science that is to be carried out with the instrument. Therefore all (qualified) *HIFI* ICC personnel will be given the opportunity to spend a reasonable amount of time on scientific research based on data obtained with the Herschel instruments (or at least closely related to 'Herschel science'). They will be encouraged to participate especially in the *HIFI* guaranteed time projects.

For their research the *HIFI* ICC personnel will likely use analysis tools available in the interactive analysis environment. As such they will be testing these tools extensively. In a similar fashion they will be testing the standard product generation software when using the standard products as a basis for their analysis.

At all times ICC observatory work will take priority over science. Therefore the ICC composition is aimed to be such that under normal operational conditions all personnel can dedicate up to 25% of their time to scientific research. Note that science time is not counted in the ICC resource estimates (appendices B and C). It is expected that no significant time will be available for science work around the in orbit check out and performance verification phases.

4.8 Management

The overall management of the *HIFI* ICC is the responsibility of the ICC manager. The ICC manager reports to the PI directly or via the *HIFI* consortium Project Manager. An appointed deputy can replace the ICC manager when needed.

The ICC manager will establish, distribute and monitor the work packages as given in appendix C. The *HIFI* ICC manager also will compile the status reports from the ICC members into general ICC status reports. He will plan and chair ICC progress meetings and monitor progress on action items to be fulfilled by ICC members

The ICC manager represents the *HIFI* ICC in the various bodies governing Herschel ground segment development (e.g. *Herschel Common Science System Management Group* –HCSSMG– and *Herschel Ground Segment Steering Group* –HGSSG) and in *HIFI* project meetings. The deputy should at all times be sufficiently informed about ICC management and planning matters that he/she can represent the ICC at these official meetings

4.8.1 ICC organization

The ICC will be divided into subgroups with specific tasks. Leaders of these subgroups report directly to the ICC manager. In the different phases of the project the composition of the ICC changes, as does the division of the ICC into subgroups with group leaders. The organisational structure of the *HIFI* ICC for operations is shown in Figure 9. Similar diagrams for each of the mission phases are presented in the following chapters.

The ICC is lead by the ICC manager, assisted by a deputy, a PA/QA engineer and a system engineer. Within the ICC five top level work groups are identified;

1. The operations group

This group is responsible for the operational tasks to be executed; looking at event logs, do initial evaluation of quality of calibration and engineering observations, do spot checking of observations, follow up help desk questions.

2. The calibration group
   This group maintains and improves the calibration of the HIFI instrument. For this the group proposes calibration observations, and analyses the resulting data. Also they maintain the relevant calibration documents and when needed provide the calibration status for use by the HSC.
3. The instrument group
   These are *HIFI* instrument engineers who evaluate data relevant for the health of the instrument to asses whether it is still operating optimally. When appropriate they will perform engineering observations and/or propose changes to the way in which the instrument is operated. This group is also responsible for OBSW changes.
4. The software group
   The software group is responsible for maintaining and improving all HIFI ground segment software; ODBMS, IA framework, CUS, IA and all its subsidiary systems etc. The HCSS related parts of this work will be done in close collaboration with the other instrument ICCs and the HSC.
5. The support group
   The group takes care of all supporting activities; computer system maintenance, secretarial work etc.

Within these groups further subdivisions are created when needed.

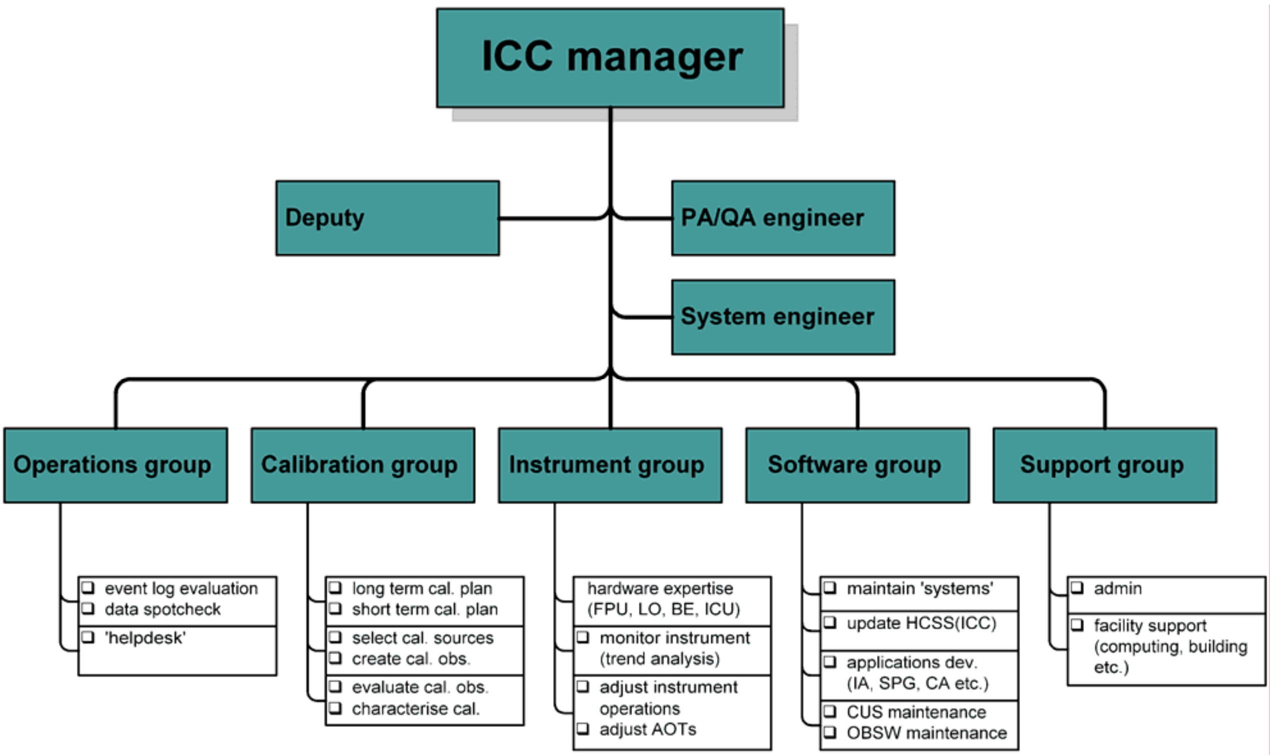

Figure 9. *HIFI* ICC organigram for operations

4.8.2 Reporting

All group leaders, supported by their team members, will submit monthly status reports to the ICC manager. These will be compiled into overall quarterly ICC status reports that will be stored in

HCSS accessible to all team members. They will also be the basis for status reports to ESA as part of the overall *HIFI* reporting.

For HCSS related work contributions for the *Common Software Development Team* (see 4.12.7) input for the CSDT monthly progress report will be supplied to the HSC development manger.

4.9 Product assurance

For the ICC one person will be responsible for product assurance and configuration control. The PA officer will make change proposals where necessary to bring ICC products to the standards as defined. The PA officer has an independent status, and is a member of the ICC management team.

The following rules apply (as a minimum) for all ICC deliverables (internal or external):

1. PA/QA for *HIFI* ICC related matters shall follow the general PA/QA strategy for *HIFI* as detailed in chapter 8 of HIFI-IID-B (TBC),
2. All software deliverables shall be constructed according to *'Guide to applying the ESA Software Engineering Standards (PSS-05-0) to small Software Projects'* (BSSC-96-2, AD5),
3. *All HIFI* ICC systems shall follow the PA/QA guidelines as set for the HCSS development (AD6, AD7, AD8)
4. *All HIFI* ICC documentation will be maintained using the HCSS configuration control system.,
5. All *HIFI* ICC software will be maintained using the HCSS configuration control system,
6. All errors in and new requirements for *HIFI* ICC software will be registered and tracked through the ESA provided on-line SPR/SCR system
7. All *HIFI* ICC changes to software or documentation that form part of the operational system are subject to approval by a Configuration Control Board.

4.10 The HIFI ICC documentation tree – TBW

4.11 The ICC development strategy

The development of the ICC will follow the same strategy as adopted for the development for the ground segment as a whole (see RD22). This is because a very large part of the ICC work in operations uses common ground segment facilities and to be sure that these common facilities can fulfil all *HIFI* ICC requirements the ICC participates both in the design as well as in the development of them. The motivation for this joint development work lies in the fact that the three ICCs, and to a large extent even the HSC, require very similar functionalities in operations. Thus much work is done in close collaboration with these groups in the context of the overall ground segment development work: joint system engineering in the HGSSE (*Herschel Ground Segment System Engineering group*), joint HCSS development in the CSDT (*Common System Development Team*) and this is jointly managed by the HCSSMG (*Herschel Common Science System Management Group*). It is expect that this joint development leads to a significant reduction of cost of the *HIFI* ICC and its development.

HIFI specific system facilities will be developed within the framework of the HCSS wherever possible. Only after a full trade-off has shown that deviating from this policy has very significant advantages will it be allowed. When needed *HIFI* related extension of the HCSS Core Class Model (CCM) will be proposed for implementation by the CSDT. Releases of *HIFI* specific systems will be timed according to the planned releases of the HCSS.

4.11.1 The HCSS release cycle

The HIFI ICC development is dependent on a regular set of releases of the HCSS and its subsystems. Currently throughout the development phase, one full release every year is foreseen (see RD22). This full release will provide a stable backup system that can be put in place in case of serious problems with the latest developer release(s).

Every four to eight weeks a developer release will be made available. The developer releases will be the stepping-stones in the iterative development cycle as outlined in the sections below. Between these releases a continuous process of updating, integrating and testing will proceed. The developer releases will (almost) always contain the most up-to-date properly functioning applications, and will likely be used most of the time for data analysis e.g. in test periods.

4.11.2 The software development and test cycle - sandboxes

To be able to effectively develop and test of new functions in the HCSS context (e.g. of *HIFI* IA applications), a developer needs a very flexible and safe environment. He needs to be able to build his application using system functions. Also he needs the ability to test his new application on real data under 'operational' conditions without actually affecting the operational systems. Where possible the *HIFI* data simulator (see section 4.6.2.4) will be used to support these tests.

Once the developer is satisfied that he has implemented the required functions properly he will hand the applications(s) over to a larger group of testers within the ICC. These testers will then again want to exercise the application(s) under circumstances that are as close as possible to the operational system without affecting the operational system. When the testers are satisfied the application does what it is supposed to do, the application will be 'promoted' to the operational system such that it becomes available for all Herschel users.

The *HIFI* ICC relies heavily on the HCSS provided mechanism of 'sandboxes' to support this development cycle. A sandbox is an environment in which the user (e.g. the developer or the tester) defines which components as used in the operational system and which 'private' components –i.e. components he can modify– he wants to have accessible. In the sandbox he can 'play' as he pleases, because whatever is inside he can make or break without affecting the operational system. At the same time he can keep on using components from outside the sandbox (e.g. operational versions of the system) in combination with the private components. This provides operationally a very safe test environment supporting all stages of software development.

The same sandbox set-up will be used to derive new *HIFI* calibration parameters and test their applicability on real observations.

4.11.3 The development paradigm: Object Orientation

All design and implementation will be carried out using Object Oriented techniques, starting off with 'use cases' for the specification of user requirements, designing class and object models based on analysis of these use cases and implementing the systems in a full fledged OO language. Finally the new functionality is tested and evaluated against the use case. This cycle iterated until the use case is completed in terms of specification as well as implementation (see Figure 10). This work will be supported by the use of Unified Modelling Language to document the specifications and design. Development will be done by frequent and rapid iterations to be able to quickly establish whether newly implemented facilities are performing according to the use case descriptions (see also
Figure 11). The details of this iterative process are elaborated in the following subsections.

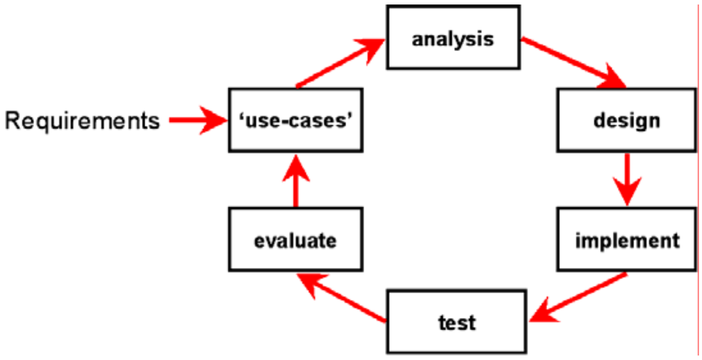

Figure 10. Basic Object Oriented analysis and design development iteration.

Figure 11: The traditional 'waterfall' and the 'many iterations' paradigms.

4.11.3.1 Use cases

For every activity carried out by the ICC a use case will be written. Such a use case can be seen as a literal scenario of the actions to be carried out by the user and the systems he/she interacts with. The use case identifies which actors (e.g. 'the user' or 'the IA system' are involved in the particular activity. The scenario itself then effectively captures the requirements in terms of functions needed by the user. The use cases specific for *HIFI* are gathered in the *HIFI* ICC use case documents (RD11), generic HCSS use cases are documented in the HCSS use case documents (RD7 and RD8). Additional requirements dealing with e.g. performance or availability (e.g. uptime) are documented in the supplementary specifications document (RD9 for generic specifications and RD13 for *HIFI* specific specifications).

Use cases will be used to describe both software systems (e.g. QLA and IA functionalities) as well as procedures (e.g. calibration processes).

Requirements that cannot be captured directly in use cases (e.g. performance requirements) are captured in supplementary specifications documents.

4.11.3.2 The domain model

From the use case initially a domain model is constructed. In such a domain model the various interactions are described on an abstract level. This analysis should lead to a better understanding of which are the fundamental entities in the various processes that together form the ICC –or ground segment– systems. Initially analysis of the domain model likely results in a review of the use case and actor descriptions.

4.11.3.3 The class model and implementation

Subsequently a system is implemented by designing classes and methods that represent the various elements and interactions as have been established in the domain model. The resulting 'class model' –when used to instantiated and manipulate real data objects– should in principle be capable of executing the steps as specified in the relevant use cases.

4.11.3.4 Testing

Testing of the newly built classes is simply done by executing the use case(s) in which they are used. This means literally following the steps in the scenario and evaluating whether all actors/systems involved can act as specified in the use case. A test report is thus a straightforward list of yes/no qualifications against each use case step. Failure of certain use case steps may lead to re-development of classes, but also to re-evaluation of the use case itself.

4.11.3.5 Review and update of use cases

Following successful completion of a use case, further development may be deemed necessary. As a result existing use cases may be extended and new use cases may be added for implementation in further iteration cycles. This again may lead to proposals for change of the *HIFI* specific or in the HCSS common class model.

4.12 Interactions

With a distributed operational concept communication is one of the most important issues to establish early. *HIFI* ICC and consortium members will visit the various consortium locations and have regular meetings. Personnel will be stationed at different consortium institutes, in particular at the ICC main node at SRON/Groningen, for longer periods. Apart from standard use of telephone, fax and electronic mail the communication system will rely heavily on HCSS, World Wide Web facilities, video conferencing, electronic whiteboards etc.

4.12.1 *HIFI* ICC internal

For its internal communication the ICC will meet regularly. Depending on the phase of the mission these will be daily (PV, check out, ILT's), weekly (operations) or bi-weekly to quarterly (development and post operations). Subgroups within the ICC will have separate work level meetings as needed. At *all* meetings minutes (or as a minimum clear decision and/or action lists) are made which will be archived for later reference.

The ICC will set up and maintain a web site to inform *HIFI* consortium members of the status of ICC work. Documents, progress reports, meeting minutes and action lists will all be made available through a central document repository (later to be replaced by HCSS - TBC). A schematic indicating the rough layout of the site is shown in Figure 12, a detailed description is given in RD16.

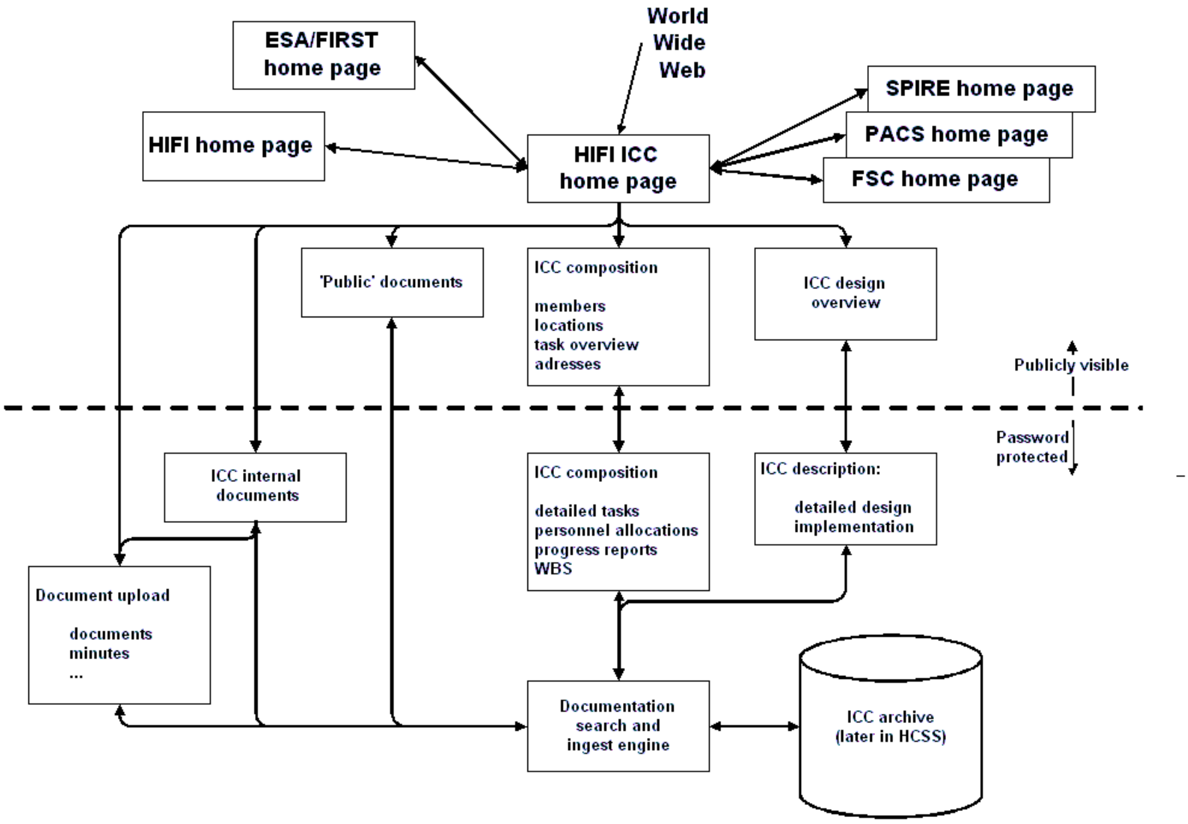

Figure 12: Layout of the *HIFI* ICC WWW pages

4.12.2 The *HIFI* project

The *HIFI* principal investigator, the *HIFI* Project manager and the *HIFI* ICC manager have bi-weekly meetings to coordinate any relevant top-level *HIFI* managerial issues (e.g. dealing with balancing instrument versus ICC priorities). Also formal requests from ESA to the *HIFI* consortium regarding ICC issues are tabled at these meetings.

The *HIFI* ICC manager is a member of the *HIFI Project Management* group, and as such he participates in the various *HIFI* project manager meetings.

4.12.3 The *HIFI* instrument hardware group

The instrument hardware group will have access to all information that the ICC has access to, and the reverse is expected to be true as well. Members of the ICC are expected to join relevant instrument group meetings regularly. In line with this the ICC system engineer is a member of the *HIFI System Engineering Team* (*HIFI* -SET).

Especially for the instrument test phases dedicated bi-weekly meetings between *HIFI* ICC and AIV personnel are organised to coordinate the development of general ground segment software and *HIFI* specific test tools.

4.12.4 The *HIFI* consortium science community

All through development, operations and post operations the astronomers in the *HIFI* consortium (i.e. PI, Co-PI's, CO-I's and associates) will provide the test bed for new data reduction and analysis systems for *HIFI* data. The *HIFI* ICC will request specific information (e.g. a judgement on the quality of a new calibration or analysis algorithm) from this group through the relevant representatives. This group will have access to Herschel data and reduction algorithms (IA, CA, SPG etc) through HCSS. Individual consortium members will be asked to join the ICC for short periods.

It is also expected that consortium members will request help from the ICC for specific instrument operations or data processing issues or e.g. for general training in the properties of *HIFI* and its data. Assistance will be given where this does not conflict with the normal ICC duties. Also visits from consortium members to learn about HIFI will be possible, in exchange for a specific ICC task to be carried out by the consortium member.

Communication with this group will be through distribution of ICC status reports and direct communication with Co-PI's and Co-Is. Co-PI's and Co-Is can also join in regular ICC meetings.

4.12.5 The Herschel project office

The formal point of contact from the *HIFI* ICC to the Herschel project office is the PI of the *HIFI* consortium.

Throughout the development phase the main communication on the management level to the Herschel project office will be through the *HIFI* project office and through the HGSAG or HSGSSG as called for in AD2.

Deliverables such as documents and software will be delivered through the HCSS.

4.12.6 MOC

Throughout the development phase co-ordination and the main formal communication with the MOC will be through the HGSAG or HSGSSG.

Deliverables and delivery procedures (wherever possible using HCSS facilities) are established jointly and documented in the *'Herschel Ground Segment Interface Requirements Document'* (HGSIRD, RD4). Any development work associated with the GSID(s) will be coordinated by the HGSSE. In the HGSSE the system engineers represent the different groups in the Herschel ground segment.

For specific (development) tasks carried out jointly with the MOC (and possibly other groups) task teams will be set up. The members of such a task team shall have regular progress meetings.

4.12.7 HSC and other ICCs

Throughout the development phase the formal co-ordination and the high-level formal communication with the HSC and the other ICCs will be through the HSGSSG (RD25). The HCSSMG (RD23) is responsible for the management of the development of the HCSS. The ICC leader is member of the HCSSMG. Ground segment system engineering work is lead by the HGSSE (RD24).

The *Common Software Development Team* (CSDT) will be responsible for the joint development of the HCSS. It will be a joint HIFI-PACS-SPIRE-HSC team managed by the HCSSMG. All ICCs and the HSC will 'donate' manpower to the CSDT to help develop the common HCSS functionalities; HCSS functionalities that are specific for an ICC or for the HSC will be developed by the teams themselves. CSDT meetings will be held regularly (several times per year) to address development coordination issues as well as specific technical problems. For specific (development) tasks within the CSDT work area (small) dedicated tiger teams will be set up that define and organise their own work to solve their particular problem. The members of such a tiger team shall have regular progress meetings and will report to the HCSSMG.

Deliverables and delivery procedures (wherever possible using HCSS facilities) will be established jointly and documented in the HGSIRD.

For Herschel cross calibration purposes and to oversee the overall calibration activities in the Herschel mission, the '*Herschel calibration steering group'* has been established. This group is lead by the HSC and meets at regular intervals (several times per year) to assess progress in the various areas relevant for instrument calibration. It has participants from all instrument groups, for *HIFI* there will be at least one representative.

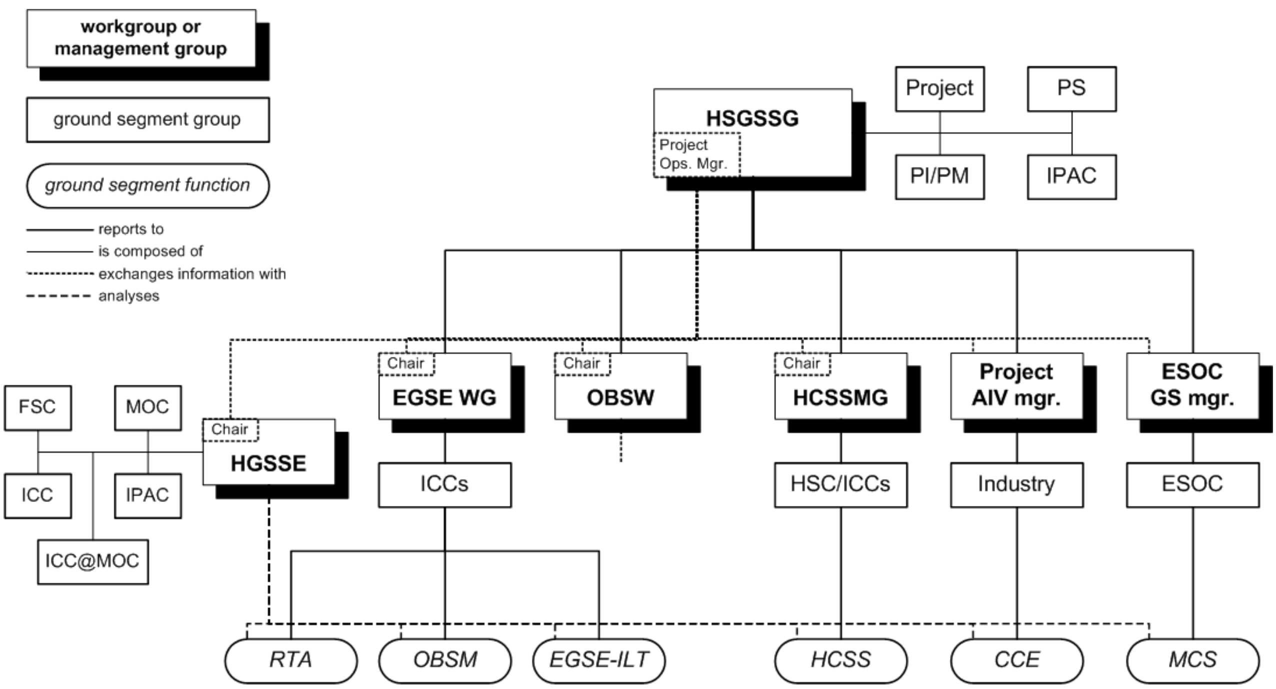

Figure 13. Relationships between *HIFI* ICC and other Herschel groups

4.13 HIFI consortium participation – ICC planning and personnel

For the *HIFI* ICC to be a success all *HIFI* consortium partners should have the same understanding of the *HIFI* ICC tasks and their responsibilities with respect to these tasks. The ICC system engineer and the ICC manager participate in the systems analysis of the *HIFI* operational requirements, the Herschel ground segment and the work the ICC has to carry out the context of the ground segment. Following this analysis a detailed work break down for the *HIFI* ICC in the development and operational phases is established (RD18). Based on this work breakdown the consortium leaders (e.g. Co-PIs) can jointly determine the responsibilities taken by the different institutes, the division into ICC subgroups and appointments of group leaders. This joint establishment of a task division will make sure that ICC work and responsibilities are distributed in an optimal fashion over the *HIFI* consortium. The resulting work responsibilities are described in the ICC work packages.

4.13.1 Required skills for *HIFI* ICC personnel

For the ICC work personnel is required capable of quickly obtaining an intimate knowledge of the instrument hardware at system and subsystem level, its operational modes and how to calibrate it. Persons with astronomical knowledge are needed to understand the observed signals towards astronomical sources. Software engineers will be needed to translate the operation, calibration and analysis procedures into software to carry out these tasks.

4.13.2 Work distribution over consortium sites

In the development phase the ICC members will need to be well connected. A number of work packages can be dealt with by small groups in consortium institutes but for some development efforts co-location may be required to efficiently co-operate. During the operational phase most of the expertise should be concentrated in one place to facilitate the by nature co-operative work of the different specialists. At some other consortium locations smaller ICC teams could be envisaged that are dedicated towards specific well defined ICC tasks. To allow the team to deliver high quality work obviously sufficient office space and facilities (e.g. computers) are required as well as a well-defined internal ICC mode of operation. It is expected that even though the level of expertise in many *HIFI* related issues within the ICC will be high, the expertise available at the consortium institutes involved in building the instrument will be called upon as well.

4.13.3 The ICC in operations

The operational composition of the ICC will be established in the course of the development phase. In this phase procedures, documentation and (software) systems and tools have to be created. Also the calibration strategy has to be designed and if needed prepared by e.g. executing dedicated observational programs using ground-based telescopes. The ICC members will have to be trained on the various *HIFI* aspects as well as in the development methods used for the creation of the Herschel ground segment. Part of this training will be obtained by participating in system and subsystem tests.

4.13.4 Business agreements

All the types of agreements on consortium resources and deliveries for the *HIFI* ICC as outlined in the above will be the laid down in *'business agreeme*nts' between SRON –the HIFI PI institute and provider of the *HIFI* ICC location and management– and the *HIFI* consortium partners. These business agreements will be modelled after those already in use for the *HIFI* hardware project. The business agreements will be established by negotiations between the *HIFI* project manager and ICC manager, supported by the PI, with the consortium partners (Co-PIs, subsystem managers etc.).

4.13.5 Public outreach and Public Relations

The main channel for outreach and PR for the overall Herschel project lies with the HSC; the HIFI PI has the responsibility for outreach and PR specifically for the HIFI project. The *HIFI* ICC in collaboration with the instrument development team will support the HIFI PI in providing him with information for this purpose. From the early integration of HIFI prototypes onward active contact will be kept with (local) press agencies (where relevant with cooperation from the SRON PR department) to report on important –in terms of newsworthy- progress. Also the progress will continuously be documented on film and/or photo for later reference.

Coinciding with major observatory events activities will be organised to inform the general public about *HIFI*, its mission and the *HIFI* consortium.

5 The development phase

5.1 Activities

5.1.1 ICC preparation and set up

Before the ICC development phase can start the ICC work breakdown and the responsibilities of the different consortium members have to be established. Firstly a small team of engineers will carry out a systems analysis of the ICC. Subsequently the *HIFI* consortium team leaders (PI, Co-PIs, ICC manger etc.) will establish a division of work and responsibility. Also some work will have to be carried out to set up procedures, communication schemes etc. In this phase the ICC as such will be quite small.

5.1.1.1 Activities

In this phase (at least) the following activities are carried out:

1. Finalise ICC management scheme taking into account the fact that there will be several (major) ICC sub groups at different locations.
2. Establish *'business agreements'* with *HIFI* consortium partners, defining their responsibilities vis-à-vis ICC development and implementation.
3. Finalise responsibilities of ICC (sub) groups.
4. Establish work environments and communication systems for the ICC (sub) groups.
5. Define work packages for the development phase.
6. Define decision points in time; when does what kind of hardware have to be purchased, when are decision made about operating systems and software platforms etc.
7. A number of documents will have to be written by the *HIFI* ICC, many for internal use, some for external use. Preparations for these documents will be started in the set up phase. A complete description of the required documents can be found in the '*ICC product tree*' (RD10)

5.1.1.2 Resources

The manpower requirements are fairly limited in this phase. The ICC manager must be identified as well as the ICC points of contact at the different *HIFI* consortium institutes. The allocated manpower will be identified in business agreements with the *HIFI* consortium partners.

The main work will be in writing documentation for which sufficient computing facilities and system support must be available. In this phase some secretarial support will be required for document editing and distribution work.

5.1.1.3 Organization

The organisation structure will be simple in this phase: there will be an ICC leader and a few subsystem leaders. Each of these heads the few personnel doing ICC related work. In many cases such subgroups will be responsible for well defined work packages.

Significant travel and (video-) teleconferencing will be required for e.g. co-ordination meetings to establish the ICC work plan for the development phase.

5.1.2 ICC and ground segment system design and development

To capture the requirements for the *HIFI* ICC a set of ICC use cases (RD12) are developed and reviewed by the *HIFI* consortium. Based on this the ICC system design and development is done in close collaboration with the *HIFI* consortium partners as well as with the other ground segment partners. Together the firstly the *HIFI* ICC design and subsequently the overall ground segment design are established and documented (RD3 and RD4). At all times *HIFI* needs are put forward to be included in the design. Use cases for the overall ground segment are developed and documented jointly with the other ICCs and HSC (RD7, RD8 and RD9). The HSC maintains an overall HCSS URD derived from these use cases (RD6). A number of use cases are analysed and transformed into domain and class models for the HCSS. These efforts are documented in joint HCSS technical notes.

Following this common work, development is started for *HIFI* specific use cases describing IA/QLA facilities, to be designed for use in tests and later during operations (RD11, and RD13). Based on the analysis of these use cases, new classes are designed and changes to the core class model are proposed to the CSDT. In this process also the interaction mechanisms between standard HCSS/IA facilities and external packages like CLASS and AIPS^{++} are designed and implemented.

As per HCSS SPMP (RD22) ICC personnel participate in the detailed design and implementation of some of the HCSS functions (e.g. the CUS). Also ICC personnel carry out specific HCSS work packages identified as instrument specific work. An example of this is the design and implementation of a *HIFI* specific data frame engine to convert *HIFI* TM packets in *HIFI* data frame objects.

5.1.3 *HIFI* building block, observing mode and AOT definition

The *HIFI* observing modes will be designed and documented (RD29, RD30 and RD31). This is done jointly with instrument specialists and consortium scientists. The aim is to minimise the number of different observing modes, as each mode will have to be scientifically verified during operations by the *HIFI* ICC both in terms of data taking and product generation. In this process of minimising the number of modes a balance has to be struck between ICC workload and a possibly serious decrease in the possible scientific topics that can be addressed using *HIFI* observations.

In the process of defining the HIFI observing modes, the different parts of an observation will be divided up into observation building blocks. These building blocks are the elements used to separate data streams for uplink and downlink data processing. Both the commands sent up as well as the data received from the instrument will be labelled with unique identifiers for each type building block. Individual building blocks will be directly commandable from the CUS. An example use of building blocks is when a calibration scientist retrieves and analyses all data taken within a *HIFI* mixer tuning building block to find trends in the mixer properties.

Based on the observing modes the Astronomical Observing Templates (AOT) for *HIFI* will be defined. These AOTs will allow the general astronomer to specify observations that are to be carried out with *HIFI*.

5.1.4 ICC required *HIFI* instrument design changes

In the ICC and ground segment design requirements on the *HIFI* instrument development are put forward to the *HIFI* system engineering team. In this team tradeoffs are made whether such ICC requirements can be adapted or not.

Requirements on the instrument development are:

- Telecommand definition, in particular the definition of commands for setting the observation and building block identifiers
- On board software design, in particular the modularity of the onboard software

- Telemetry definition, in particular the use of APID to separate data streams and the labelling of telemetry packets with observation and building block identifiers
- Properties of the internal calibrators and the level of accuracy of their use

5.1.5 Calibration

Calibration activities start with establishing the overall *HIFI* calibration strategy and writing this down in the *'HIFI calibration plan'* (RD14). The *HIFI* calibration group carries out this work. Following the adopted strategy (types of) astronomical calibration sources have to be selected and characterised through modelling and/or observations. In this process the calibration plan will probably undergo changes as well. Following the laid out strategy a plan for the Performance Verification phase has to be established in which observations and calibrations to be carried out in PV are detailed.

Also support will have to be given to the HSC for the preparation of the of the overall observatory PV plan which should include HIFI contributions relevant for e.g. cross-calibration. This activity will be coordinated by the Herschel Calibration Steering Group.

In the test periods data will be taken that will be used to establish the pre-flight calibration of *HIFI*. These data will be analysed with the various analysis programs provided in RTA, QLA and CA (see section 4.6.3.4 and 4.6.3.5).

5.1.6 Integration and tests

5.1.6.1 Subsystem and acceptance tests

In these tests instrument subsystems are tested. There is little direct involvement in the test work by ICC personnel.

5.1.6.2 ICC tests

To date no internal ICC interfaces or systems have been identified that are not already tested under the HCSS system tests.

In preparation for the ILTs the ICC systems (primarily the HCSS with *HIFI* specific IA and QLA applications) will be tested as well as the interfaces between these systems and the EGSE. ICC and AIV personnel will carry out this work jointly.

5.1.6.3 Instrument Level Tests (ILT)

A (incomplete) model of the instrument is tested at SRON in an environment simulating the operational conditions. Commands are given through the EGSE and real time instrument data are analysed using this system as well. Further analysis is carried out off-line accessing the data through HCSS. Ideally at the DM ILTs, but definitely at the QM ILTs operational as well as data analysis procedures are tested on real instrument hardware. In this period such procedures can be further developed and optimised for satellite operations. By participation in these tests ICC personnel will gain hands-on experience with behaviour of the instrument.

The logical system set up as designed by the HGSSE and the EGSE work groups for the ILTs (see RD3) is given in Figure 14. Using an EGSE set up mimicking the operational environment (with the EGSE-ILT component simulating the MOC, up link, down link and CDMS systems) in-flight procedures can be sent to the instrument, and telemetry can be 'received' and stored in HCSS.

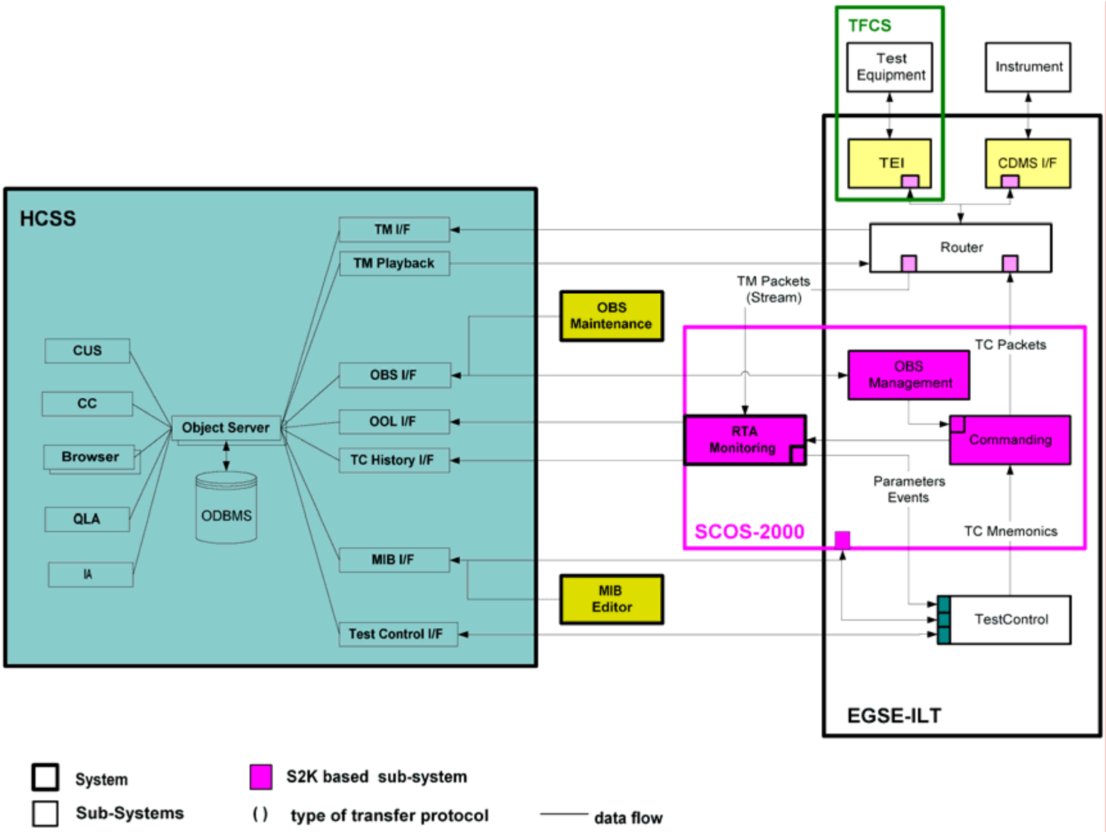

Figure 14: Ground segment set up for Instrument Level Tests (from RD3).

Data are analysed in real time using RTA and off line from HCSS using IA and CA. The acceptable time delays between data transmission from the instrument and receival at any of the ICC work places (see section 4.4) is given in Table 3.

ICC personnel will participate extensively in the ILTs as they present an ideal learning ground as well as a test bed for procedures and analysis software.

Location	Data	Delay	Driver
ILT			
ICC@ICC	HK Science	~1 min. ~1 min.	At the ICC only off-line analysis is carried out on data taken during ILTs. Feedback for tests is given after analysis of complete data sets.
ICC@EGSE	HK	<2 sec.	Personnel at the EGSE station need to interact directly with the instrument. Feedback is real time.

Table 2: acceptable data transmission delays during ILT.

5.1.6.4 Integrated System Test (IST)

The integrated system tests are carried out with the instrument integrated with the satellite at the prime contractor premises. Only pre-programmed test procedures are carried out under ESA responsibility. Instrument specialists monitor the instrument behaviour at the Central Checkout

Equipment (CCE) and (possibly) at a parallel EGSE/instrument station. Although these tests are more restricted, they are the only tests involving the entire satellite. Here especially procedures for check out can be exercised.

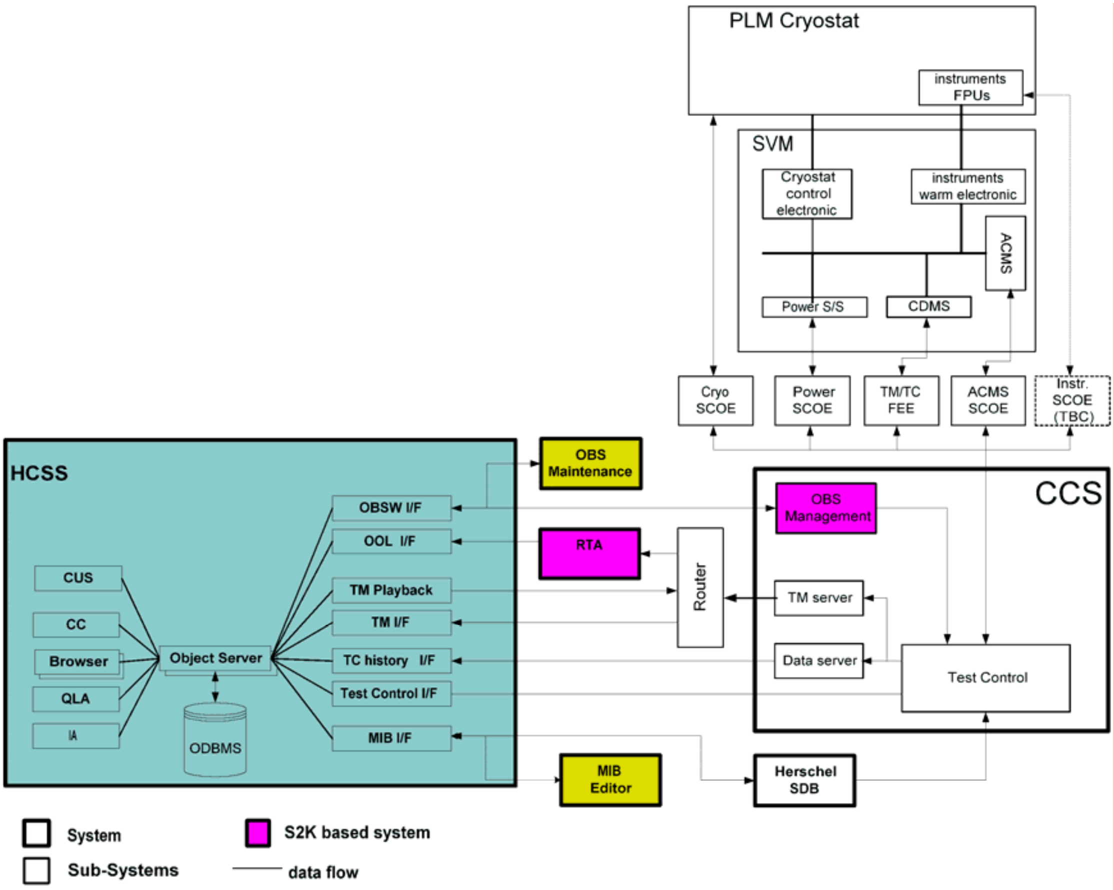

Figure 15. Ground segment set up for Integrated System Tests (from RD3).

Location	Data	Delay	Driver
ICC@ICC	HK Science	~10 min ~10 min	Only off-line analysis with little or no feedback to the tests.
ICC@EGSE (TBC)	HK	<5 sec.	Monitoring of instrument parallel with ICC@CCE
ICC@CCE		<2 sec.	Personnel at the CCE station need to be able to interact directly with the instrument. If any, the feedback is real time.

Table 3: acceptable data transmission delays during IST.

5.1.6.5 Ground segment test (GST)

There will be a number of tests of the integrated Ground Segment system in which the ICC will participate. The plans for the ground segment tests are given in RD26. These tests are carried out to verify that the ground segment and the interfaces between ground segment elements have been implemented such that operations can be carried out successfully. As a side effect these tests give a good training to ICC personnel in preparation for operations. The tests are listed in Table 4.

Test	Date	Duration
SVT0	L – 18 mo. (Aug. '05)	ICC possibly not involved
SVT1/EE1	L – 9 mo. (Apr. '06)	Approx. 3 weeks
SVT2/EE2	L – 6 mo. (Aug. '06)	Approx. 2 weeks
GS simulations	L – 4 mo. (Nov. '06)	TBD

Table 4. Ground verification segment tests and simulations.

5.1.7 Verification of *HIFI* observing modes and scientific analysis tools

Before operations the final deliveries of the *HIFI* observing modes and the various systems used for data analysis need to be verified, as they will be used in the observatory. This verification is carried out by taking ILT and IST data that were obtained by executing the standard HIFI observing modes and processing these data using the SPG, QCP and SA systems. This clearly requires that sufficient AOT-based test measurements have been carried out during the various tests.

5.1.8 ICC and Herschel (ground segment) reviews

In the development phase a number of Herschel (ground segment) reviews are identified. Because a major part of the ICC work is actually ground segment work, these reviews explicitly review the ICCs as well. For that purpose the ICC review cycle will be synchronised with the overall ground segment review cycle as much as possible. The reviews that are to be held/planned are listed in Table 5.

Review	Date	Aim
HCSS V0.1 SSR/PDR	1/12/2000	Review HCSS V0.1 requirements and design with respect to implementation of system to support ILT in 2002
HIFI ICC Preliminary Definition Review	3/4/2001	Review of ICC requirements on *HIFI* instrument in preparation of overall *HIFI* PDR
GS Requirements Review	Feb 2003	
HIFI calibration review	Nov. 2003	Review of the calibration strategy and plans for the *HIFI* instrument
Mission level Critical Design Review	Dec. 2003	
GS Design Review (L-3 yr.)	Feb. 2005	
GS Implementation Review (L-1 yr.)	Aug. 2006	
GS Readiness Review (L-3 mo.)	Mar 2007	
Operations readiness review (L-1 mo.)	Jul. 2007	
Mission commissioning review	Jan. 2008	

Table 5: *HIFI* ICC and Herschel ground segment reviews.

5.1.9 Preparations for operation

5.1.9.1 The *HIFI* long term calibration plan

A long-term calibration plan will serve as the baseline in which the purpose and frequency of specific calibration observations will be given. It should contain a complete list of suitable calibration sources and their parameters. It is likely that in the course of the mission the long-term calibration plan will be adjusted.

Wherever possible the calibration observations (internal as well as external) will be done using standard scientific observing modes. This will lead to calibration parameters that are measured and derived in a fashion identical to the science observations themselves, resulting in higher calibration accuracy.

The calibrations foreseen for routine flight operations as well as the external calibration sources that are to be used are documented in the *HIFI* calibration plan (RD14).

5.1.9.2 PV preparation

In the development phase the full PV plan will have to be established. The PV plan will be derived from the overall calibration strategy as laid down in the *HIFI* calibration plan (RD14). This means defining a schedule of observations to be carried out in the PV phase and implementing this schedule by generating the relevant observations and scheduling instructions for inclusion in the mission database.

The creation of PV schedules will be done using the MPS functions available in the HCSS, likely fully under the responsibility of the ICC. Since the formal observing schedule interface is between the HSC and MOC, the ICC prepared schedules will be sent to the MOC via the HSC (after approval by the PS).

5.1.9.3 ICC training

All ICC developers will have to be trained in Object Oriented techniques. They will have to be schooled in the use of the unified modelling language and in the concepts behind use case definition and analysis. Specifically software implementers will also have to be trained in the use of the UML tool TogetherJ, the implementation languages Java and Jython and in the ODBMS Versant.

Most -if not all- *HIFI* ICC personnel must get some hands on experience with doing and analysing astronomical sub millimetre observations (e.g. by performing observations using JCMT, CSO and/or IRAM).

5.1.9.4 Training of incoming personnel

It is expected that outside personnel will be allocated to the ICC for short terms. Examples of this are the planned co-location of ESA personnel for periods of few months every year, visits by IPAC representatives or visits form consortium members. All these incoming personnel are expected to come to the ICC to take up a specific development or operational task; visits only to get information from the ICC will not be allowed.

The incoming personnel will have to learn about the intricacies of *HIFI*, its operations and the relevant data analysis tools. Also they will have to be instructed in the standard *HIFI* ICC work procedures. The workload associated with this kind of training is very hard to estimate as it depends strongly on the background of the persons involved and the number of visitors that will actually come. To make such incoming personnel effective in helping completing the HIFI ICC tasks visits should at minimum be several months. This training will only be given if the net effect is really positive for the ICC.

The requirement that ICC personnel are working a significant fraction of their time on ICC dedicated tasks (see section 4.2.1) also applies to these incoming personnel, clearly time for their training needs to be added to that.

5.2 External deliveries and deliverables

In the development phase a number of deliveries to other Herschel partners have to be made, and a number of deliveries to the ICC are expected. These are given in Table 6. Note that for systems the deliverables implicitly includes delivery of the relevant documentation (installation manuals, user manuals etc.).

From	To	What	Delivery date
HIFI instrument	*HIFI* ICC	MIB versions for HCSS Vn.m tests	HCSS Vn.m -2 months
HIFI instrument	*HIFI* ICC	Instrument TM ICD	Q2 2002
HIFI instrument	*HIFI* ICC	DM QLA specifications	DM ILT-2 months
HIFI instrument	*HIFI* ICC	QM QLA specifications	QM ILT-2 months
HIFI instrument	*HIFI* ICC	FM QLA specifications	FM ILT-2 months
HIFI instrument	*HIFI* ICC	Instrument User Manual	L-12 months
HIFI instrument	*HIFI* ICC	In Flight Operational Procedures	L-12 months
HIFI instrument	*HIFI* ICC	Check Out plans and procedures	L-12 months
HIFI instrument	*HIFI* ICC	MIB	L-12 months
HIFI instrument	*HIFI* ICC	MIB editor	L-12 months
IFSI	*HIFI* ICC	OBSM	L-12 months
IFSI	*HIFI* ICC	OBSW user manual	L-12 months
HSC	*HIFI* ICC	HCSS V0.1	June 2002
HSC	*HIFI* ICC	HCSS V0.2	May 2004
HSC	*HIFI* ICC	HCSS V0.3	December 2004
HSC	*HIFI* ICC	HCSS V0.4	December 2005
HSC	*HIFI* ICC	HCSS V1.0	December 2006
HIFI ICC	HSC	AOT descriptions	Q3 2005
HIFI ICC	HSC	Observers manual	Q2 2006 TBC
HIFI ICC	HSC	SPG modules	L-12 months TBC
HIFI ICC	HSC	QCP modules	L-12 months TBC
HIFI ICC	HSC	PV plan	L-8 months TBC
HIFI ICC	HSC	PV schedule(s)	L-4 months TBC
HIFI ICC	MOC	Information for HIFI instrument simulator	Starting Q1 2003

Table 6. ICC deliveries and deliverables in the development phase.

5.3 Organisation

The organisation of the ICC in the development phase is given in Figure 16. It derives directly from the organisation for operations in that the same groups are needed except for the 'operations group' who deal primarily with the logging handling of day-to-day events.

For major development projects specific subgroups are formed. The leader of such a group provides a detailed work plan reports directly to the ICC manager.

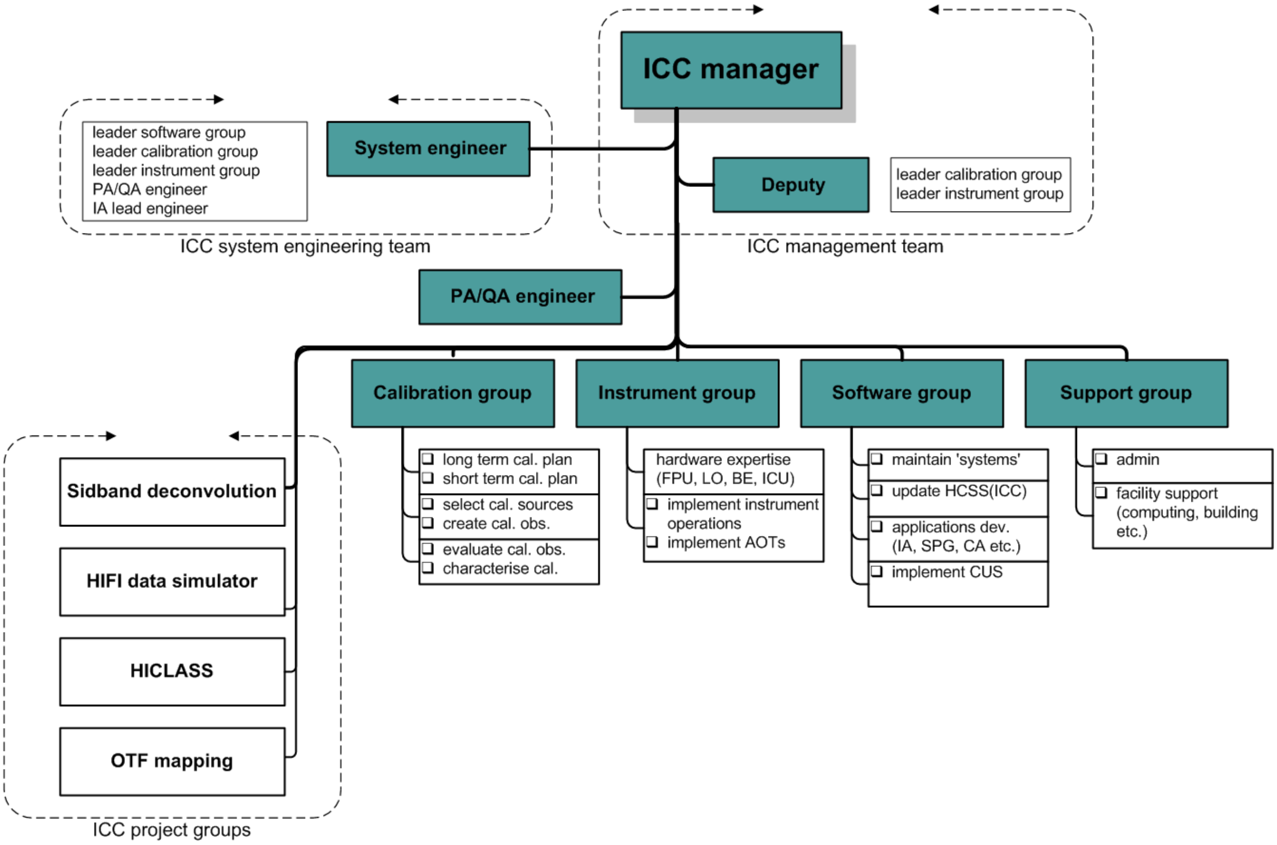

Figure 16: *HIFI* ICC organigram for the development phase.

6 In orbit Check Out and Performance Verification

In this phase the instrument and satellite are in flight and all contact with the instrument goes according to predefined procedures executed by MOC personnel.

The ground segment operational configuration in this phase in indicated in Figure 2.

6.1 Activities

The details of the activities during this phase will be established in the ICC development phase. Therefore the following sections can only be seen as indicative for what activities will be performed and what kind of resources are required to carry out all ICC tasks.

6.1.1 In orbit Check Out

The in orbit Check Out is intended to verify that the instrument has survived the hardships of launch and space flight and is –in principle- useable for scientific observations.

In the in orbit Check Out phase the predefined and tested check out procedures are executed on the instrument in flight. Instrument parameters (mainly housekeeping data) are monitored by the MOC. The ICC personnel at the MOC shall analyse the real time data using RTA to establish the status of the instrument. MOC personnel, in close contact with the ICC instrument specialists, will do all instrument commanding.

After transmission of the telemetry to HCSS further detailed analysis will be carried out at the ICC using IA.

Location	Data	Delay	Driver
ICC@ICC	HK Science	~10 min. ~10 min.	Only off-line analysis with little or no feedback to the tests.
ICC@MOC		< 2 sec.	Personnel at the instrument station need to monitor the instrument in real time. Similar (the same?) tests will be carried out as in IST, and thus time scale for data to arrive should be the same. Interaction with the instrument is done via the MOC spacecraft operators.

Table 7: acceptable data transmission delays during in orbit Check Out.

6.1.2 Performance Verification

The Performance Verification phase is intended to obtain a first characterisation of the instrument in terms of stability, sensitivity, resolution etc. For this purpose a PV schedule is prepared in the period before launch containing a balanced set of internal and external calibration observations. Note that also in this phase the effect of Herschel pointing errors requires special attention for the highest frequency bands of *HIFI*.

The predefined PV schedule is followed as closely as possible. The schedule is changed only when detailed analysis shows that the pre-planned schedule is not suitable for further characterisation of the instrument. . Since there is only limited ground contact, schedule changes will only be possible on a time scale of TBD days. In this case new calibration sequences are generated and submitted to the HSC (TBC) for scheduling.

ICC personnel at the MOC monitor data in real time. Most more detailed analysis is done off line at the ICC using IA facilities.

Location	Data	Delay	Driver
ICC@ICC	HK	~10 min.	Only off-line analysis with little or no feedback.
	Science	~30 min.	Only off-line analysis with feedback to the observing schedule on timescale of day(s).
ICC@MOC		< 1 min.	Only for monitoring, little or no feedback to operations expected.

Table 8: acceptable data transmission delays during PV.

6.1.3 Verification of *HIFI* observing modes and scientific analysis tools

As part of performance verification also the *HIFI* observing modes and the various systems used for data analysis need to be verified, now for the first time using real astronomical observations. The verification is done by spot-checking selected (dedicated) standard *HIFI* AOT observations on celestial sources and processing the data with the production versions of SPG, QCP and SA.

The HSC will carry out large-scale user trials of these systems as extra verifications that they function properly.

The astronomical community will be informed of the conclusions of this verification through the HSC.

6.2 Organisation

During check out and PV the full ICC organization is required as the workload and complement will be likely higher than that of the routine operations phase. This is reflected in the organigram already shown in Figure 9; it is the same as for operations.

7 Operations

HIFI flight operations are driven by two of the ICC's main tasks: monitoring the instrument health and calibrating the instrument. These main tasks are carried out by analysing instrument science data as well as housekeeping data and –when needed- planning specific (calibration) observations (internal and external). For the analysis various software tools (see section 4.5) will be used, leading to a third major operational task: the (further) development and maintenance of analysis software. Finally, if the analysis of the instrument behaviour requires it changes to the operational modes of the instrument will be implemented.

In this phase there is no real time interaction with the instrument, observations are carried out according to a predefined schedule generated on a TBD-weeks timescale. Science data will typically be analysed on the next working day. House keeping (event) data are evaluated as soon as they arrive, so as to be able to start 'emergency' procedures within the ICC if non-nominal instrument behaviour is detected.

When serious anomalies occur in the routine phase it will be possible to revive the operational set-up and associated delivery time scales as specified for PV or even C/O (see sections 6.1.1and 6.1.2).

7.1 Activities

The details of the activities during the operations phase will be established in the ICC development phase. Therefore the following sections can only be seen as indicative for what activities will be performed and what kind of resources are required to carry out all ICC tasks.

7.1.1 Monitoring instrument health

The first priority is general monitoring of the health of the instrument and follow up of anomalous behaviour of the instrument. The activities carried out for monitoring purposes are listed in Table 9.

When	What	Notes
Every workday	Inspect real time log files prepared by MOC	
	Inspect *HIFI* health and status parameters generated onboard	
	Inspect observations which are 'suspect' based on MOC logs or health/status parameters	
Every week	Inspect specific observations carried out for monitoring purposes	1
	Inspect typical science observations for anomalies	2
As requested	Inspect specific observations which are 'suspect' (e.g. after comments from end users)	

Table 9. Activities carried out for *HIFI* instrument monitoring.
Notes:
1 - activity combined with standard calibration work (section 7.1.2)
2 - activity combined with evaluation of scientific processing software

When anomalies are reported by e.g. MOC personnel or end-users investigating their science observations the relevant data and/or housekeeping parameters will be analysed. If needed special calibration or engineering observations are proposed. Changes to the operational modes or on board software may be proposed following such 'trouble shooting' work.

A significant part of the analysis work for health monitoring and anomaly follow up can be done using RTA or QLA-type facilities. This is especially true for the inspection of the health and status parameters in combination with the MOC logs. Detailed data analysis will be carried out in the more general IA/CA/TA environment.

The acceptable delays in receiving instrument telemetry in the routine operations phase are given in Table 10.

Personnel that has detailed understanding of the hardware and the functioning of the *HIFI* instrument will be required for this work.

Location	Data	Delay	Driver
ICC@ICC	HK	~10 min.	Mainly used for first evaluation whether any (serious) anomalies occurred and to plan subsequent ICC activities. Data further used for off-line analysis with feedback to the scheduling process.
	Science	~2 hour.	Only off-line analysis with feedback to the observing schedule on timescale of days.
ICC@MOC		N/A	

Table 10: acceptable data transmission delays during routine operations.

7.1.2 Instrument calibration

For instrument calibration data are taken in the internal calibration modes of the instrument and towards external sources in specific operating modes. The data obtained in this fashion are compared with models or other observations of similar sources. The work can be divided in two parts: calibration planning and calibration analysis.

In Table 11 the ICC activities that are carried out in the framework of *HIFI* calibration are given.

When	What	Notes
Every week	Select calibrations to be carried out in next period	
	Select sources suitable for desired calibrations	
	Make relevant observation specifications and submit to HSC	1
Continuously	Monitor overall status and progress of instrument calibration	
	Adjust long term calibration plan when needed	
	Find (information on) calibration sources	

Table 11. Calibration activities carried out in operations.
1 - activity combined with instrument health monitoring (section 7.1.1)

7.1.2.1 Calibration planning

For every calibration cycle a series of observations will be selected based on the long-term calibration plan. AOTs or CUS scripts are constructed for the observation and these are handed over to the HSC for scheduling.

To monitor the progress of *HIFI* calibration and for maintenance of the long-term calibration plan scientists are needed. Data aides can carry out the actual specification of calibration observations and submission to the HSC.

7.1.2.2 Calibration analysis

Having carried out the calibration observations, they must be processed and analysed. Especially the analysis and interpretation will be a major task. All results from calibration work will be compiled into calibration reports.

When	What	Notes
Every week	Process calibration observations of previous period	1
	Analyse calibration data of previous period	
	Add conclusion of calibration analysis to calibration reports	

Table 12. Calibration analysis activities.
1 - standard processing software should be used to provide extra testing for the standard processing software

Data aides can carry out the standard processing. The detailed calibration analysis will require several scientists who are knowledgeable both in the instrument behaviour and in the properties of the observed calibration sources.

7.1.2.3 Support for cross-calibration

The HIFI ICC will give TBD (limited) support to Herschel observatory cross-calibration as identified by the Herschel Calibration Steering Group.

7.1.3 Further development and validation of software tools

Maintenance of all ICC software tools (the IA environment, RTA, QLA, CA, instrument simulator etc.) will be driven by operational requirements and shall receive high priority during the operational phase. Further development of SPG and SA are less critical operationally. Development of these packages will be science driven and will be supported by the *HIFI* science consortium (definitely for testing, possibly for development as well). The maintenance will follow proper coding standards and take place within the HCSS defined configuration control scheme.

After updates the various systems used for data analysis will be validated using real astronomical observations like during PV. The verification is done using spot checks on the (dedicated) standard *HIFI* AOT observations on celestial sources as defined during PV and processing the data with the production versions of SPG, QCP and SA. Where needed the standard test set is extended to cover changes in operational behaviour of the instrument.

The HSC will carry out user extensive trials of these systems as extra verifications that they function properly.

The astronomical community will be informed of the conclusions of this verification through the HSC.

7.1.4 Changing *HIFI* operational modes

It is expected that during operations it will be found that (some of) the operating modes of *HIFI* as defined pre-launch are sub-optimal for space conditions. In this case the operating modes will be adapted by modifying the operational instrument settings and/or relevant software. The modifications will be tested on the instrument simulator to verify that they were implemented correctly and have the desired effect on instrument operations. Subsequently the modified operational mode will be delivered to HCSS together with specific test observations. After evaluation of these tests has shown the correct implementation of the change the new operational mode can be installed for scheduling scientific observations.

The ICC system group will design a change to the operational mode, the software group will carry out the necessary modifications. The PA/QA engineer will check testing.

7.1.5 Changing *HIFI* operations

7.1.5.1 OBSW changes - TBW

7.1.5.2 TM/TC definition changes - TBW

7.1.5.3 Testing - TBW

7.1.5.4 Deliveries - TBW

7.1.6 Operations support

During operations the more complex queries with regard to operations of the *HIFI* instrument will be sent via the HSC helpdesk to the ICC. These will be dealt with initially by the systems group, who when needed will ask help from other team members. As the mission progresses it is expected that more and more queries will regard calibration matters, thus at some stage the calibration group will become the initial point of contact.

General Herschel operations will be supported in terms of assisting HSC personnel in cross calibration matters.

7.1.7 Science data analysis

7.1.7.1 Science demonstration phase

In the science demonstration phase a number of observations will be performed to demonstrate the scientific capabilities of *HIFI* and the data reduction systems. These will be the first 'standard' HIFI observations to be reduced using the SPG in a 'standard' mode, and as such an important test for the proper functioning of SPG. It is to be expected that after running SPG on these data significant interactive processing will need to be done to fully exploit the capabilities of the HIFI instrument. Here the deep instrument understanding needs to be combined with a full grasp of the functionalities available in the IA system. ICC members will play an important role both in analysing these data as well as in upgrading IA functions to incorporate understanding gained in the exercise.

7.1.7.2 Key programmes

The *HIFI* ICC will not support the preparation and/or analysis of the so-called key-programs, the ICC is not scoped to take up this task. If these need to be supported a significant level of extra manpower will be required.

7.1.7.3 Coordination of (consortium) science data reduction

In operations some coordination will be needed for the data reduction of astronomical observations that are expected to be of importance for the calibration of *HIFI* as well as for the monitoring of the instrument. The ICC will take the lead in organising this. Also the *HIFI* consortium – in practice the main body of testers for the *HIFI* data analysis software – when processing their data will want up to date information from the ICC w.r.t. the quality of the current analysis software and the expected improvements. Again a coordinating role is envisaged for the ICC.

7.1.8 ICC support

Support of the daily ICC work consists of two types of work; clerical support and computer systems maintenance. Both will be on a normal workday schedule during operations. In PV phase 7 days per week support is required.

7.1.9 Reporting – TBW

7.2 Organisation

The organization of the ICC will be the same as shown in Figure 9.

8 Post operations

8.1 Activities - TBW

8.2 Organisation - TBW

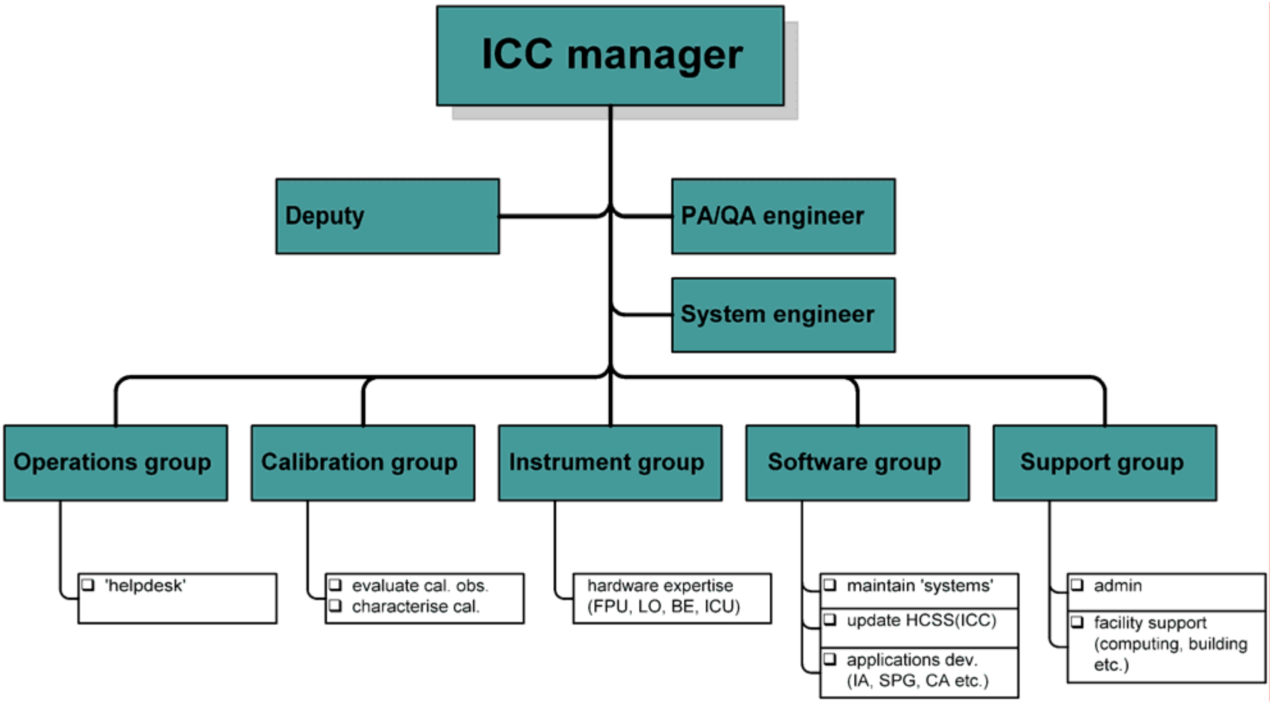

Figure 17. *HIFI* ICC organigram for post operations.

9 Risks and risk mitigation

There are a number of risk areas in the HIFI ICC development and its schedule. The risks identified so far are discussed in the following sections for the different phases.

9.1 Development phase: not enough personnel available at the appropriate time

9.1.1 Risk item

Given the pressures on the consortium to provide *HIFI* hardware components within the schedule set by the ESA project, it is not inconceivable that ICC personnel will be diverted from ICC tasks to assist in hardware development.

9.1.2 Risk mitigation

A reduction of ICC manpower will require re-scoping and/or rescheduling of ICC development work. Several areas of de-scoping can be identified. These can be prioritised based on the prime task of the *HIFI* ICC which is to firstly maintain the health and safety of the instrument and to secondly use the instrument as efficiently as possible to carry out scientific observations.

- IA development
  With limited ICC manpower the first reduction that will be done is work in the area of IA facilities not absolutely needed for ICC operational tasks (specifically Science Analysis, and the Quality Control Pipeline). Following this support for pipeline verification will be reduced.
- End user support
  When there is still insufficient ICC personnel also direct support for *HIFI* users will be diminished.
- Reducing the number of observational modes
  An additional way of reducing ICC effort is by de-commissioning *HIFI* operational modes. This will reduce effort both in the area of providing calibration parameters for these modes as well as providing analysis tools for them.
- Calibration work
  As a last resort calibration work that is not absolutely needed to maintain reasonable state of HIFI operations for the minimum set of observing modes.

Clearly such re-scoping will have to be agreed with the *HIFI* consortium partners.

9.2 Development methodology costs more effort than expected

9.2.1 Risk item

The chosen development methodology has a risk in that personnel (especially older personnel) will have to be trained in object oriented technology and the relevant development tools. In principle this could lead to development delays due to the relatively large training overhead (although it should be noted here that experience has already shown that younger astronomers and software developers easily adapt to this methodology). In any case a fairly steep learning curve is expected resulting in relatively long lead times before operational systems become available.

9.2.2 Risk mitigation

This risk can be mitigated by proper progress monitoring such that cost increase can be seen ahead of time. When delays do become evident also here a solution must be found in either increasing the ICC size or de-scoping the ICC (see section 9.1).

9.3 IA/QLA framework not available for ILT

9.3.1 Risk item

To build QLA applications as needed to support the HIFI tests in ILT a proper IA/QLA framework will be needed. If not enough functionalities are available in time for ILT, the HIFI ICC will have to develop the relevant QLA applications based on another environment (or from scratch). Note that this could mean not only extra effort on the application development side but also for e.g. archiving.

9.3.2 Risk mitigation

This potential problem is kept in check by being actively involved in the management process of the common IA development through membership of the HCSSMG, HGSSG and the Herschel IA work group. This way the needs of *HIFI* are directly taken along in the decision making process of what functions shall be implemented first. Also this way information on development priorities that might negatively impact *HIFI* will be obtained early on in the process, allowing renegotiation and/or re-scheduling of activities and resources.

9.4 Missing HCSS functionalities - TBW

9.4.1 Risk item

9.4.2 Risk mitigation

9.5 Environment to properly test OBSW updates not available - TBW

9.5.1 Risk item

9.5.2 Risk mitigation

A ICC location and facilities

The current baseline is to house the *HIFI* ICC at the Rijks Universiteit Groningen (RUG) at the premises of the Space Research Organisation of the Netherlands (SRON) and the Kapteyn Astronomical Institute (KAI). The two institutes will jointly operate and support the ICC and its infrastructure. Table 13 indicates what kind of infrastructure (rooms, computing facilities) are needed if all personnel identified in Table 26 is at a single location. At times when the ICC is more dispersed more facilities and equipment will be needed.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Personnel	1.0	3.5	9.0	15.7	20.9	22.6	21.5	21.2	19.0	14.4	12.1	11.8
Infrastructure												
Desks	2	4	10	16	21	23	22	22	20	15	13	12
Rooms	2	3	4	6	8	9	8	8	8	6	5	5
Computing												
CPU's	2	4	10	16	21	23	22	22	20	15	13	12
Printers		1	2	3	4	5	4	4	4	3	3	2

Table 13. Infrastructure requirements for *HIFI* ICC

A.1 Network

To support the data analysis needs of e.g. the ICC calibration scientists all CPUs must be connected through a high speed network (>100Mb/sec). Similar high-speed connections are necessary to the other Herschel ground segment elements to be able to use HCSS properly.

A high-speed network (100Mb/sec capability) exists in the SRON/KAI premises. The local routers are connected to the high speed Dutch network (planned speed 640Mb/sec in early 2000).

A.2 Support

General system support for maintenance of the facilities (computers, building etc.) will be given by SRON/KAI. This includes making available general facilities (copiers, communication equipment etc.) and office supplies.

General clerical/administration support is expected from SRON/KAI at a level of maximum 0.5-1.0 FTE in the busiest ICC work periods (2005-2008).

B Contributing institutes – TBC

The currently (21 December 2004) foreseen overall manpower profile for the *HIFI* ICC in the development phase is summarised in Table 14. This is still a very preliminary allocation; firstly for some consortium partners the contribution is not yet defined (e.g. US, Poland, Sweden, Switzerland and Canada), secondly some contributions are still very much contingent on funding by national agencies. In the following subsections and accompanying tables the details – as known today – for each country are given.

In establishing the total size of the *HIFI* ICC not all proposed contributions are taken into account. Allocations less than 0.1 FTE (or equivalently 4 weeks work or work visits) have been omitted, as these do not represent a really effective contribution. Such limited contributions are completely taken up by learning and communication with other ICC members (and those other persons actually lose time…).

The lowest two lines of Table 14 give the amount of manpower needed as estimated from the work packages as given in appendix C and the manpower shortage if all those work packages are to be completed.

HIFI ICC allocation	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Dev	Ops	Pops	Total
Netherlands	0.8	1.4	3.1	4.4	5.7	5.6	5.4	6.5	6.2	4.2	3.3	3.3	32.8	17.0	7.9	57.7
USA			0.1	0.2	0.2	0.6	1.3	1.3					3.7			3.7
Germany		0.2	0.4	0.8	0.8	1.4	3.0	3.0	3.2	1.6	1.6	1.6	9.6	8.0		17.6
France	0.3	1.4	2.0	1.4	1.5	1.8	3.3	3.0	1.1				14.7	1.1		15.8
Italy		0.1	0.6	0.5	0.7	0.7	1.0	1.2	1.2				4.8	1.2		6.0
Spain			0.1	0.1	0.7	1.8	2.5	1.8	1.8				7.0	1.8		8.8
Sweden																
Poland						0.6	1.0	1.0	1.0				2.6	1.0		3.6
Switzerland																
Canada						0.2	1.2	1.4	1.4	1.4	1.2	0.2	2.8	4.2		7.0
ESA					0.5	0.5	0.5	0.5	0.2	0.2	0.2	0.2	2.0	0.7		2.7
Total per year	1	3	6	7	10	13	19	20	16	7	6	5	80	35	8	123
Total needed	1	3	6	7	10	18	23	23	17	12	10	9	92	47	18	157
Extra needed						5	4	3	1	5	4	4	12	12	10	34

Table 14. Overview of allocated manpower for *HIFI* ICC development work.

In Figure 18 the build up of HIFI ICC manpower is graphically indicated. The different colours represent the different countries; the dark blue background shows the total manpower requirement as estimated from the ICC work packages. Note that the large discrepancy from 2007 onwards is somewhat artificial since most consortium partners as yet have no insight into their funding situation for operations and post operations.

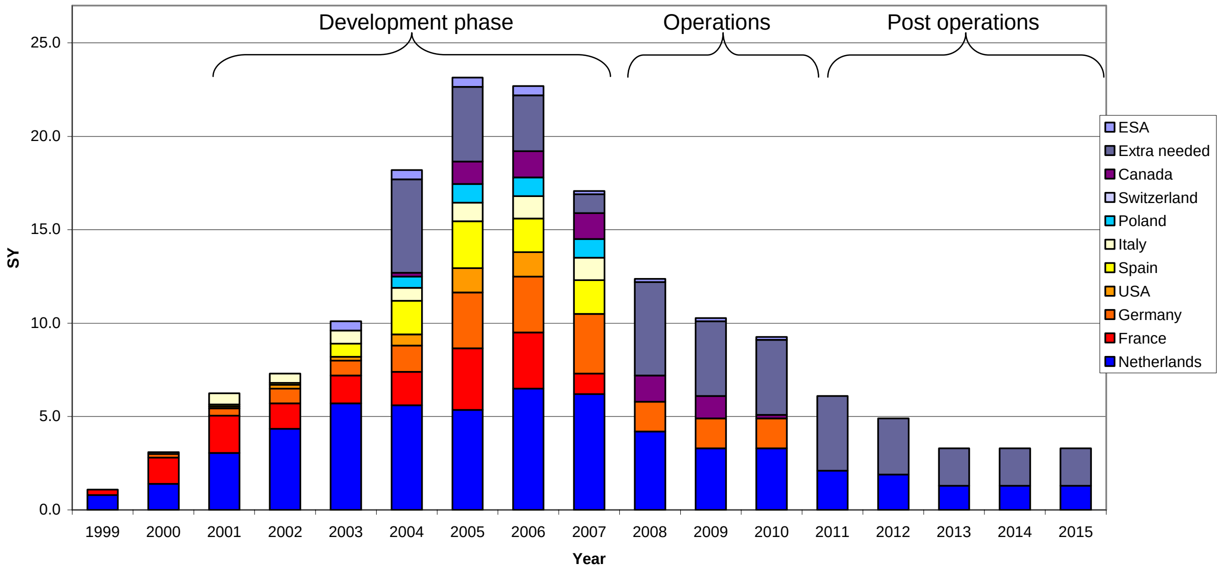

Figure 18. Consortium manpower allocation for the *HIFI* ICC.

B.1 Netherlands: SRON, KAI

This section gives an initial estimate of the total budget involved in the *HIFI* ICC. All amounts are in thousands of Euros (k€). The estimates are based on the manpower plan given in Table 26.

Note that at this time the budget does not include post operations and that the listed numbers are based on 2002 prices and 0% inflation

B.1.1 Manpower

The manpower currently planned to be available from SRON for ICC work is listed in Table 15. The position 'NN-system' is expected to be filled by one of the AIV or system engineers once the instrument hardware phase activities reduce.

Note that L.Dubbeldam does not formally fall under the ICC but as member of the *HIFI* instrument consortium he is actively involved in work on TC/TM and test script definition as listed in the work package definitions.

HIFI ICC allocation	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Dev	Ops	Pops	Total
P. Roelfsema	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.4	0.4	4.6	1.8	1.2	7.6
A. de Jonge	0.3	0.4	0.5	0.5	0.3	0.5	0.5	0.5	0.2	0.2	0.2	0.2	3.5	0.8	1.0	5.3
D. Kester			0.3	0.3	0.3	0.5	0.3	0.5	0.7	0.7	0.7	0.7	2.0	2.8	2.0	6.8
J. Bresser					0.5											
Comp. supp. (KAI/SRON)			0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.6	0.4	0.5	1.5
D. Beintema	0.1	0.1	0.2	0.4	0.4	0.3							1.5			1.5
W. Jellema						0.1	0.2	0.5	0.5	0.2			0.8	0.7		1.5
N. Whyborn							0.2	0.5	0.5	0.2			0.7	0.7		1.4
G. de Lange							0.2	0.5	0.5	0.2			0.7	0.7		1.4
NN-system																
P. Zaal		0.2	0.6	0.6	0.7	0.7	0.5						3.3			3.3
NN-software							0.2	0.7	0.7	0.7	0.7	0.7				
G. Wierstra				0.5	0.5	0.7	0.7	0.7	0.7				3.1	0.7		3.8
V. Ossenkopf				0.4	0.4	0.4	0.4	0.4	0.4				2.0	0.4		2.4
D. Teyssier				0.1	0.7	0.4							1.2			
F. Helmich			0.3	0.3	0.4	0.4	0.6	0.6	0.6	0.6	0.6	0.6	2.6	2.4	1.6	6.6
K. vd Hucht		0.1	0.1	0.1	0.2											
NN																
L. Dubbeldam			0.4	0.4	0.4	0.4	0.4	0.4	0.2	0.2						
R. Shipman				0.1	0.3	0.5	0.5	0.5	0.6	0.6	0.6	0.6	1.9	2.4	1.6	5.9
Total per year	0.8	1.4	3.1	4.4	5.7	5.6	5.4	6.5	6.2	4.2	3.3	3.3	28.5	13.8	7.9	49.0

Table 15. SRON/KAI manpower allocation for ICC work.

B.1.2 Building and office

The available offices at the University of Groningen (RUG) in the Kapteyn Astronomical Institute (KAI) and SRON are expected to be sufficient to house all *HIFI* ICC staff. Therefore only remodelling (e.g. changing some walls and/or doors) and decoration (desks etc) cost need to be considered. The budget foresees k€ 1.5 ad k€ 0.5 respectively for these. Refurbishment is foreseen every 6 years.

B.1.3 Computing facilities

The computing facilities required for the ICC are estimated as roughly one Pentium IV 2GHz class CPU per ICC member. Current prices for these are about k€ 4. Each machine will be replaced after 3 years. Per 5 personnel one printer (of about k€ 2.5) will be required. These will also be replaced after 3 years. Finally k€ 2.5 per year per extra CPU is allocated for software purchases and k€ 0.5 per year for each CPU for maintenance.

It should be noted that the cost listed in Table 16 are valid if *all* ICC personnel are at *one* location *all* the time. In the development phase the ICC will in practice be distributed over the consortium institutes, and each then provide facilities for the ICC personnel. When the operations ICC starts building up at Groningen it is expected that (some of) this hardware will be transported there as well for use by the ICC.

B.1.4 Travel

It is expected that *HIFI* ICC team members will be travelling significantly throughout all mission phases, however the travel profile will be very different for the different team members. Per person an average of 2 international trips (at k€ 1.5 per trip) and 4 national trips (at k€ 0.2 per trip) is used for the overall budget.

B.1.5 Cost overview

The overview of all main budget items for the *HIFI* ICC is given in Table 16. Note that especially in the early years existing computing facilities etc. can probably be used.

		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Dev.	Ops.	Total
Personnel		1	3	7	10	21	23	21	20	17	12	10	9	105	48	153
Infrastructure investments																
Desks	k€	1	1	2	2	6	1					4	4	12	8	20
Rooms	k€	3	2		2	6	2							14		14
Computing investments																
CPU's	k€	8	4	16	12	56	12	4	8	44				120	44	164
Printers	k€		3		3	5	5			3	5			15	8	23
Software	k€	1	4	14	13	46	20	11	10	9	7	5	5	117	25	142
Travel cost																
International	k€	6	9	21	30	66	72	63	60	51	39	30	30	327	150	477
National	k€	2	2	6	8	18	19	17	16	14	10	8	8	87	40	127
Miscellaneous	k€	1	3	7	10	21	23	21	20	17	12	10	9	105	48	153
Total	k€	22	27	65	78	224	153	115	114	136	73	57	56	797	322	1119

Table 16. Main budget items required for the *HIFI* ICC.

B.2 United States: JPL/IPAC

The manpower currently planned to be available from the United States (JPL and IPAC) for ICC work is listed in Table 17.

***HIFI* ICC allocation**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Dev**	**Ops**	**Pops**	**Total**
Steve Lord			0.1	0.2	0.2	0.4	0.4	0.4					1.7			1.7
Pat Morris						0.2	0.4	0.4					1			1
NN-NHSC							**0.5**	**0.5**					1			1
Total per year			0.1	0.2	0.2	0.6	1.3	1.3					3.7			3.7

Table 17. Manpower allocation for ICC work from US consortium partners.

B.3 Germany: KOSMA, MPfR

The manpower currently planned to be available from Germany for ICC work is listed in Table 18. The contributions of C. Kramer and C. Gal are mainly in the context of the calibration group.

***HIFI* ICC allocation**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Dev**	**Ops**	**Total**
C. Kramer – KOSMA		0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2				1.3	0.2	1.5
C. Gal – KOSMA		0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2				1.3	0.2	1.5
V. Ossenkopf – KOSMA				0.4	0.4	0.4	0.4	0.4	0.4				2	0.4	2.4
F. Schmuelling - KOSMA						0.1	0.1	0.1					0.3		0.3
C.Comito - Bonn						0.5	0.5	0.5					1.5		1.5
NN1							**0.8**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**	1.6	3.2	4.8
NN2							**0.8**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**	1.6	3.2	4.8
NN3									**0.8**	**0.8**	**0.8**	**0.8**		3.2	
P. Boerner - MPAE						0.5	0.5	0.5					1.5		1.5
C. Jarchow						0.1	0.1	0.1					0.3		
Total per year		0.2	0.4	0.8	0.8	1.4	3	3	3.2	1.6	1.6	1.6	9.6	7.2	16.8

Table 18. Manpower allocation for ICC work from German consortium partners.

B.4 France: CERS, LRM/ENS, Bordeaux

The manpower currently planned to be available from France for ICC work is listed in Table 19. The contributions of D. Texier, T. Jacq and C. Ceccarelli are mainly in the context of the calibration group.

HIFI ICC allocation	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Dev	Ops	Pops	Total
E. Caux - CESR	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1				0.8	0.1		0.9
O. Coeur-Joly - CESR	0.1	0.2	0.4	0.3	0.4	0.7	0.5	0.5	0.5				3.1	0.5		3.6
C. Nguyen - CESR							**0.5**	**0.5**	**0.5**				1.0	0.5		1.5
J.H. de Ragniac - CESR/CNRS					0.2	**0.3**	**0.8**	**0.8**					2.1			2.1
M. Belgacem - CESR			0.1	0.1	0.1	0.4	0.4	0.2					1.3			1.3
J.M. Larre - CESR		0.1	0.3	0.2									0.6			0.6
M. Perault - LRM/ENS	0.1	0.1	0.2	0.2	0.2		**0.2**	**0.2**					1.0			1.0
D. Teyssier - LRM/ENS		0.4	0.6	0.3									1.3			1.3
M. Gerin - ENS		0.1	0.1		0.1								0.3			0.3
E. Falgarone																
NN1CNES TBD LRM/ENS							**0.4**	**0.4**					0.8			0.8
F. Boulanger - IAS																
E. Dartois - IAS					0.2		**0.2**	**0.2**					0.5			0.5
N. Biver - LESIA																
J. F. Rabasse - LRM/ENS		0.2			0.2	0.2	0.2	0.1					0.9			0.9
T. Jacq - Bordeaux		0.1	0.1	0.1									0.3			0.3
F. Herpin - Bordeaux				0.1	0.1	0.1	0.1	0.1					0.5			0.5
C. Ceccarelli - Bordeaux		0.1	0.1										0.2			0.2
Total per year	0.3	1.4	2.0	1.4	1.5	1.8	3.3	3.0	1.1				14.7	1.1		15.8

Table 19. Manpower allocation for ICC work from French consortium partners.

B.5 Italy: IFSI, CAISMI

The manpower currently planned to be available from Italian consortium partners for ICC work is listed in Table 20. C. Codella is currently not any more associated with the *HIFI* project, however in the future he might be involved in calibration group work (TBC). A. Lorenzani will work a major part of 2001 and 2002 at SRON/Groningen.

HIFI ICC allocation	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Dev	Ops	Pops	Total
C. Codella – IFSI		0.1	0.1										0.2			0.2
A di Giorgio - IFSI							0.3	0.5	0.5				0.8	0.5		1.3
A. Lorenzani – CAISMI			0.5	0.5	0.7	0.7	0.7	0.7	0.7				3.8	0.7		4.5
Total per year		0.1	0.6	0.5	0.7	0.7	1	1.2	1.2				4.8	1.2		6

Table 20. Manpower allocation for ICC work from Italian consortium partners.

B.6 Spain: CSIC

The manpower currently planned to be available from Spain for ICC work is listed in Table 21.

HIFI ICC allocation	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Dev	Ops	Pops	Total
J. Martin-Pintado			0.1	0.1	0.1	0.1	0.1	0.1	0.1				0.6	0.1		0.7
D. Teyssier						0.3	0.7									
J Corrales Garcia					0.6	0.8	0.8	0.8	0.8				3	0.8		3.8
I. Rodriguez						0.6	0.9	0.9	0.9				3.3	0.9		4.2
Total per year			0.1	0.1	0.7	1.8	2.5	1.8	1.8				6.9	1.8		8.7

Table 21. Manpower allocation for ICC work from Spanish consortium partners.

B.7 Sweden

The manpower currently planned to be available from Sweden for ICC work is listed in Table 22.

HIFI ICC allocation	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Dev	Ops	Pops	Total
NN1																
NN2																
Total per year																

Table 22. Manpower allocation for ICC work from Swedish consortium partners.

B.8 Poland

The manpower currently planned to be available from Poland for ICC work is listed in Table 23.

HIFI ICC allocation	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Dev	Ops	Pops	Total
J. Grygorsczuk						0.5	0.5	0.5	0.5				2	0.5		2.5
J. Borowski						0.5	0.5	0.5	0.5				1.5	0.5		2
Total per year						1	1	1	1				3.5	1		4.5

Table 23. Manpower allocation for ICC work from Polish consortium partners.

B.9 Switserland

The manpower currently planned to be available from Switzerland for ICC work is listed in Table 24.

HIFI ICC allocation	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Dev	Ops	Pops	Total
NN1																
NN2																
Total per year																

Table 24. Manpower allocation for ICC work from Swiss consortium partners.

B.10 Canada

The manpower currently planned to be available from Canada for ICC work is listed in Table 25.

***HIFI* ICC allocation**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Dev**	**Ops**	**Pops**	**Total**
NN1							0.3	0.5	0.5	0.5	0.5	0.2	0.8	1.7		2.5
NN2						0.2	0.9	0.9	0.9	0.9	0.7		2	2.5		4.5
Total per year						0.2	1.2	1.4	1.4	1.4	1.2	0.2	2.8	4.2		7

Table 25. Manpower allocation for ICC work from Canadian consortium partners.

C ICC work packages – TBC

Table 26 gives the overview of the top-level work areas as defined for the ICC development and operational phases. For each area an estimated manpower level is given. A graphical representation is given in Figure 19. In Table 27, Table 29 and Table 30 this is further expanded per work package for development, operations and post operations phase respectively. These manpower estimates should be considered a first estimate, they need further elaboration with the *HIFI* consortium partners. Note that a number of work packages correspond directly to HCSS work package as defined in the HCSS SPMP (RD22).

More details on the individual work packages are given in the '*HIFI ICC work packages'* (HIFI-ICC-2000-022 - RD18).

WP nr.	WP name	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Dev	Ops	Pops	Totals
Mngt	Management	0.3	0.3	0.7	1.0	1.0	0.9	1.1	1.1	0.9	0.7	0.7	0.7	6.5	3.1	1.5	11.0
SysE	System Engineering	0.4	0.7	0.8	0.6	0.5	0.4	0.4	0.3	0.1	0.1	0.2	0.2	3.9	0.5	0.4	4.8
UpL	Uplink		0.6	2.1	1.1	1.3	1.6	2.1	1.1	0.5	0.2	0.2	0.2	9.8	1.1		11.0
DwnL	Downlink	0.4	0.5	1.7	3.0	4.9	10.3	12.4	12.9	6.5	5.2	3.9	3.5	45.9	19.0	10.2	75.1
InTst	Integration and testing				0.3	0.3	2.0	3.9	3.2	0.5	0.5	0.5	0.5	9.6	2.0	0.5	12.1
Cal	Calibration		0.4	0.8	1.1	1.5	1.8	2.3	2.3	4.6	3.9	2.6	2.6	10.3	13.6	4.5	28.4
Doc	Documentation							0.6	0.6	0.3	0.2	0.2	0.1	1.2	0.8	0.5	2.5
Ops	Operational tasks					0.3	0.3	0.5	1.1	3.0	1.3	1.1	1.1	2.1	6.5	0.2	8.7
PAQA	Product/Quality Assurance		0.1	0.2	0.4	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.1	1.6	0.3	0.2	2.1
Misc	Miscellaneous		0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.7	0.6	0.5	1.8
	Totals:	1.1	2.6	6.3	7.4	10.1	17.6	23.5	22.9	16.6	12.3	9.5	9.0	91.6	47.5	18.4	157.4
	Available ICC persons:	1.0	3.0	6.0	7.0	10.0	13.0	19.0	20.0	16.0	10.0	10.0	10.0	79.0	46.0	31.0	156.0
	Persons 'short':						4.6	4.5	2.9	0.6	2.3			12.6	1.4		1.4

Table 26. Overview of estimated HIFI ICC resource level requirements.

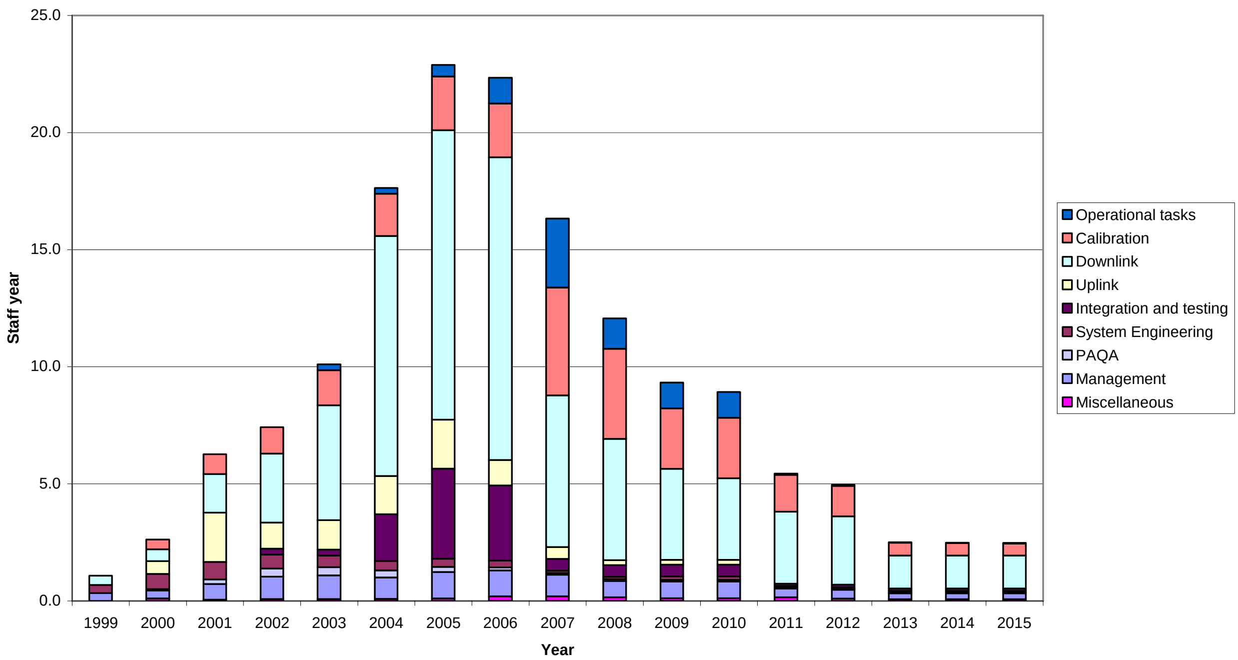

Figure 19. Required *HIFI* manpower build-up

C.1 HIFI work packages – development phase

WP nr.	WP name	1999	2000	2001	2002	2003	2004	2005	2006	Totals
Mngt	**Management**	**0.3**	**0.3**	**0.7**	**1.0**	**1.0**	**0.9**	**1.1**	**1.1**	**6.5**
Mngt-1	HIFI ICC management	*0.22*	*0.12*	*0.12*	*0.22*	*0.22*	*0.12*	*0.12*	*0.12*	*1.3*
Mngt-1.1	Maintain top level documents	0.20	0.10	0.10	0.20	0.20	0.10	0.10	0.10	1.1
Mngt-1.4	HIFI management meetings	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.2
Mngt-2	Maintain ICC development planning			*0.15*	*0.30*	*0.25*	*0.15*	*0.15*	*0.10*	*1.1*
Mngt-2.1	Consolidate availability of resources			0.10	0.20	0.20	0.10	0.10	0.05	0.8
Mngt-2.2	Maintain ICC schedule			0.05	0.10	0.05	0.05	0.05	0.05	0.4
Mngt-3	HCSS management		*0.04*	*0.04*	*0.04*	*0.04*	*0.04*	*0.04*	*0.04*	*0.3*
Mngt-3.1	HCSSMG telecons		0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.1
Mngt-3.2	HCSS management meetings		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Mngt-3.3	HSGSSG meetings		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1
Mngt-4	Meetings in which most/all of ICC participates	*0.12*	*0.19*	*0.36*	*0.40*	*0.50*	*0.61*	*0.82*	*0.85*	*3.8*
Mngt-4.1	ICC progress meetings	0.02	0.06	0.12	0.14	0.20	0.26	0.38	0.40	1.6
Mngt-4.2	ICC consortium meetings	0.01	0.03	0.06	0.07	0.10	0.13	0.19	0.20	0.8
Mngt-4.3	CSDT meetings	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.6
Mngt-4.4	HIFI consortium meetings	0.01	0.02	0.03	0.04	0.05	0.07	0.10	0.10	0.4
Mngt-4.5	IA management group meetings			0.02	0.02	0.02	0.02	0.02	0.02	0.1
Mngt-4.6	IA architecture group meetings			0.05	0.05	0.05	0.05	0.05	0.05	0.3
SysE	System Engineering	**0.4**	**0.7**	**0.8**	**0.6**	**0.5**	**0.4**	**0.4**	**0.3**	**3.9**
SysE-1	Maintenance of system design for ILT		0.20	0.20	0.10	0.10	0.05	0.05		0.7
SysE-2	ILT integration and test preparation				0.10	0.05	0.05			0.2
SysE-3	HGSSE meetings	0.05	0.15	0.15	0.10	0.10	0.05	0.05	0.05	0.7
SysE-4	HIFI system engineering	0.10	0.10	0.20	0.20	0.20	0.20	0.20	0.20	1.4
SysE-5	Herschel GS system engineering	0.20	0.20	0.20	0.10	0.05	0.05	0.05	0.05	0.9
UpL	Uplink		**0.6**	**2.1**	**1.1**	**1.3**	**1.6**	**2.1**	**1.1**	**9.8**
UpL-1	Common Uplink system		*0.30*	*0.20*						*0.5*
UpL-1.1	Architectural design and prototyping		*0.30*	*0.20*						*0.5*
UpL-1.1.1	Architecture and skeleton implementation		0.20	0.10						0.3
UpL-1.1.2	Language used for specifying modes and building blocks		0.10	0.10						0.2
UpL-2	Instrument commanding		*0.25*	*1.40*	*0.81*	*1.01*	*1.23*	*1.39*	*0.59*	*6.7*
UpL-2.1	AOT definition		0.05	0.05	0.05	0.30	0.30	0.50	0.30	1.6
UpL-2.2	Test procedure definition			0.05	0.05	0.30	0.50	0.20		1.1
UpL-2.3	Building block definition				0.10	0.10	0.30	0.60	0.20	1.3
UpL-2.4	TC definition			0.50	0.25	0.10	0.05	0.05	0.05	1.0
UpL-2.5	TM definition			0.50	0.25	0.10	0.02	0.02	0.02	0.9
UpL-2.6	MIB editor		0.20	0.20	0.01	0.01	0.01	0.01	0.01	0.5
UpL-2.7	Population of MIB			0.10	0.10	0.10	0.05	0.01	0.01	0.4
UpL-3	HIFI instrument simulator									
UpL-3.1	HIFI simulator use case analysis									
UpL-3.2	HIFI science simulator - ICU commandinng implementation									
UpL-3.3	HIFI science simulator - HRS simulator									
UpL-3.4	HIFI science simulator - WBS simulator									
UpL-3.5	HIFI science simulator - infrastructure implementation									
UpL-4	HIFI instrument time estimator			*0.50*	*0.30*	*0.05*	*0.30*	*0.60*	*0.40*	*2.2*
UpL-4.1	HIFI time estimator use case analysis			0.10	0.10					0.2
UpL-4.2	HIFI time estimator baseline implementation			0.40	0.20					0.6
UpL-4.3	HIFI time estimator development iterations					*0.05*	*0.30*	*0.60*	*0.40*	*1.4*
UpL-4.3.1	Implement HIFI time estimator use cases					0.05	0.10	0.20		0.4
UpL-4.3.2	Implement further time estimator use cases						0.20	0.40	0.40	1.0
UpL-5	Instrument scheduling					*0.20*	*0.10*	*0.10*	*0.10*	*0.5*
UpL-5.1	Investigate HIFI scheduling strategies					0.20	0.10	0.10	0.10	0.5
DwnL	Downlink	**0.4**	**0.5**	**1.7**	**3.0**	**4.9**	**10.3**	**12.4**	**12.9**	**45.9**

WP nr.	WP name	1999	2000	2001	2002	2003	2004	2005	2006	Totals
DwnL-1	HCSS infrastructure		*0.10*	*0.40*	*0.20*	*0.05*	*0.05*	*0.05*		*0.9*
DwnL-1.1	Data ingestor - HIFI specific elements		*0.10*	*0.20*	*0.10*	*0.05*	*0.05*	*0.05*		*0.6*
DwnL-1.1.1	HIFI data frame processing engine		0.10	0.20	0.10					0.4
DwnL-1.1.2	HIFI HK ingestor					0.05	0.05	0.05		0.2
DwnL-1.2	Router			0.20	0.10					0.3
DwnL-2	Interactive Analysis	*0.40*	*0.40*	*0.95*	*1.45*	*1.65*	*3.85*	*3.35*	*2.60*	*14.7*
DwnL-2.1	System	*0.40*	*0.40*	*0.75*	*0.95*	*0.15*	*0.40*	*0.40*	*0.20*	*3.7*
DwnL-2.1.1	IA/QLA: AD&Proto (1)	0.20	0.20	0.20						0.6
DwnL-2.1.2	IA/QLA:AD & proto (2) - product and process framework			0.40	0.80					1.2
DwnL-2.3	HIFI IA system design	0.20	0.20	0.10	0.10	0.10	0.20	0.20	0.10	1.2
DwnL-2.4	IA use case analysis (system level)			0.05	0.05	0.05	0.20	0.20	0.10	0.7
DwnL-2.5	IA baseline implementation			*0.20*	*0.50*	*1.50*	*2.00*	*1.50*	*1.50*	*7.2*
DwnL-2.5.1	Implementation of HIFI specific IA component			0.20	0.20		0.50			0.9
DwnL-2.5.2	Implementation of HCSS common IA component					1.50	1.50	1.50	1.50	6.0
DwnL-2.6	IA development iterations						*0.60*	*0.60*	*0.50*	*1.7*
DwnL-2.6.1	Implement HIFI IA use case NNN						0.10	0.10		0.2
DwnL-2.6.2	Implement further IA use cases						0.50	0.50	0.50	1.5
DwnL-2.7	HIFI data simulator						*0.85*	*0.85*	*0.40*	*2.1*
DwnL-2.7.1	Establish HIFI data simulator use cases						0.05	0.05	0.10	0.2
DwnL-2.7.2	Design implement HIFI data simulator						0.50	0.50	0.10	1.1
DwnL-2.7.3	HIFI science simulator - ICU commandinng implementation						0.20	0.20	0.10	
DwnL-2.7.4	HIFI science simulator - HRS simulator									
DwnL-2.7.5	HIFI science simulator - WBS simulator									
DwnL-2.7.6	HIFI science simulator - infrastructure implementation						0.10	0.10	0.10	0.3
DwnL-3	Quick Look Analysis			*0.20*	*0.40*	*2.00*	*2.40*	*1.50*	*0.57*	*7.1*
DwnL-3.1	QLA use cases			*0.20*	*0.30*	*0.50*	*0.20*	*0.20*	*0.02*	*1.4*
DwnL-3.1.1	Write and maintain QLA use cases			0.20	0.20	0.20	0.10	0.10	0.02	0.8
DwnL-3.1.2	Analyse QLA use cases				0.10	0.30	0.10	0.10		0.6
DwnL-3.2	QLA baseline implementation				*0.10*	*1.50*	*1.70*	*0.70*	*0.30*	*4.3*
DwnL-3.2.6	Basic functions				0.10	0.20	0.50			0.8
DwnL-3.2.7	Mixer QLA applications					0.50	0.50	0.20		
DwnL-3.2.8	HRS QLA applications						0.50	0.30	0.20	
DwnL-3.2.9	WBS QLA application					0.80	0.20	0.20	0.10	
DwnL-3.3	QLA development iterations						*0.50*	*0.60*	*0.25*	*1.4*
DwnL-3.3.1	Implement HIFI QLA use case NNN						0.30	0.30		0.6
DwnL-3.3.2	Implement further QLA use cases						0.20	0.30	0.25	0.8
DwnL-4	Calibration Analysis				*0.30*	*0.80*	*1.90*	*2.80*	*2.70*	*8.5*
DwnL-4.1	CA use cases				*0.20*	*0.50*	*0.40*	*0.30*	*0.20*	*1.6*
DwnL-4.1.1	Write and maintain CA use cases				0.20	0.50	0.20	0.10	0.10	1.1
DwnL-4.1.2	Analyse CA use cases						0.20	0.20	0.10	0.5
DwnL-4.2	CA baseline implementation						0.50	0.50		1.0
DwnL-4.3	CA development iterations							*1.00*	*2.00*	*3.0*
DwnL-4.3.1	Implement HIFI CA use case NNN							0.50	0.50	1.0
DwnL-4.3.2	Implement further CA use cases							0.50	1.50	2.0
DwnL-4.6	HIFI Sideband deconvolution				0.10	0.30	1.00	1.00	0.50	2.9
DwnL-5	Trend Analysis						*0.10*	*0.40*	*1.60*	*2.1*
DwnL-5.1	TA use cases						*0.10*	*0.20*	*0.30*	*0.6*
DwnL-5.1.1	Write and maintain TA use cases						0.10	0.20	0.10	0.4
DwnL-5.1.2	Analyse TA use cases							0.10	0.10	
DwnL-5.2	TA baseline implementation							0.20	0.30	0.5
DwnL-5.3	TA development iterations								*1.00*	*1.0*
DwnL-5.3.1	Implement HIFI TA use case NNN								0.50	0.5
DwnL-5.3.2	Implement further TA use cases								0.50	0.5
DwnL-6	Science Analysis			*0.10*	*0.30*	*0.20*	*0.65*	*1.55*	*3.05*	*5.9*
DwnL-6.1	SA use case analysis			*0.10*	*0.30*	*0.20*	*0.45*	*0.05*	*0.05*	*1.2*
DwnL-6.1.1	Establish and maintain EUR			0.10	0.20	0.05	0.05	0.05	0.05	0.5

WP nr.	WP name	1999	2000	2001	2002	2003	2004	2005	2006	Totals
DwnL-6.1.2	Partition EUR in tasks that are ICC or non-ICC work				0.05	0.05	0.20			0.3
DwnL-6.1.3	Find options to implement SA tasks under ICC responsibility				0.05	0.05	0.10			0.2
DwnL-6.1.4	Design architecture to support all implementation options					0.05	0.10			0.2
DwnL-6.2	SA baseline implementation						0.20	1.00		1.2
DwnL-6.3	SA development iterations							*0.50*	*3.00*	*3.5*
DwnL-6.3.1	Implement HIFI SA use case NNN							0.50	1.00	1.5
DwnL-6.3.2	Implement further SA use cases								2.00	2.0
DwnL-7	Standard Product Generation				*0.30*	*0.20*	*1.30*	*2.70*	*2.40*	*6.9*
DwnL-7.1	Definition of the 'HIFI standard product'				0.30	0.20	0.20	0.20	0.10	1.0
DwnL-7.2	SPG use cases						*0.20*	*0.20*		*0.4*
DwnL-7.2.1	Write and maintain SPG use cases						0.20	0.20		0.4
DwnL-7.2.2	Analyse SPG use cases									
DwnL-7.3	SPG baseline implementation						0.50	0.50		1.0
DwnL-7.4	SPG development iterations							*1.00*	*1.50*	*2.5*
DwnL-7.4.1	Implement HIFI SPG use case NNN							1.00	0.50	1.5
DwnL-7.4.2	Implement further SPG use cases								1.00	1.0
DwnL-7.5	OTF mapping						0.40	0.80	0.80	2.0
InTst	Integration and testing				**0.3**	**0.3**	**2.0**	**3.9**	**3.2**	**9.6**
InTst-1	ICC systems integration				*0.15*	*0.15*	*0.20*	*0.05*	*0.10*	*0.7*
InTst-1.1	Write test plan				0.10	0.10	0.20			0.4
InTst-1.2	Verification				0.05	0.05		0.05	0.10	0.3
InTst-2	HIFI ILT: DM				*0.10*		*0.70*	*0.50*		*1.3*
InTst-2.1	Support ILT integration				0.10					0.1
InTst-2.2	Test operator for DM AIT						0.20			0.2
InTst-2.3	DM data analysis						0.50	0.50		1.0
InTst-3	HIFI ILT: CQM					*0.10*	*0.80*			*0.9*
InTst-3.1	Support ILT integration					0.10	0.10			0.2
InTst-3.2	Test operator for CQM AIT						0.20			0.2
InTst-3.3	CQM data analysis						0.50			0.5
InTst-4	HIFI ILT: FM						*0.30*	*2.50*	*1.50*	*4.3*
InTst-4.1	Support ILT integration						0.10			0.1
InTst-4.2	Test operator for FM AIT						0.10	0.50		0.6
InTst-4.3	FM data analysis						0.10	2.00	1.50	3.6
InTst-5	Participation in IST							*0.80*		*0.8*
InTst-5.1	IST integration							0.10		0.1
InTst-5.2	Test operator for IST							0.20		0.2
InTst-5.3	IST data analysis							0.50		0.5
InTst-6	Project								*1.60*	*1.6*
InTst-6.1	EE1								0.30	0.3
InTst-6.2	EE2								0.30	0.3
InTst-6.3	GS sim.								1.00	1.0
Cal	Calibration		**0.4**	**0.8**	**1.1**	**1.5**	**1.8**	**2.3**	**2.3**	**10.3**
Cal-1	Calibration meetings		*0.02*	*0.04*	*0.12*	*0.20*	*0.20*	*0.20*	*0.20*	*1.0*
Cal-1.1	HIFI calibration group meetings		0.02	0.04	0.10	0.16	0.16	0.16	0.16	0.8
Cal-1.2	Herschel calibration steering group meetings				0.02	0.04	0.04	0.04	0.04	0.2
Cal-2	HIFI calibration plan		*0.40*	*0.80*	*1.00*	*1.20*	*1.40*	*1.20*	*1.20*	*7.2*
Cal-2.1	Write calibration plan		0.40	0.50	0.50	0.50	0.50	0.50	0.50	3.4
Cal-2.2	Write calibration use cases			0.30	0.50	0.50	0.20			1.5
Cal-2.3	Write PV plan						0.50	0.50	0.50	1.5
Cal-2.4	HIFI calibration budget					0.20	0.20	0.20	0.20	0.8
Cal-3	Establish pre-flight calibration						0.10	0.80	0.80	1.7
Cal-4	Perform ground based observations					0.10	0.10	0.10	0.10	0.4
Cal-5	Establish in-flight calibration									
Doc	Documentation							**0.6**	**0.6**	**1.2**
Doc-1	HIFI observers manual							*0.50*	*0.50*	1.0

WP nr.	WP name	1999	2000	2001	2002	2003	2004	2005	2006	Totals
Doc-2	Document nnn							*0.10*	*0.10*	0.2
Ops	Operational tasks					**0.3**	**0.3**	**0.5**	**1.1**	**2.1**
Ops-1	Create and schedule calibration observations								0.5	0.5
Ops-2	Instrument healt monitoring									
Ops-3	On board software maintenance					0.20	0.20	0.20	0.20	0.8
Ops-4	Science verification									
Ops-5	Quality control					*0.05*	*0.05*	*0.10*	*0.20*	*0.4*
Ops-5.1	Define quality control criteria					0.05	0.05	0.10	0.20	
Ops-5.2	Perform quality control									
Ops-6	HSC support (helpdesk etc.)							0.20	0.20	0.4
PAQA	Product/Quality Assurance		**0.1**	**0.2**	**0.4**	**0.4**	**0.3**	**0.2**	**0.1**	**1.6**
PAQA-1	Maintain HIFI ICC PA/QA plans			0.10	0.20	0.10	0.05	0.01	0.01	0.5
PAQA-2	PA/QA of HIFI ICC specific systems			0.05	0.10	0.20	0.20	0.20	0.10	0.9
PAQA-3	PA/QA on OBSW		0.05	0.05	0.05	0.05	0.05	0.01	0.01	0.3
Misc	Miscellaneous		**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.2**	**0.7**
Misc-1	Training		*0.08*	*0.02*						*0.1*
Misc-1.1	OOAD course		0.08							0.1
Misc-1.2	Versant course			0.02						
Misc-2	System maintenance		0.01	0.01	0.01	0.01	0.01	0.02	0.05	0.1
Misc-3	Admin Support		0.02	0.02	0.02	0.02	0.03	0.04	0.10	0.2
Misc-4	Public relations				0.05	0.05	0.05	0.05	0.05	0.3
	Totals:	**1.1**	**2.6**	**6.3**	**7.4**	**10.1**	**17.6**	**23.5**	**22.9**	**91.6**
	Available ICC persons:	1	3	6	7	10	13	19	20	79.0

Table 27. *HIFI* work package allocation for the development phase.

C.2 HIFI work packages contributing to the common ground segment

For information Table 28 gives the work packages that are considered to be part of the contribution to the common ground segment work (HGSSE, CSDT, etc.).

WP nr.	WP name	1999	2000	2001	2002	2003	2004	2005	2006	Totals
Mngt-4.3	CSDT meetings	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.6
Mngt-4.5	IA management group meetings			0.0	0.0	0.0	0.0	0.0	0.0	0.1
Mngt-4.6	IA architecture group meetings			0.1	0.1	0.1	0.1	0.1	0.1	0.3
SysE-3	HGSSE meetings	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.7
SysE-5	Herschel GS system engineering	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	
UpL-1	Common Uplink system		0.3	0.2						0.5
DwnL-1.2	Router			0.2	0.1					0.3
DwnL-2.1.1	IA/QLA: AD&Proto (1)	0.2	0.2	0.2						0.6
DwnL-2.1.2	IA/QLA:AD & proto (2) - product and process framework			0.4	0.8					1.2
DwnL-2.5.2	Implementation of HCSS common IA component					1.5	1.5	1.5	1.5	6.0
	Totals:	0.5	0.9	1.4	1.1	1.7	1.6	1.6	1.6	9.3

Table 28. *HIFI* work packages relevant for the common ground segment systems

C.3 HIFI work packages – operations phase

WP nr.	WP name	2007	2008	2009	2010	Totals
Mngt	Management	**0.8**	**0.7**	**0.7**	**0.7**	**2.9**
Mngt-1	HIFI ICC management	*0.22*	*0.22*	*0.22*	*0.22*	*0.9*
Mngt-1.1	Maintain top level documents	0.20	0.20	0.20	0.20	0.8
Mngt-1.4	HIFI management meetings	0.02	0.02	0.02	0.02	0.1
Mngt-2	Maintain ICC development planning	*0.10*	*0.10*	*0.10*	*0.10*	*0.4*
Mngt-2.1	Consolidate availability of resources	0.05	0.05	0.05	0.05	0.2
Mngt-2.2	Maintain ICC schedule	0.05	0.05	0.05	0.05	0.2
Mngt-3	HCSS management	*0.03*	*0.03*	*0.03*	*0.03*	*0.1*
Mngt-3.1	HCSSMG telecons	0.02	0.02	0.02	0.02	0.1
Mngt-3.2	HCSS management meetings	0.01	0.01	0.01	0.01	0.0
Mngt-4	Meetings in which most/all of ICC participates	*0.45*	*0.35*	*0.35*	*0.35*	*1.5*
Mngt-4.1	ICC progress meetings	0.26	0.20	0.20	0.20	0.9
Mngt-4.2	ICC consortium meetings	0.13	0.10	0.10	0.10	0.4
Mngt-4.4	HIFI consortium meetings	0.06	0.05	0.05	0.05	0.2
SysE	System Engineering	**0.1**	**0.1**	**0.2**	**0.2**	**0.5**
SysE-1	Maintenance of system design for ILT					
SysE-2	ILT integration and test preparation					
SysE-3	HGSSE meetings	0.05	0.05	0.05	0.05	0.2
SysE-5	Herschel GS system engineering	0.05	0.05	0.10	0.10	0.3
UpL	Uplink	**0.7**	**0.4**	**0.4**	**0.4**	**1.7**
UpL-1	Common Uplink system	*0.10*	*0.10*	*0.10*	*0.10*	*0.4*
UpL-1.2	Development iterations	0.10	0.10	0.10	0.10	0.4
UpL-2	Instrument commanding	*0.31*	*0.21*	*0.21*	*0.21*	*0.9*
UpL-2.1	AOT definition	0.10	0.05	0.05	0.05	0.3
UpL-2.2	Test procedure definition					
UpL-2.3	Building block definition	0.10	0.05	0.05	0.05	0.3
UpL-2.4	TC definition	0.05	0.05	0.05	0.05	0.2
UpL-2.5	TM definition	0.05	0.05	0.05	0.05	0.2
UpL-2.6	MIB editor	0.01	0.01	0.01	0.01	0.0
UpL-2.7	Population of MIB					
UpL-3	HIFI instrument simulator	*0.05*	*0.05*	*0.05*	*0.05*	*0.2*
UpL-3.1	HIFI simulator use case analysis					
UpL-3.3	HIFI simulator development iterations	*0.05*	*0.05*	*0.05*	*0.05*	*0.2*
UpL-3.3.1	Implement HIFI instrument simulator use case NNN					
UpL-3.3.2	Implement further instrument simulator use cases	0.05	0.05	0.05	0.05	0.2
UpL-4	HIFI instrument time estimator	*0.20*				*0.2*
UpL-4.1	HIFI time estimator use case analysis					
UpL-4.3	HIFI time estimator development iterations	*0.20*				*0.2*
UpL-4.3.1	Implement HIFI time estimator use case NNN					
UpL-5.1	Investigate HIFI scheduling strategies	0.20				0.2
DwnL	Downlink	**6.5**	**5.2**	**3.9**	**3.5**	**19.0**
DwnL-1	HCSS infrastructure	*0.02*	*0.02*	*0.02*	*0.02*	*0.1*
DwnL-1.1	Data ingestor - HIFI specific elements	*0.02*	*0.02*	*0.02*	*0.02*	*0.1*
DwnL-1.1.1	HIFI data frame processing engine	0.01	0.01	0.01	0.01	0.0
DwnL-1.1.2	HIFI HK ingestor	0.01	0.01	0.01	0.01	0.0

WP nr.	WP name	2007	2008	2009	2010	Totals
DwnL-2	Interactive Analysis	*0.65*	*0.40*	*0.40*	*0.40*	*1.9*
DwnL-2.3	HIFI IA system design	0.10	0.10	0.10	0.10	0.4
DwnL-2.4	IA use case analysis (system level)	0.05	0.05	0.05	0.05	0.2
DwnL-2.6	IA development iterations	*0.50*	*0.25*	*0.25*	*0.25*	*1.3*
DwnL-2.6.1	Implement HIFI IA use case NNN					
DwnL-2.6.2	Implement further IA use cases	0.50	0.25	0.25	0.25	1.3
DwnL-3	Quick Look Analysis	*0.10*	*0.10*	*0.10*	*0.10*	*0.4*
DwnL-3.1	QLA use cases					
DwnL-3.1.1	Write and maintain QLA use cases					
DwnL-3.1.2	Analyse QLA use cases					
DwnL-3.3	QLA development iterations	*0.10*	*0.10*	*0.10*	*0.10*	*0.4*
DwnL-3.3.1	Implement HIFI QLA use case NNN					
DwnL-3.3.2	Implement further QLA use cases	0.10	0.10	0.10	0.10	0.4
DwnL-4	Calibration Analysis	*2.00*	*1.50*	*1.00*	*1.00*	*5.5*
DwnL-4.1	CA use cases					
DwnL-4.1.1	Write and maintain CA use cases					
DwnL-4.1.2	Analyse CA use cases					
DwnL-4.3	CA development iterations	*2.00*	*1.50*	*1.00*	*1.00*	*5.5*
DwnL-4.3.1	Implement HIFI CA use case NNN					
DwnL-4.3.2	Implement further CA use cases	2.00	1.50	1.00	1.00	5.5
DwnL-5	Trend Analysis	*0.80*	*0.80*	*0.60*	*0.60*	*2.8*
DwnL-5.1	TA use cases	*0.30*	*0.30*	*0.10*	*0.10*	*0.8*
DwnL-5.1.1	Write and maintain TA use cases	0.20	0.20			
DwnL-5.1.2	Analyse TA use cases	0.10	0.10	0.10	0.10	
DwnL-5.3	TA development iterations	*0.50*	*0.50*	*0.50*	*0.50*	*2.0*
DwnL-5.3.1	Implement HIFI TA use case NNN					
DwnL-5.3.2	Implement further TA use cases	0.50	0.50	0.50	0.50	2.0
DwnL-6	Science Analysis	*1.60*	*1.70*	*1.20*	*1.10*	*5.6*
DwnL-6.1	SA use case analysis	*0.10*	*0.20*	*0.20*	*0.10*	0.6
DwnL-6.1.1	Establish and maintain EUR	0.10	0.20	0.20	0.10	0.6
DwnL-6.1.2	Partition EUR in tasks that are ICC or non-ICC work					
DwnL-6.1.3	Find options to implement SA tasks under ICC responsibility					
DwnL-6.1.4	Design architecture to support all implementation options					
DwnL-6.3	SA development iterations	*1.50*	*1.50*	*1.00*	*1.00*	*5.0*
DwnL-6.3.1	Implement HIFI SA use case NNN					
DwnL-6.3.2	Implement further SA use cases	1.50	1.50	1.00	1.00	5.0
DwnL-7	Standard Product Generation	*1.31*	*0.66*	*0.56*	*0.26*	*2.8*
DwnL-7.1	Definition of the 'HIFI standard product'	0.01	0.01	0.01	0.01	0.0
DwnL-7.2	SPG use cases	*0.30*	*0.15*	*0.05*		*0.5*
DwnL-7.2.1	Write and maintain SPG use cases	0.20	0.10			
DwnL-7.2.2	Analyse SPG use cases	0.10	0.05	0.05		
DwnL-7.4	SPG development iterations	*1.00*	*0.50*	*0.50*	*0.25*	*2.3*
DwnL-7.4.1	Implement HIFI SPG use case NNN					
DwnL-7.4.2	Implement further SPG use cases	1.00	0.50	0.50	0.25	2.3
InTst	Integration and testing	**0.5**	**0.5**	**0.5**	**0.5**	**2.0**
InTst-1	ICC systems integration					
InTst-1.1	Write test plan					
InTst-1.2	Verification					
InTst-4	HIFI ILT: FM	*0.50*	*0.50*	*0.50*	*0.50*	*2.0*

WP nr.	WP name	2007	2008	2009	2010	Totals
InTst-4.1	Support ILT integration					
InTst-4.2	Test operator for FM AIT					
InTst-4.3	FM data analysis	0.50	0.50	0.50	0.50	2.0
Cal	Calibration	**4.6**	**3.9**	**2.6**	**2.6**	**13.6**
Cal-1	Calibration meetings	*0.10*	*0.10*	*0.09*	*0.08*	*0.4*
Cal-1.1	HIFI calibration group meetings	0.06	0.06	0.05	0.04	0.2
Cal-1.2	Herschel calibration steering group meetings	0.04	0.04	0.04	0.04	0.2
Cal-2	HIFI calibration plan	*1.00*	*0.50*	*0.25*	*0.25*	*2.0*
Cal-2.1	Write calibration plan	0.25	0.25	0.25	0.25	1.0
Cal-2.2	Write calibration use cases					
Cal-2.3	Write PV plan	0.25				0.3
Cal-2.4	HIFI calibration budget	0.50	0.25			0.8
Cal-3	Establish pre-flight calibration	0.25				0.3
Cal-4	Perform ground based observations	0.25	0.25	0.25	0.25	1.0
Cal-5	Establish in-flight calibration	3.00	3.00	2.00	2.00	10.0
Doc	Documentation	**0.3**	**0.2**	**0.2**	**0.1**	**0.8**
Doc-1	Observers manual	0.20	0.10	0.10		0.4
Doc-2	Doc nnn	0.10	0.10	0.10	0.10	0.4
Ops	Operational tasks	**3.0**	**1.3**	**1.1**	**1.1**	**6.5**
Ops-1	Create and schedule calibration observations	0.10	0.10	0.10	0.10	0.4
Ops-2	Instrument healt monitoring	0.50	0.50	0.50	0.50	2.0
Ops-3	On board software maintenance	0.20	0.05	0.05	0.05	0.4
Ops-4	Science verification	1.50	0.30	0.20	0.20	2.2
Ops-5	Quality control	*0.60*	*0.30*	*0.20*	*0.20*	*1.3*
Ops-5.1	Define quality control criteria	0.10	0.10			0.2
Ops-5.2	Perform quality control	0.50	0.20	0.20	0.20	1.1
Ops-6	HSC support (helpdesk etc.)	0.05	0.05	0.05	0.05	0.2
PAQA	Product/Quality Assurance	**0.1**	**0.1**	**0.1**	**0.1**	**0.3**
PAQA-1	Maintain HIFI ICC PA/QA plans	0.01	0.01	0.01	0.01	0.0
PAQA-2	PA/QA of HIFI ICC specific systems	0.05	0.05	0.05	0.05	0.2
PAQA-3	PA/QA on OBSW	0.01	0.01	0.01	0.01	0.0
Misc	Miscellaneous	**0.2**	**0.2**	**0.1**	**0.1**	**0.6**
Misc-1	Training					
Misc-1.1	OOAD course					
Misc-1.2	Versant course					
Misc-2	System maintenance	0.05	0.05	0.05	0.05	0.2
Misc-3	Admin Support	0.10	0.05	0.02	0.02	0.2
Misc-4	Public relations	0.05	0.05	0.05	0.05	0.2
	Totals:	**16.7**	**12.4**	**9.7**	**9.2**	**47.9**

Table 29. *HIFI* work package allocation for operations.

C.4 HIFI work packages – post operations phase

WP nr.	WP name	2011	2012	2013	2014	2015	Totals
Mngt	Management	**0.4**	**0.4**	**0.2**	**0.2**	**0.2**	**1.5**
Mngt-1	HIFI ICC management	0.11	0.11	0.06	0.06	0.06	0.4
Mngt-1.1	Maintain top level documents	0.10	0.10	0.05	0.05	0.05	0.4
Mngt-1.4	HIFI management meetings	0.01	0.01	0.01	0.01	0.01	0.1
Mngt-2	Maintain ICC development planning	0.04	0.04	0.04	0.04	0.04	0.2
Mngt-2.1	Consolidate availability of resources	0.02	0.02	0.02	0.02	0.02	0.1
Mngt-2.2	Maintain ICC schedule	0.02	0.02	0.02	0.02	0.02	0.1
Mngt-3	HCSS management	0.02	0.02	0.02	0.02	0.02	0.1
Mngt-3.1	HCSSMG telecons	0.01	0.01	0.01	0.01	0.01	0.1
Mngt-3.2	HCSS management meetings	0.01	0.01	0.01	0.01	0.01	0.1
Mngt-4	Meetings in which most/all of ICC participates	0.20	0.20	0.13	0.13	0.13	0.8
Mngt-4.1	ICC progress meetings	0.08	0.08	0.05	0.05	0.05	0.3
Mngt-4.2	ICC consortium meetings	0.08	0.08	0.05	0.05	0.05	0.3
Mngt-4.4	HIFI consortium meetings	0.04	0.04	0.03	0.03	0.03	0.2
SysE	System Engineering	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.4**
SysE-3	HGSSE meetings	0.02	0.02	0.02	0.02	0.02	0.1
SysE-5	Herschel GS system engineering	0.05	0.05	0.05	0.05	0.05	0.3
DwnL	Downlink	**3.1**	**2.9**	**1.4**	**1.4**	**1.4**	**10.2**
DwnL-1	HCSS infrastructure						
DwnL-2	Interactive Analysis	0.32	0.32	0.20	0.20	0.20	1.2
DwnL-2.3	HIFI IA system design	0.05	0.10	0.10	0.10	0.10	0.5
DwnL-2.4	IA use case analysis (system level)	0.02	0.02				0.0
DwnL-2.6	IA development iterations	0.25	0.20	0.10	0.10	0.10	0.8
DwnL-2.6.1	Implement HIFI IA use case NNN						
DwnL-2.6.2	Implement further IA use cases	0.25	0.20	0.10	0.10	0.10	0.8
DwnL-4	Calibration Analysis	1.00	1.00	0.50	0.50	0.50	3.5
DwnL-4.1	CA use cases						
DwnL-4.3	CA development iterations	1.00	1.00	0.50	0.50	0.50	3.5
DwnL-4.3.1	Implement HIFI CA use case NNN						
DwnL-4.3.2	Implement further CA use cases	1.00	1.00	0.50	0.50	0.50	3.5
DwnL-5	Trend Analysis	0.50	0.50	0.10	0.10	0.10	1.3
DwnL-5.1	TA use cases						
DwnL-5.3	TA development iterations	0.50	0.50	0.10	0.10	0.10	1.3
DwnL-5.3.1	Implement HIFI TA use case NNN						
DwnL-5.3.2	Implement further TA use cases	0.50	0.50	0.10	0.10	0.10	1.3
DwnL-6	Science Analysis	1.00	1.00	0.50	0.50	0.50	3.5
DwnL-6.1	SA use case analysis						
DwnL-6.3	SA development iterations	1.00	1.00	0.50	0.50	0.50	3.5
DwnL-6.3.1	Implement HIFI SA use case NNN						
DwnL-6.3.2	Implement further SA use cases	1.00	1.00	0.50	0.50	0.50	3.5
DwnL-7	Standard Product Generation	0.25	0.10	0.10	0.10	0.10	0.7
DwnL-7.2	SPG use cases						
DwnL-7.4	SPG development iterations	0.25	0.10	0.10	0.10	0.10	0.7
DwnL-7.4.1	Implement HIFI SPG use case NNN						
DwnL-7.4.2	Implement further SPG use cases	0.25	0.10	0.10	0.10	0.10	0.7
InTst	Integration and testing	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.5**
InTst-1	ICC systems integration						
InTst-1.1	Write test plan						
InTst-1.2	Verification						
InTst-4	HIFI ILT: FM	0.10	0.10	0.10	0.10	0.10	0.5
InTst-4.1	Support ILT integration						
InTst-4.2	Test operator for FM AIT						

WP nr.	WP name	2011	2012	2013	2014	2015	Totals
InTst-4.3	FM data analysis	0.10	0.10	0.10	0.10	0.10	0.5
Cal	Calibration	**1.6**	**1.3**	**0.6**	**0.5**	**0.5**	**4.5**
Cal-1	Calibration meetings	*0.07*	*0.05*	*0.05*	*0.03*	*0.02*	*0.2*
Cal-1.1	HIFI calibration group meetings	0.03	0.03	0.03	0.03	0.02	0.1
Cal-1.2	Herschel calibration steering group meetings	0.04	0.02	0.02			0.1
Cal-2	HIFI calibration plan	*0.50*	*0.25*				*0.8*
Cal-2.1	Write calibration plan						
Cal-2.2	Write calibration use cases						
Cal-2.4	HIFI calibration budget	0.50	0.25				0.8
Cal-4	Perform ground based observations						
Cal-5	Establish in-flight calibration	1.00	1.00	0.50	0.50	0.50	3.5
Doc	Documentation	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.5**
Doc-1	Observers manual						
Doc-2	Doc nnn	0.10	0.10	0.10	0.10	0.10	0.5
Ops	Operational tasks	**0.1**	**0.1**	**0.0**	**0.0**	**0.0**	**0.2**
Ops-6	HSC support (helpdesk etc.)	0.05	0.05	0.02	0.02	0.02	0.2
PAQA	Product/Quality Assurance	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**
PAQA-1	Maintain HIFI ICC PA/QA plans	0.01	0.01	0.01	0.01	0.01	0.1
PAQA-2	PA/QA of HIFI ICC specific systems	0.02	0.02	0.02	0.02	0.02	0.1
PAQA-3	PA/QA on OBSW	0.01	0.01	0.01	0.01	0.01	0.1
Misc	Miscellaneous	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.5**
Misc-1	Training						
Misc-1.1	OOAD course						
Misc-1.2	Versant course						
Misc-2	System maintenance	0.05	0.05	0.05	0.05	0.05	0.3
Misc-3	Admin Support	0.10	0.05	0.02	0.02	0.02	0.2
Misc-4	Public relations						
	Totals:	**5.5**	**5.1**	**2.6**	**2.6**	**2.6**	**18.3**

Table 30. *HIFI* work package allocation for post operations.

D ICC planning

D.1 ICC planning – development phase

The milestones that are relevant for the development phase of the HIFI ICC are listed in Table 31.

WBS	Task_Name	Finish_Date
M-1.1	DM	August 04
M-1.3	QM	20/12/04
M-1.4	FM	1/3/06
M-1.5	SVT0	1/9/05
M-1.6	Launch	1/8/07
M-2.1	SSR V0.1	Fri 1/12/00
M-2.2	SIPs	Tue 10/4/01
M-2.3	Req.	Fri 1/3/02
M-2.5	Impl.	Fri 3/3/06
M-2.6	Readiness	Fri 1/12/06
M-3.1	ICC PDR	Tue 3/4/01
M-3.2	HIFI PDR	Thu 26/4/01
M-3.3	HIFI CDR	Tue 16/12/03
M-4.1	OBSW Req. /Design Review	Mon 2/4/01
M-4.2	OBSW Interm. Review	Tue 17/7/01
M-5.1.1	HCSS V0.1-1	Mon 3/12/01
M-5.1.2	HCSS V0.1-2	Mon 1/4/02
M-5.1.3	HCSS V0.2	Mon 2/12/02
M-5.1.4	HCSS V0.3	May 2005
M-5.1.5	HCSS V0.4	Wed 1/12/05
M-5.1.7	HCSS V1.0	Fri 1/12/06
M-5.2.1	#1:MIB format	Thu 1/3/01
M-5.2.2	#2: Science TM	Tue 1/5/01
M-5.2.3	#6: OBS format	Thu 1/11/01
M-5.3.1	#3: OOL data	Sat 1/1/00
M-5.3.2	#4:NRT TM ICD	Tue 1/5/01
M-5.3.3	#5:TC history	Sat 1/1/00
M-5.3.4	#7: FCSS-RTA TM I/F	Sat 1/1/00
M-5.3.5	#8: RTA-FCSS data I/F	Sat 1/1/00
M-5.3.6	#9: FCSS OBS I/F	Mon 3/12/01
M-5.3.7	#10: FCSS MIB I/F	Thu 1/11/01
M-5.3.8	#11: EGSE-ILT- FCSS TP I/F	Sat 1/1/00

Table 31. Milestones relevant for the HIFI ICC development phase

In Figure 20 a very preliminary overview is given of the ICC planning for the development phase. For a number of work packages details still have to be decided on, and for most resource assignments (if any) are tentative.

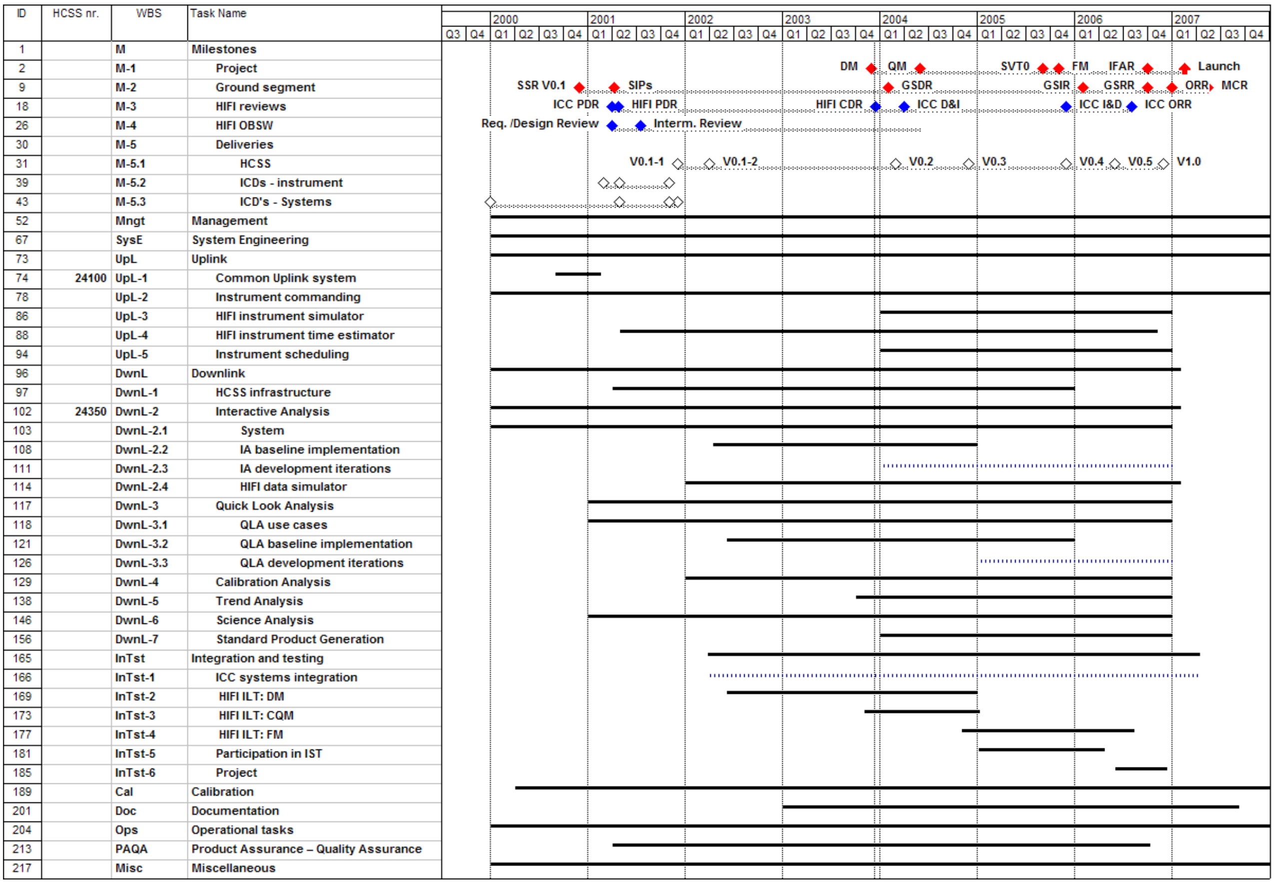

Figure 20. Overview of ICC planning for the development phase.

D.2 ICC planning – operations phase

TBW

D.3 ICC planning – post operations phase

TBW

E Responsibilities of the ground segment elements – SIRD definition

For completeness the main responsibilities of the ground segment elements as listed in the SIRD (AD2) and Scenarios documents (RD2) are repeated here.

E.1 HIFI ICC responsibilities

- Development phase:
  - follow *HIFI* instrument development,
  - produce instrument user manual,
  - design HCSS jointly with HSC, ICCs and MOC,
  - design ICC relevant HCSS parts,
  - design and implement ICC operational software systems (IA, RTA, QLA, CA, command translators, time estimator, *HIFI* simulator etc.) and procedures (IFOP etc.),
  - define and implement *HIFI* AOTs,
  - prepare *HIFI* calibration plan,
  - determine *HIFI* pre-flight calibration,
  - participate in *HIFI* tests and characterisation,
  - support HSC with proposal evaluation,
- Operations:
  - monitor *HIFI* operations and instrument health,
  - maintain and optimise *HIFI* observing modes and AOTs,
  - maintain (and further develop) ICC operational software systems and, procedures,
  - prepare, submit and analyse specific calibration observations,
  - maintain and optimise the *HIFI* calibration plan,
  - support HSC in answering *HIFI* specific queries,
- Post operations:
  - refine *HIFI* calibration and instrument understanding,
  - support HSC with *HIFI* specific queries,

E.2 HSC responsibilities

- Development phase:
  - design HCSS jointly with ICCs and MOC,
  - design HSC relevant HCSS parts,
  - implement and maintain HCSS,
  - design and implement HSC operational software systems and procedures (e.g. proposal handling, scientific mission planning),
  - support OTAC, issue call(s) for proposals, carry out initial proposal screening,
  - support organisation and implementation of survey programmes,
  - support user community in observation preparation phase,
- Operations:
  - maintain HCSS,
  - support Herschel user community (e.g. helpdesk),
  - carry our scientific mission planning,
  - prepare Sequenced Observation Lists (SOL) for use by the MOC ,
  - monitor progress of science programmes, adjust priorities when needed,
  - communicate mission progress and general information to community,
  - issue further call(s) for proposals, assist community and OTAC,
- Post operations:
  - support Herschel user community (e.g. helpdesk),

- record Herschel project knowledge for posterity (explanatory supplement),
- maintain HCSS for post operations use,

E.3 MOC responsibilities

- Development phase:
  - design MOC relevant HCSS parts,
- Operations:
  - make detailed schedule from SOL,
  - compile schedule with command translator to binary code for instrument commanding,
  - command and monitor (in semi-real time) satellite and instruments,
  - monitor satellite and instrument health,
  - record satellite and instrument telemetry and make it available through HCSS,
  - make satellite parameters (e.g. orbit data) available through HCSS,

F SIRD-SIP compliance matrix

F.1 Functional Requirements

Requirement	Fulfilled in
ICCF-005	Section 4.1, appendix E
ICCF-010	This document
ICCF-015	Section 4.5
ICCF-020	Section 4.5, appendix D
ICCF-025	Sections 4.12.5, 4.12.6, 4.12.7
ICCF-030	Section 5.1.8
ICCF-035	Section 4.5
ICCF-040	Section 4.8 (TBW)
ICCF-045	*HIFI* ICC hardware specification (RD20)
ICCF-050	Section 5.1.3
ICCF-055	Section 5.1.3
ICCF-060	Section 5.1.3
ICCF-065	Section 5.1.3
ICCF-070	Section 4.6.2.2
ICCF-075	Instrument group responsibility (see section 4.1, RD17)
ICCF-080	Section 5.1.3
ICCF-085	Instrument group responsibility (see section 4.1, RD17)
ICCF-090	Instrument group responsibility (see section 4.1, RD17)
ICCF-095	Instrument group responsibility (see section 4.1, RD17)
ICCF-100	Instrument group responsibility (see section 4.1, RD17)
ICCF-102	Section 4.8 (TBW)
ICCF-105	Section 4.6.2.3
ICCF-110	Instrument group responsibility (see section 4.1, RD17)
ICCF-115	Section 5.1.6.5
ICCF-120	Section 4.6.1
ICCF-125	Section 4.6.1
ICCF-130	Section 4.6.3
ICCF-135	Section 5.1.5
ICCF-140	Section 5.1.5
ICCF-145	Section 5.1.5
ICCF-146	Key programme support TBD

Functional requirements (cont.)

Requirement	Fulfilled in
ICCF-150	Instrument group responsibility (TBD see section 4.1, RD17)
ICCF-152	Instrument group responsibility (see section 4.1, RD17)
ICCF-155	Instrument group responsibility (see section 4.1, RD17)
ICCF-160	Section 7.1.5 (TBW)
ICCF-165	Section 4.12.7
ICCF-170	Section 4.12.6
ICCF-175	Section 4.6.1
ICCF-176	Section 4.6.1
ICCF-177	Section on HCSS integration and test TBW
ICCF-180	Section 4.9
ICCF-185	Section 4.9
ICCF-190	Section 4.8 (TBW)
ICCF-195	Section 5.1.6.5 and Section on Integration and Test Team TBW
ICCF-200	Section 5.1.6.5
ICCF-205	Section on instrument station and deliveries TBW

F.2 Operational Requirements

Requirement	Fulfilled in
ICCO-005	Section on ICC training TBW
ICCO-010	Section on training for HSC/MOC TBW
ICCO-015	Section 6.1.1 (partially TBW)
ICCO-020	Section 7.1.4 (partially TBW)
ICCO-025	Section 7.1.6
ICCO-027	Section 7.1.4 (partially TBW)
ICCO-030	Section 7.1.2.1
ICCO-035	Section 7.1.1
ICCO-040	Section 7.1.1
ICCO-042	Section on aperture misalignments TBW
ICCO-045	Section 7.1.1, 7.1.2
ICCO-050	Section 7.1.2
ICCO-055	Section 7.1.4
ICCO-060	‘Instrument specific modes’ N/A for *HIFI* (TBC)
ICCO-065	Section 7.1.3
ICCO-070	Section 7.1.1
ICCO-075	Section 7.1.2
ICCO-080	Section 7.1.3, 7.1.7
ICCO-085	Section 7.1.9 (TBW)

F.3 Post-Operations Requirements – TBW

Requirement	Fulfilled in
ICCA-005	
ICCA-010	
ICCA-015	
ICCA-020	
ICCA-025	
ICCA-030	
ICCA-035	
ICCA-040	
ICCA-045	
ICCA-050	

F.4 Performance and Availability Requirements – TBW

Requirement	Fulfilled in
PERF-000 PERF-002	
PERF-003	
PERF-004	
PERF-060	
PERF-060b	
PERF-061	
PERF-062	

F.5 Product Assurance and Quality Assurance Requirements

Requirement	Fulfilled in
PAQA-001	Section 4.9
PAQA-002	Section 4.9
PAQA-010	Section 4.8 (TBW)
PAQA-010a	Section 4.8 (TBW)
PAQA-010b	Section 4.8 (TBW)
PAQA-010c	Section 4.8 (TBW)
PAQA-011	Section 4.9
PAQA-012	N/A ICC (TBC)
PAQA-020	Section 5.1.6.5
PAQA-022	*HIFI* ICC product tree (RD10)
PAQA-023	Section **Error! Reference source not found.**
PAQA-024	Section 5.1.6.5
PAQA-025	Section 5.1.6.5
PAQA-026	Section 5.1.6.5
PAQA-030	*HIFI* ICC hardware specification (RD20)
PAQA-031	Section 4.9
PAQA-032	HCSS Software Project Management Plan (RD22)
PAQA-033	This document

F.6 Management Requirements

Requirement	Fulfilled in
MNGT-001	Section 4.5
MNGT-003	Section 4.5, 4.12.5, 4.12.6, 4.12.7
MNGT-004	Section on Integration and Test Team TBW
MNGT-010	This document
MNGT-011	This document
MNGT-011a	Section 4, 4.13, 6, 7, 8
MNGT-011b	Section 3
MNGT-011c	Appendix C and *HIFI* ICC work packages (RD18)
MNGT-011d	*HIFI* ICC work packages (RD18)
MNGT-011e	Appendix D and *HIFI* ICC planning (RD19)
MNGT-011f	Section 4.8 (TBW)
MNGT-012	Section on reporting TBW
MNGT-020	Section 4.5
MNGT-022	Section 4.5
MNGT-023	Section 4.5
MNGT-024	Section 4.8.2 (TBW)
MNGT-024a	Section 4.8.2 (TBW)
MNGT-024b	Section 4.8.2 (TBW)
MNGT-024c	Section 4.8.2 (TBW)
MNGT-024d	Section 4.8.2 (TBW)
MNGT-024e	Section 4.8.2 (TBW)
MNGT-024f	Section 4.8.2 (TBW)
MNGT-024g	Section 4.8.2 (TBW)
MNGT-025	Section 4.8 (TBW)