SPIRE

SUBJECT: **Spire ICC Scenarios**

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Glossary

AOT	Astronomical Observation Template
AVM	Avionics Model
CC	Configuration Control
CCB	Configuration Control Board
CCS	Central Checkout System
CDMS	Command and Data Management System
CQM	Cryogenic Qualification Model
CUS	Common Uplink System
CVS	Concurrent Versions System
DAPSAS	Data Processing and Science Analysis Software
EGSE	Electrical Ground Support Equipment
ESOC	European Space Operations Centre
FM	Flight Model
FS	Flight Spare (model)
HCSS	Herschel Common Science System
HGS	Herschel Ground Segment
HOTAC	Herschel Observing Time Allocation Committee
HSC	Herschel Science Centre
IA	Interactive Analysis
ICC	Instrument Control Centre
ICCDT	ICC Definition Team
ICSTM	Imperial College of Science Technology and Medicine
IFSI	Istituto di Fisica dello Spazio Interplanetario
ILT	Instrument Level tests
ISDT	ICC Software Development Team
IST	Integrated System tests
MCS	Mission Control System
MIB	Mission Information Base
MOC	Mission Operations Centre
MPS	Mission Planning System
OBS	On-Board Software
OBSMF	On-Board Software Maintenance Facility
ODBMS	Object Data Base Management System
PFM	Proto Flight Model
PHS	Proposal Handling System
PI	Principle Investigator
QLA	Quick Look Analysis
RAL	Rutherford Appleton Laboratory
RTA	Real Time Assessment
S/C	Spacecraft
SCOM	Science Operations Manager
SCOS	Spacecraft Operating System
SIRTF	Space Infrared Telescope Facility
SPG	Standard Product Generation
SPOT	SIRTF Planning Observation Tool
STM	Structural Thermal Model
SW	Soft Ware
TC	Telecommand
TEI	Test-Equipment-Interface
TFCS	Test Facility Control System
TM	Telemetry

SCOPE

This document describes the work done by the SPIRE ICC in the context of the Herschel operations and SPIRE testing. It is intended to be a high level overview of activities undertaken by the ICC and the interfaces both within the ICC and between the ICC and other parts of the ground segment. A more detailed description of how the ICC will operate is given in the ICC use case document and a detailed breakdown of the

1. DOCUMENTS

1.1 Applicable Documents

AD1	SPIRE Science Implementation Plan	K. J. King	SPIRE-RAL-DOC-000018
AD2	FIRST Science Operations Implementation Requirements Document	P. Estaria	PT-03646
AD3	SPIRE Scientific Requirements	W. Gear and M. Griffin	SPIRE-UCF-PRJ-000064

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1.2 Reference Documents

RD1	SPIRE ICC Use Cases	M. Sauvage	
RD2	SPIRE ICC Work Packages	K. King	SPIRE-RAL-DOC-001198
RD3	FIRST Operations Scenario Document		FIRST/FSC/DOC/0114

2. INTRODUCTION

This document is a high level description of those activities in the Herschel ground segment which have an involvement by the SPIRE ICC. The next two sections introduce the Herschel ground segment and the SPIRE ICC then the remainder of the document is divided into mission phases and for each phase it describes the main activities of the ICC.

The SPIRE ICC organisation and development is described in section 5. The SPIRE ICC has undergone a definition process, initially the basic requirements, given in section 4, were expanded to user requirements documents. These have then been used as a basis for the more definitive use cases (RD1) which are considered to be the baseline for ICC definition.. This document should be considered to be an accompanying high level overview of those SPIRE ICC activities described in the use cases.

3. THE HERSCHEL GROUND SEGMENT

The Herschel Ground Segment (HGS) consists of three major decentralized components. The Mission Operations Centre (MOC) located at ESOC, the Instrument Control Centres (ICCs) located at (or near) the PI institutes and the Herschel Science Centre (HSC) which will be located at a suitable place in an ESA member state, e.g. Vilspa (Spain).

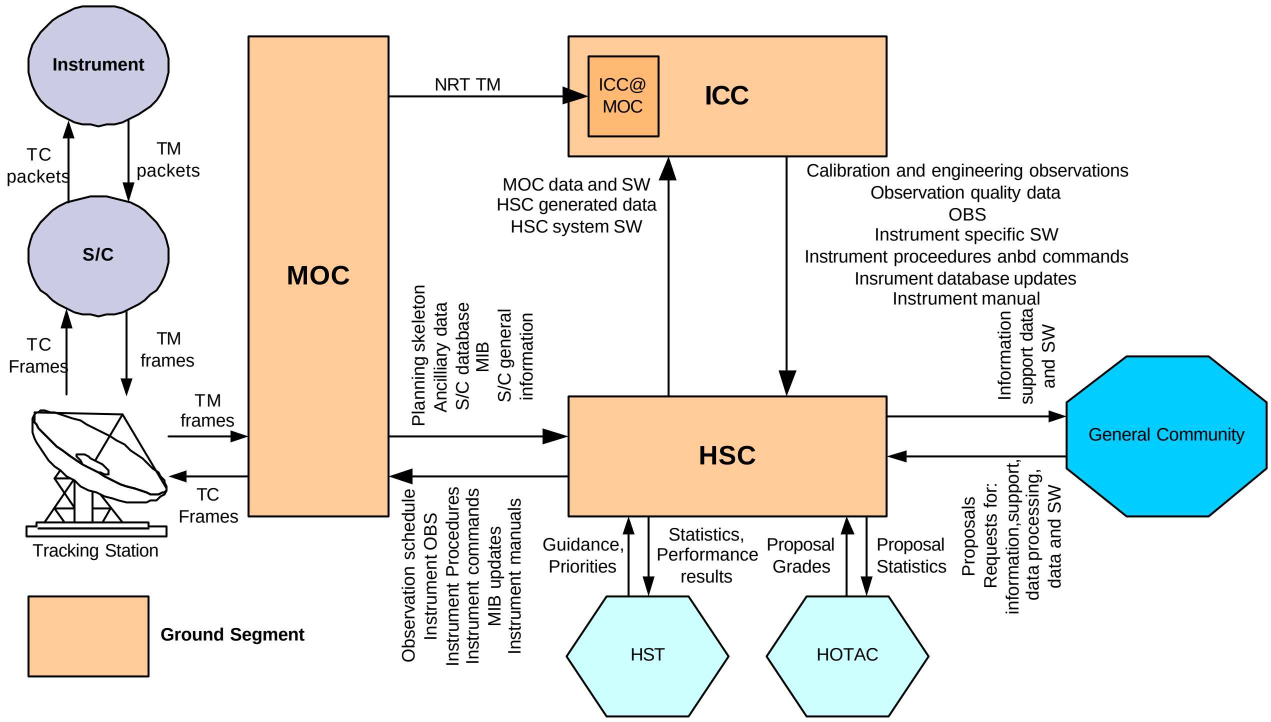

Figure 3.1: The Herschel Ground Segment

3.1 The MOC

The MOC is responsible for all aspects of spacecraft (S/C) operation as well as the safety of the instruments during the in-orbit phase only. This includes generating all commands to be up-linked to the satellite, receiving, recording for safekeeping, and consolidation of the telemetry data and making these data available to the rest of the Ground Segment. It is also responsible for maintaining the instrument and spacecraft databases shared by the MOC, ICCs, and HSC, and of the SCOS-2000 system used by the MOC and the ICCs.

3.2 The HSC

The HSC is the single-point interface to the outside world for all Herschel observatory matters. In particular, it will issue calls for observing time proposals, it will handle proposals, it will provide general community support and give support to ESA Public Relations and science communications activities. To do this task it will provide the framework for the interfaces with the astronomer for all community interaction, e.g. for information gathering, proposing, data browsing and retrieval, on-demand data processing, and generation of quick-look products. It will also perform the detailed scientific mission planning and provide quality control information on all observational data. It will provide, manage, and maintain the central

Herschel data base, and all the HSC software subsystems and will also?populate, along with the ICCs, the Herschel database with characterisation, science, and operational data to ensure overall ground segment consistency with respect to instrument configuration, including onboard software. Another role will be to ?co-ordinate the cross-calibration between Herschel instruments, and between Herschel and other facilities.

3.3 The ICCs

The Instrument Control Centres (ICC, at least one centre per instrument) are responsible for the successful operation of their respective instruments, and for making possible the processing of the resulting data and each ICC performs tasks dedicated to their particular instrument..

Each ICC is responsible for providing a number of software systems. Prior to operations each ICC will develop their instrument Quick Look Analysis (QLA) and Interactive Analysis (IA) systems, 'time estimator' software and command generation facilities. They will also contribute towards the common software in the Herschel Common Science System (HCSS, see below). During operations the ICCs will be responsible for the maintenance or continuing development of these systems plus the maintenance of the instrument onboard software (OBS) once it has been generated and validated by the instrument teams.

During operations, each ICC is responsible for instrument status and health, the maintenance of the instrument, the instrument calibration and the instrument data processing. To prepare for this, prior to operations they will monitor the instrument development and testing and develop expertise in the instrument ground calibration.

3.4 The HCSS

All three of the major components of the HGS share a common science database and software system known as the Herschel Common Science System (HCSS). The HCSS groups all Herschel Ground Segment (HGS) functionalities that are common to the science and instruments operations. It includes the major following functions.

- Definition of proposals and observations
- Scheduling of observations
- Observations commanding generation
- Analysis of the instrument science data
- Processing and quality assessment of observation science data
- The storage and retrieving of all instrument and science relevant data

Each of these major functions is implemented by an HCSS subsystem or component. The HCSS includes the following subsystems:

- CUS: common uplink system for definition of observation templates and observation commanding generation
- PHS: proposal handling system for definition of proposals and observations
- MPS: mission planning system for scheduling of observations
- CC: configuration control system for HCSS data, software and documentation
- Browsers
- IA: interactive analysis system for an instrument

- SPG/QCP: subset of IA for producing standard data products and quality assessment for observation science data

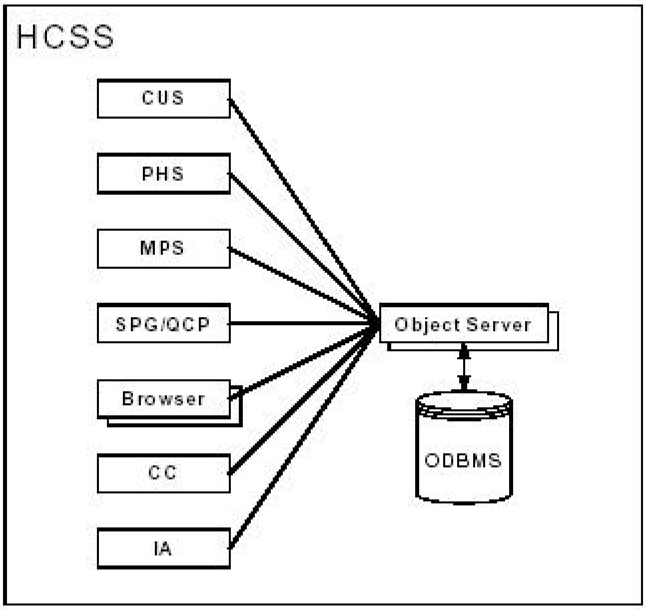

Figure 3.2: The HCSS

At the heart of the HCSS is an object-oriented database management system (ODBMS) for storage and retrieval (querying) of all the Herschel mission artefacts relevant to science and instruments operations. This ODBMS acts as a data server for each of the HCSS sub-systems as well as for RTA playback and the OBS Management. All the above HCSS sub-systems will interact directly with the ODBMS or via specific object servers to retrieve and/or store their input and output data. The CUS and MPS are complex systems and hence are described below, other HCSS components are described in this document where appropriate.

3.5 The CUS

The CUS concept is based on four levels of abstraction.

1. The **observation** level defines the scientific, calibration or engineering observation and its associated parameters. This abstraction level will typically also define scheduling constraints or instructions.
2. The **observation mode definition** contains the definition of the observation defined as written in a scripting language. It defines how the observation type and parameters should be translated into a sequence of observation building blocks. During such a translation, all input can be checked for correct syntax and parameter range and validity.
3. The **observation building blocks** are the next level of abstraction. This is used to define how the observation is functionally structured by a sequence of measurement 'steps'. It corresponds to a high level description of the observation in the user domain, typical building blocks are e.g. *do_dark_measurement* or *perform_scan(start,stop)*. The building blocks are defined in the **building block definitions**, which are also defined using the scripting language. The definition specifies how the building blocks should be translated into a sequence of command mnemonics. Since

observation building blocks can also take parameters, the translation step performs parameter validity and range/limit checks next to syntax checking.

4. The next abstraction level is then a sequence of **relative time-tagged telecommand (TC) mnemonics**. These are instrument commands (or EGSE commands). Instrument commands correspond to an on-board function or control procedure (OBCP) or a more fundamental instrument command that needs no further expansion/translation by the DPU/ICU. The difference between this abstraction level and the observation building blocks (OBBs) is somewhat artificial since OBBs could also be defined as OBCPs. From the user or developer point of view this difference is nevertheless important since observation building blocks are defined in the user domain whereas on-board control procedures are defined in the instrument domain, and also data reduction algorithms may benefit if the downlink (telemetry) organisation (data model) is based on observation building blocks.

3.6 The Mission Planning System

The MPS will schedule observations at absolute time, based on absolute observation time windows given in a planning skeleton. Once produced, the schedule is exported to MOC for further processing, uplink and eventually on-board execution.

The commands generated by the MPS correspond to S/C commanding requests and instrument TC mnemonics and are time tagged relative to the start of the observation. The sequence is then incorporated in to the schedule and the relative time tagging is then translated into absolute time. The MPS will support the multiple scheduling (and therefore execution) of an observation request and in effect, will create an instance of observation, each time an observation request will be scheduled.

The observation instance will be stored into the HCSS and the TM resulting from the observation execution will then be linked to this instance of observation. For this purpose, the MPS will generate as part of the instrument commands related to an observation, TC mnemonics carrying the observation instance id (ObsId) and observation building block instances ids (BbId).

4. THE ORGANISATION AND DEVELOPMENT OF THE SPIRE ICC

4.1 ICC Organisation

The SPIRE ICC is distributed across three main sites, RAL, ICSTM and CEA Saclay.

- The ICC Operations Centre located at RAL (UK) will be primarily responsible for maintaining the operational status and performance of the instrument. It is expected that this center will be staffed by people who have been involved in the ground testing and calibration of the instrument and have therefore gained an in-depth knowledge of its operation.This centre will be the single interface between the ICC and the rest of the Herschel Ground Segment.

- Two ICC Data Processing and Science Analysis Software (DAPSAS) Centres located at ICSTM (UK) and CEA, Saclay (France). These centres will monitor the scientific quality of the science products, and design the science processing and analysis software, that is distributed through the whole SPIRE consortium. They will provide co-ordination of all the scientific data processing and analysis software development and maintenance activities. The staff from these Centres will participate in the instrument development, AIV and calibration activities during the ICC development phase in order to build up expertise in the instrument and its operation. They will additionally be responsible for the generation and validation, to the relevant standards, of each version of the Interactive Analysis software delivered to the HSC. (Note: the Operations Centre will be responsible for its delivery and configuration control.)

4.2 ICC Development.

An ICC Definition Team (ICCDT) has been set up to define the ICC design and operations concept. Members of this team include the ICC Scientist, ICC Development Manager , ICC Software Manager and ICC Software Engineers. It’s major tasks include:

- Defining the requirements on the ICC.
- Defining an operations concept for the ICC within the Herschel Ground Segment
- Generating a set of work packages for the implementation and operation of the ICC though the different mission phases

The baseline for the development process is the Object Oriented Design paradigm with the requirements specified in terms of use-cases. Use-cases have the advantage of describing how the system works and are widely considered to capture more functional requirements than the user-requirements document (URD) methodology. However the ICC also have developed a set URDs to capture the user requirements on the system from external users. Each use-case has been discussed and agreed by the entire ICCDT and then used to generate a set of work packages. The work packages identified are listed in RD2 and the use-cases in RD1.

The ICC Steering Group, formed under the chairmanship of the ICC Scientist, is monitoring this design process, and reviewing the outputs of the ICC Definition Team. One of its prime responsibilities is to agree on the allocation of ICC workpackages between ICC contributors. This group is comprised of the PI, the Co-PI, The Project Scientists, the Instrument Scientist, the Systems Engineer, the managers of the two DAPSAS Centres and the ICC Development Manager.

The ICC Development Manager is responsible for overseeing the implementation of these decisions through the DAPSAS Centres' Managers.

The ICC Software Development Manager leads a software development team (ISDT), consisting of software engineers from all the contributing countries. This team is responsible for provision of the ICC software systems. The first major development of the ISDT is the QLA system. This is a distributed development under control of the ISDT and is led by the ICC Software Manager. The ESA Concurrent Versions System (CVS) is used as a common storage area and configuration control system. ICC developers all use a SPIRE area of this system with modified code being added to the common repository used for developed software. This easily enables code to be shared across multiple sites. The main sources of communication are via an ISDT mailing list plus regular progress meetings and telecons.

4.3 ICC Operations

The work of the ICC during operations will organised into areas, with each area being the responsibility of a single team. Each team will work one or more aspects of instrument operation, calibration and scientific output and will led by a person with the appropriate expertise. It is expected that these team leaders will be located at one of the centres but the team members will be drawn from other centres and indeed the wider consortium. The work at any centre will broadly reflect its area of responsibility. These teams will be co-ordinated by a group which will overview all aspects of the SPIRE operations, including instrument performance and data analysis (SODAG). This group, led by the PI, will meet at regular intervals to review progress and formulate future activities.

The three centres will provide facilities for the teams to work together at the same location for substantial periods if necessary. An example would be members of DAPSAS centres and the consortium joining the operations team at RAL for extended periods at appropriate times, particularly during the operations phase. In the same way, members of the operations team will contribute to work carried out at DAPSAS centres in areas of work where they have relevant expertise.

RAL will provide the interface for the ICC centres to (a copy of) the ESA database and facilities for running internal ICC software i.e. software that requires specific hardware or software licences which would preclude distribution across the consortium.

5. INSTRUMENT LEVEL TESTS

The main activity during the instrument level test (ILT) phase will be the assembly and testing of the SPIRE instrument. There will be four models tested during this phase:

- The structural thermal model (STM) is a mechanical form and fit model which will be vibration tested and thermally tested to check that the components can withstand launch and space conditions.
- The warm electronics and commanding scheme will be tested on the avionics model (AVM), which consists of the on-board computer and a simulator for the detector and mechanism readout and control units.
- The cryogenic qualification model (CQM) will be used to characterise and verify the instrument scientific performance with functionally representative cold sub-systems and warm electronics units.
- The Proto-Flight Model (PFM) will be the instrument model that is intended for flight and will be built to full flight quality. It is expected that this model will later be used as the flight model (FM).
- The Flight Spare Model (FS) will be a spare model made to the same specification as the instrument flight model and is likely to be based on the CQM.

For testing, all functional models (i.e. not the STM) will be connected to the electrical ground support equipment (EGSE). The EGSE with a spacecraft simulator (CDMS), passes the telecommands (TC) and the telemetry (TM) between the instrument and the ground systems (see figure 5.1) It includes the Spacecraft Operating System (SCOS 2000) which is used to generate TC and also provides the real time assessment (RTA). Data storage will be in a local installation of the HCSS database. There will be a copy of the database situated in the test laboratory which will be isolated from the outside world during tests, plus a second copy inside the RAL firewall but accessible to all ICC members plus authorised users via a portal (see figure 5.2). This copy will be updated regularly between tests. The Mission Information Base (MIB, see section 5.4) is the instrument database and is stored in the HCSS. The MIB will be to be the storage location of the command mnemonics which will be used by the CUS system to generate test observations. These test observations are then instantiated when a request from a user is received via test control. The output of the tests are monitored via displays on the QLA screens and this may consist of real-time TM taken directly from the router or playback TM from the HCSS database via the router.

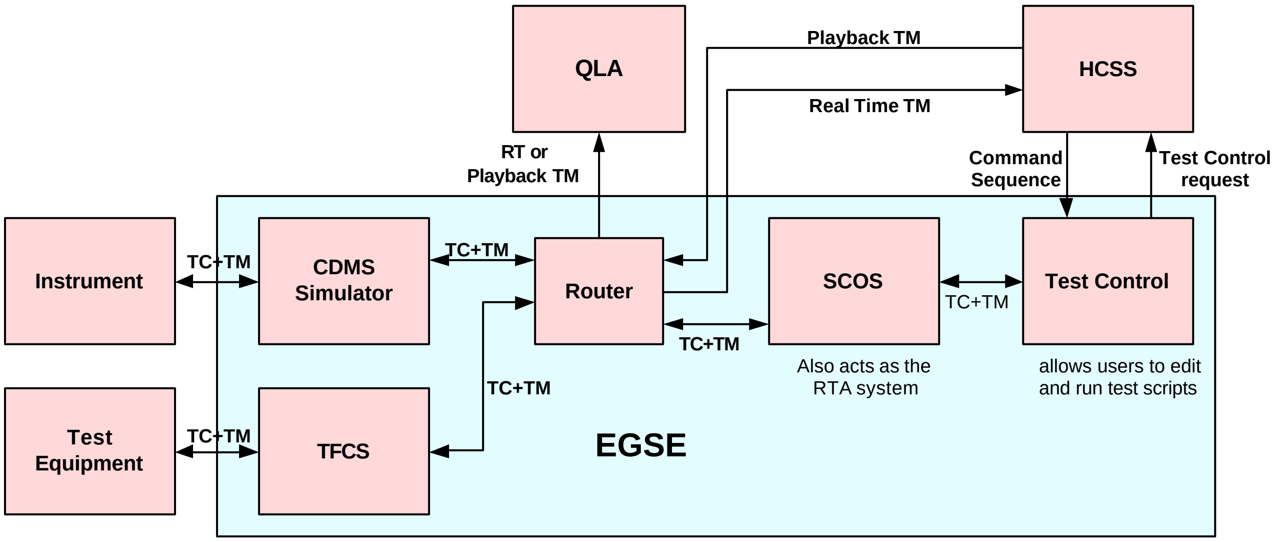

Figure 5.1: Data flow in ILT

5.1 Preparation of tests

The tests are defined at high level in overall test plans for each model. Where appropriate these are then specified in more detail in individual specification documents. The test specifications are then expanded further into test scripts.

It is expected that initially the instrument will be commanded using individual command mnemonics defined in the MIB. Once confidence is gained in sending a set of commands, these can be put together in the CUS.

To facilitate this building up process the CUS logic allows for the definition of high level commands. These high level commands can be put together to form a 'building block' (see section 3.5), and building blocks can then be put together to form observation templates. These three types of CUS component are combined using a simple 'CUS language' which is a tailor made language for the CUS. Once observation templates are defined, the CUS can then be run with a set of input parameters (e.g. S/N) to produce observations. The observations are then manually put together into 'test scripts'.

5.2 Real-time running of tests

The test scripts will be run on the test control system. The test scripts will not only allow the instrument to be commanded but also the test equipment e.g. cryostat, telescope simulator, cold blackbody etc via the Test Facility Control System (TFCS). Each test equipment subsystem will be able to receive instructions and/or transmit data to a Test-Equipment-Interface (TEI) that decodes telecommands (TC), and compiles telemetry (TM) packets to be transferred to SCOS 2000.

The instrument output will be monitored by both the SCOS system, which allows a check on the housekeeping data and by the QLA system which allows a near real time assessment to be made of the scientific quality of the data. The QLA system is a tailor made system for SPIRE, although the interface to the telemetry router in the EGSE and the QLA infrastructure are common.

5.3 Off-line Analysis of tests

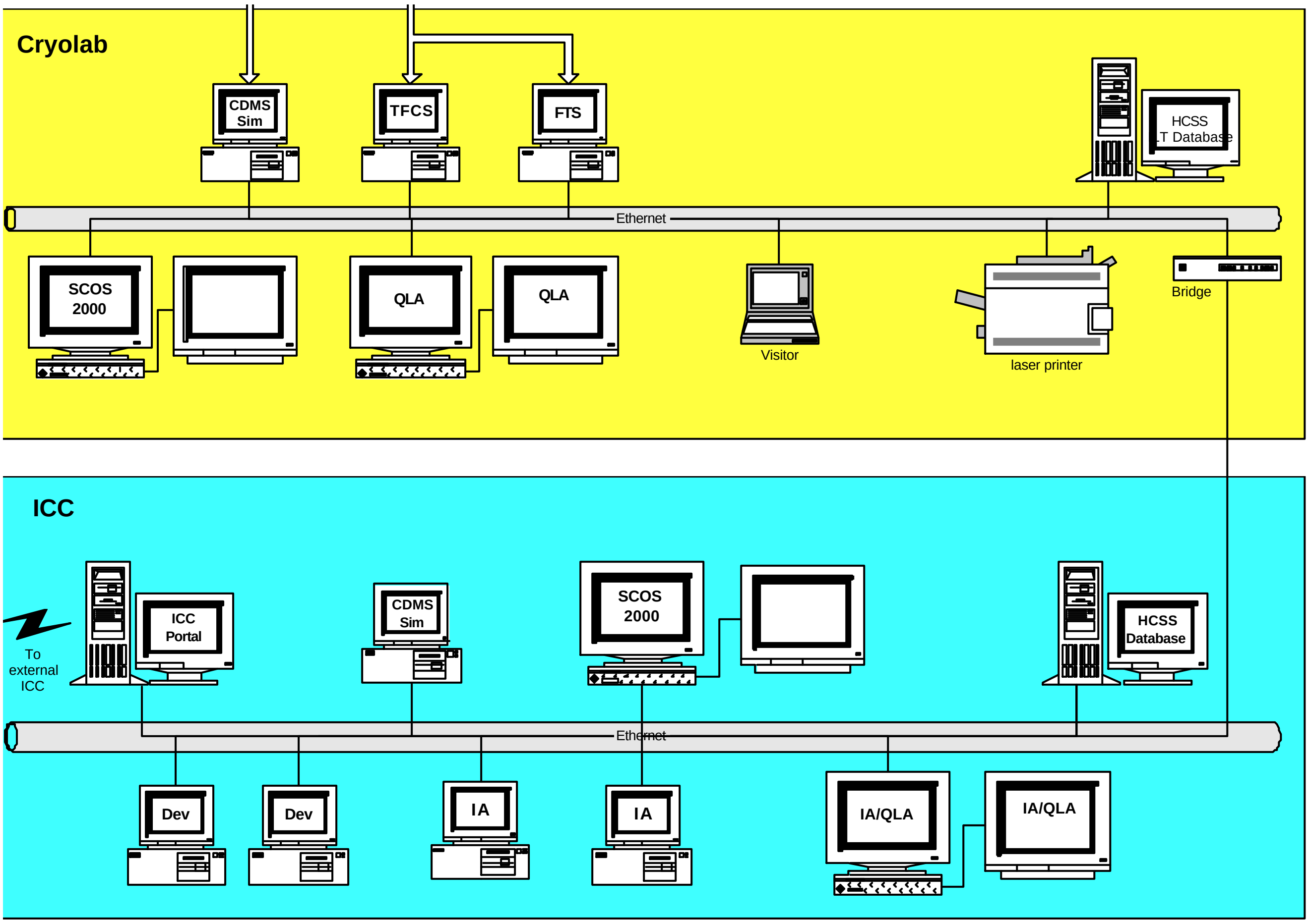

Figure 5.2: ILT Configuration at RAL

Test data will be stored in raw form (telemetry packets) in the test facility (cryolab) copy of the HCSS database. Also stored will be 'processed' data produced by data analysis routines within QLA. After being made available, the data can then be accessed by authorised users through an interface to the ICC copy of the database which will be made available through the ICC portal machine. The access mechanism is TBD but it could either allow authorised users access from any location or it could be granted on the basis of domain names.

To support further processing of the test data, the ICC will provide some software tools for offline analysis, which will be formally part of the QLA system, but may have components that will also be used as a basis for IA. The implementation of IA as a common system is under discussion but it is likely to be implemented in Java using a common infrastructure. The ICC software manager will define the coding standards and 'rules' that will allow the QLA offline processing software to be used as a part of the IA system. External sites (e.g. IPAC or the consortium) will be will be positively encouraged to meet these standards, however the ICC could accept inputs as 'algorithm only' and in these cases it would need to re-code. Outputs from offline analysis e.g. calibration files, parameter limits, and trend tables will be stored back in the database.

5.4 Provision of instrument data-base (MIB)

The instrument database (MIB) is being developed at the operations center at RAL using the MIB editor system. The instrument database is then used to produce and update satellite database. The satellite database contains information about the configuration of the instrument and the satellite monitoring software (SOCS 2000), the uplink (TC) and the downlink (TM) data.

The database contains the following information:

- Configuration of the SCOS 2000 system, e.g. views, calibration tables, derived parameters definition, mimic displays…
- Definition of downlink telemetry, e.g. structure and definition of instrument house keeping telemetry, as well as information to detect out-of-limit values in the telemetry.
- Definition of uplink, e.g. command mnemonics, command parameters, command packets, command sequences.

The database will have the same format for all three instruments and it will be generated by the database editor supplied with SCOS-2000. Each instrument generates a set of plain ASCII files which will be imported in the different systems using them: the MOC system, RTA, and the HCSS.
The source of the database is the same for all systems in the HGS (i.e. the HCSS, the MOC system, RTA and EGSE-ILT, which are all SCOS-2000 based) and the source maintenance is under responsibility of the MOC.

5.5 Changes to On-board Software

The on-board software (OBS) is being developed at IFSI and this development is done in close consultation with the instrument team. During the pre-operations phases, the OBS is not updated or tested under the responsibility of the ICC, however members of the ICC will monitor the updates and tests in preparation for operations. The software will be first tested on the AVM. This will verify the software and it will then be used for testing the CQM, PFM and FS. It is likely that the testing of each will require further updates to the OBS.

6. INTEGRATED SYSTEM TESTS

The Integrated System Test (IST) phase will cover many aspects of instrument operations, from functional tests to the validation of engineering observations and AOTs. During these tests, the main difference with respect to routine operations phase is that there is no MOC and these tests will be conducted by industry using the Central Checkout System (CCS) either on the satellite prime contractor's premises or at ESTEC. Following IST there are also ground segment tests and simulations, system validation tests and end to end tests which are similar from an ICC point of view and are hence included in this section.

The objectives of ISTs are to verify the functionality of the instruments and to verify correct implementation of all interfaces between instruments and S/C on both sides. Following integration of the instruments into the satellite, ISTs provide as flight-representative environment to the instruments as possible to validate instrument general health, instrument performance and compatibility between the instruments.

As far as the test set-up and 1 g conditions allow, the ISTs will cover all aspects of instrument operations. The laboratory environment will be replaced by the S/C. Test control and uplink/downlink functionalities will be covered by the satellite EGSE and will fall under the responsibility of the prime contractor. However, it is clear that due to missing S/C functions (e.g. attitude control) and missing ground segments elements (e.g. MOC), some shortcomings of the IST set-up have to be accepted and missing elements or functions will be simulated to the extent possible.

6.1 Preparation of tests CUS etc.

These tests will have been defined during ILT and the main aim will be to check that the instrument is still functioning correctly and the performance is nominal. Therefore it is expected that any test script development will be minimal, although some may be required in the case of optimising after a component failure.

During this phase there may also be an opportunity to increase understanding of the instrument and possibly further fine tune observing modes by testing on the flight spare. If this is done, specific test scripts will need to be developed.

6.2 Real-time running of tests

The main difference in running the IST is that the SPIRE team will not be able to command the instrument as this is done by the prime contractor using their system. As no test equipment will be used the only telemetry source will be the spacecraft and instrument, although the shutter telemetry may be in separate packets. The QLA system will continue to be used for IST and is likely to be run via QLA scripts developed in ILT. The development work on the QLA system during IST is expected to be minimal.

Any tests on the flight spare model will be done at RAL with the same lab set up at ILT.

6.3 Off-line analysis of tests

IST data will be stored in the data based and analysed offline using tools developed during ILT. As IA will become increasingly mature during this phase it may be possible to use IA for part of the analysis.

One of the main results to come out of the offline analysis will be a final estimate of sensitivities which will allow the Time Estimator software to be completed and delivered to the HSC. This software will be used by Herschel proposers to estimate how much time they will need to carry out their scientific programmes.

6.4 Changes to On-board Software

See section 5.5.

Pre-Launch, Launch and Early Orbit Phase

The launch and early orbit phase describes the launch and first few orbits where orbital parameters are established. During this phase all Herschel instruments will be switched off and there are no specific ICC activities in this phase.

6.5 Training

In the last year before launch, in preparation for operations, the ICC is likely to expand its membership. The new members will require training on the operational systems and the existing members will need training on those ICC systems they are not familiar with. The mechanism for this training is TBD but could consists of experts in particular systems holding training courses in their systems. These experts may be either existing ICC members or personnel from other teams (e.g. the MOC).

7. COMMISSIONING PHASE

The commissioning phase describes the phase where the instruments are first switched on and the instrument (and spacecraft) functionality is fully checked out.

The activities of the instrument commissioning phase will focus on switch on, functional checkout of the (prime) instrument subsystems and their modes, similar to the tests carried out during the Integrated System Tests, plus observations to confirm the instrument/satellite system characteristics (e.g. instrument aperture pointing).

7.1 Preparation of tests

The functional tests used for commissioning will be a standard set of tests, which would have been initially developed in ILT and repeated in IST. The observations to characterise the spacecraft characteristics (e.g. to establish focal plane geometry) will be new observations for commissioning phase, however the scope of these will be well known and can be prepared before launch.

If the instrument behaviour is very different to expectations, it may be necessary to change some observations and facilities will be available both at the MOC site and at the ICC sites to do this.

7.2 Real-time running of tests

The functional tests will be run by members of the ICC, situated at the MOC location in real-time. The data from these tests will be monitored, as they were for IST, on the RTA and QLA systems. Instrument parameters (e.g. detector settings) may be required to be updated on a time scale determined by the speed of data analysis and decision taking i.e. within minutes of each test stage. Following the result of each test the ICC will give a ‘go’ or ‘no go’ for the next test to be performed. If a test fails, a pre-determined course of action will be followed, and in most cases this will involve switching the instrument off until the cause of failure is determined.

7.3 Off-line analysis of tests at ICC@MOC

The ICC@MOC is that part of the ICC located at MOC for the duration of commissioning phase. It is likely that the personnel situated at MOC will be those who have participated in the IST and they will have a good general background of instrument behaviour. A working ICC software environment will be available at MOC allowing the possibility to prepare/modify test/calibration observations and command sequences off line plus the possibility to run the instrument analysis environment, in particular its real-time RTA/QLA parts. The data transfer time from the satellite to the ICC@MOC should allow such activities on a near real time timescale, i.e. not introducing dead periods on timescales significantly larger than the inevitable signal travel time.

The ‘instrument representative’ at the MOC will be responsible for conducting the tests, and providing confirmation of their correct execution. A communication link from the ICC@MOC to the spacecraft controller is used to provide verbal communication between the instrument representatives and the spacecraft controller during tests.

It is not expected that the ICC@ICC will monitor all the tests as they may be carried out at any time of day or night (the staff at the ICC@MOC will work shifts, as required by the timing of the tests).

However, the ICC@MOC will be provided with both telephone and network links to the ICC@ICC in order to allow the monitoring of the tests by the ICC@ICC and to allow discussion between the instrument experts, at the ICC, and the 'instrument representative' at the MOC.

7.4 Off-line analysis of tests at ICC@ICC

The members of the ICC located at the ICC sites will have access to commissioning data. Depending on expertise, e.g. OBS expertise at IFSI, the ICC@ICC will either have a direct role in detailed analysis of commissioning data or an intermediary role in facilitating instrument experts in their analysis. It is expected that instrument experts either in the ICC@ICC or in the instrument team will be on standby in case of an instrument problem. If this occurs, the appropriate expert may either remotely diagnose the problem or join the ICC@MOC while this takes place.

7.5 Changes to On-board Software

During commissioning phase the OBS may be changed in response to an instrument anomaly or a different instrument behaviour to that on the ground. In some cases, where there may be a danger to the instrument, the ICC will need to stop SPIRE operation, and it may take the ICC some time to generate, validate and verify the new OBS. Copies of the OBS Maintenance Facility (OBSMF) will be situated at IFSI, where the software is developed, at the RAL operations center and at the ICC@MOC. Updates to the software could take place at any of these sites and these will be approved by both the ICC and the OBS team at IFSI before delivered to the MOC.

7.6 Monitoring of Instrument Health and Safety

The commissioning tests determine the instrument status and ability to operate in space, and information on the health and safety of the instrument is given as one of the outputs of the tests. As the tests are conducted, the instrument health and safety will be considered at each step if any danger to the instrument is perceived a pre-agreed course of action will be followed, which in most cases are likely to mean that instrument operations are suspended. This decision is likely to be taken by the ‘instrument representative’ in the ICC@MOC. The mechanism for resumption of operation is TBD but may involve an ‘executive’ decision from the instrument scientist or the PI in addition to the ICC.

8. PERFORMANCE VERIFICATION PHASE

The Performance Verification (PV) phase is intended to obtain the in-flight characterisation of the instrument e.g. in terms of stability, sensitivity, resolution, timing, and calibration parameters and to verify the observation templates supplied to observers (Astronomical Observation Templates, AOTs). A schedule of astronomical observations and (internal) calibrations, defined and iterated pre-launch, is executed using normal observatory procedures.

This schedule is based upon an agreed in-orbit calibration and AOT verification plans generated jointly by the ICC and the HSC. The calibration plan will contain a description of all planned calibration activities and associated calibration sources (internal and astronomical) required to fully characterise the instrument. The AOT verification plan will contain a description of a set of observations needed to verify the AOTs. It is important that both the plans 'stretch' the parameter space of instrument capabilities in order to cover the parameter space of the routine phase observation programme, and to verify or generate new values for observation optimisation. Following this programme the ICC will recommend to the HSC, those AOTs which should be released for use. It may also use this data to select the more optimal of two similar AOTs e.g. FTS step and look or continuous scanning.

Most of the detailed analysis, in particular of the science data, is done offline at the ICC using IA facilities. However, during the PV phase there will be limited ground contact with the S/C although it can be assumed to be somewhat relaxed against the stringent definition that applies during routine phase. The baseline for the SPIRE ICC is that it will not be present at MOC during PV phase but the ICC commissioning capability will be retained at MOC and if necessary the data can be monitored on arrival by ICC personnel present at MOC.

8.1 Preparation of ordinary observations

Ordinary observations will be used in PV phase for the following purposes:

- to support the calibration of the instrument
- to confirm the instrument is performing as expected and hence the validation and verification of the observing modes
- to decide between equivalent or similar observing modes

The ordinary observations used in PV phase will be planned and scheduled before launch and will be the implementation of the detailed calibration and AOT verification plans. The calibration plan will detail how the calibration will be derived i.e. what observations are needed and what reliance on other calibration parameters, each calibration table needs before it can be generated. The ICC will select targets based on calibration need and visibility constraints. This 'master' target list will not only include those objects visible assuming the nominal launch date but will also take other parts of the sky into consideration in case of a launch slip (TBC).

The observations will be entered using the proposal handling system (PHS). This system, which is part of the HCSS, will allow observers to enter their observations in terms of objects, AOT, S/N, etc and will have similar functionally to the SIRTF SPOT system. It will support the definition and submission of observations based on the observation modes as defined with the CUS. In the process of defining observations within the PHS information about the building blocks composing a given observing mode will be available to the user to aid him or her in understanding how the observation will be executed. Estimated times are fed back to the proposers so that they can fine-tune their proposals. The main outputs of the PHS are so-called observation requests, which are inputs to the Mission Planning System.

The HCSS will support remote access to the PHS at the HSC, using e.g. WWW technologies and public network, hence it will be available at all ICC sites.

8.2 Preparation of calibration/engineering observations

Some PV observations will not be able to be executed using standard AOTs and these will have to done using non-standard tailor-made observations developed using the CUS (see section 3.5 for a description of the CUS). These observations will be used for very specific cases of instrument calibration or for instrument diagnostic purposes e.g. fine stepping the BSM. They will not use the standard command sequences (generated by AOTs) but will use a 'manually' assembled sequence of instrument commands and consisting of 'blocks'. Once the template is defined in the CUS it will then be possible to use the PHS to enter the parameters to fill in the template.

Like the ordinary observations, the calibration or engineering observations will be prepared prior to launch. Some observations will already be in the system as a result of testing but it is likely that new observations will be needed in order to make measurements that can only done in space. The entering of CUS scripts requires a licence for the versant database in the HCSS and the current baseline is that this database will only be available at the operations centre site at RAL. Remote access to this and other ICC systems will be available from the other two sites, however, in the particular case of running the CUS scripting tool, remote access might prove impractical.

If the definition of a new observation goes below building-block level i.e. uses individual commands or defines a new building blocks, it should be agreed by an instrument expert, who will check that it does not compromise the instrument safety. All observations will be tested on the spacecraft simulator before being uplinked.

8.3 Scheduling and Re-Scheduling

In PV phase, the ICC will be responsible for scheduling observations using the mission planning system (see section 3.6, this is done by the HSC is routine phase). At present the timing of the re-scheduling of PV phase observations has not yet been agreed between the ICCs, the HSC and the MOC. However, assuming an 'ISO like' PV phase where the three instruments are scheduled on a rotating daily basis, then there is clearly a need from the ICC, for a minimum turnaround time from observation to schedule of 3 days, where it would be possible to re-schedule standard observations. More complicated examples, i.e. where the CUS template needs to be modified, may take longer.

As PV phase progresses, if detailed analysis shows that the pre-planned schedule is not suitable for further characterisation of the instrument, it will be possible to change (near) future calibration observations which will be then inserted into subsequent observing schedules. This will either be done by ICC members using the standard AOT entry tools or by running pre-defined templates in the CUS. In some cases it may be necessary to define a new CUS template.

8.4 Processing & Analysis of ordinary observations

The SPIRE data processing will be done via the interactive analysis system which is developed and maintained under the sole responsibility of the ICC. The HSC will use the IA to carry out the scientific data processing using the IA in a 'pipeline' configuration i.e. Standard Product Generation (SPG). As a result of this pipeline processing a set number of reduced data products will be stored in the HCSS.

The IA is likely to have a 'core' IA which will consist of those modules required for processing scientific observations. It is currently very much under discussion whether those modules required to generate calibration files, trend analysis data and instrument diagnostic files etc will formally be part of the IA system or will – in name at least – form a separate 'calibration' or 'specialist' IA. The current baseline, however is that there will be a single IA system, and that the entire system is open to all users.

An IA user may start their IA session from any standard product down to the data frame level (or possibly the packet level). The ICC teams will use the SPG and 'interactive' analysis to not only verify the AOTs in terms of whether they are the best way to operate the instrument in space, but also to verify the SPG data analysis i.e. the IA system itself, and to develop interactive strategies which will be documented for users.

The current baseline for SPIRE IA is that it will be a specific software for all SPIRE data reduction. It will have a distributed development across all ICC sites and will be written in Java with a common (Herschel) infrastructure. The advantage of this approach is that the IA can be run on any platform which will enable members of the ICC located at different sites to work together easily. It may be necessary to update IA as PV phase progresses and it is to be expected that during PV phase there will be several 'developer' releases which will remain internal to the ICC until the start of routine phase.

8.5 Processing & Analysis of calibration/engineering observations

Calibration and engineering observations stored in the HCSS database will be analysed to the maximum extent possible using standard (SPG) IA reduction steps with further analysis being completed using the wider system. For some engineering observations QLA may also be used. Although most calibration analysis will be carried out by members of the ICC, some calibration analysis may also be done by an instrument specialist at the HSC.

The analysis, split into specialist teams, leads to an assessment of the instrument status and behaviour. This will be reviewed on a regular basis throughout PV phase (e.g. weekly) by the entire ICC, and the reviews could either be done in ICC meetings or via tele- or video-conferencing. As a result of each review, the analysis, calibration trend tables or specific calibration parameters or tables needed in data processing will be updated in the ICC database. It is also possible that it will be necessary to also update the processing software, and it could be anticipated that there will be several 'developers' releases. As calibration tables are likely to be changing on a weekly basis during this phase it is not likely that a user release of the calibration file/IA system in the HSC will take place until the end of PV phase.

8.6 Optimising observing modes/AOT parameters

The observing modes and AOT parameters will have been established in ground testing. The PV phase observations will give an indication of the instrument behaviour and in many cases a direct comparison can be made with how it was behaving on the ground, although some parameters e.g. telescope temperature can only be determined in space. The PV data may indicate that the observing mode templates need to be updated. Reasons for this include:

- the sensitivity has changed,
- calibration parameters determined in space are different to predictions
- instrument anomalies
- a better way of achieving the same science is found

If performance has changed e.g. sensitivities might have changes or mechanism limits might be refined, then an update will be made to the observing mode template by editing the CUS. In the case of a sensitivity change, the time estimator used by SPIRE observers will also need to be updated. Changes to observing modes may also need to be implemented in the MIB and/or the OBS. Any changes to observing modes will have to be implemented via the SPR/SCR system and the HSC will inform observers if they need to update their proposals.

8.7 Optimising data processing

The ICC data processing is initially developed and refined using test data in the ILT phase and IST phases. In PV phase it is likely to be refined as a better understanding of the instrument is achieved and/or refinements are made to the observing modes.

The specialist teams within the ICC will work on processing algorithms and associated calibration files. They will do this by using the IA system alone or by combining its use with their own external algorithm development environments e.g. IDL. Once a prototype algorithm or calibration file, are ready, the algorithm and/or calibration file and a set of test results will be submitted to the regular meeting of the ICC for discussion.

A particular aspect of PV phase is that many calibration tables will need to be generated for the first time using in-space data. These tables may have a dependency on other tables and for this reason a particular team may need to wait for another team's output (note it is expected that individual ICC members will belong to multiple teams). Team outputs will be part of the detailed PV schedule in the calibration plan and, to review progress, the ICC will need very frequent meetings in this phase. If approved, calibration files will be put into the database directly and algorithm updates will be coded to IA coding standards and enter the internal software update system described in section 0. Note one of the outcomes of this analysis might be a suggestion for a better way of operating the instrument.

8.8 Monitoring of Instrument Health and Safety

Following on from commissioning phase, the ICC will start the regular monitoring of the health and performance of SPIRE in PV phase. This will either be done within the scope of the operations team or a separate trend analysis team TBD. Although the team is likely to be led by an ICC member at the operations center (as instrument knowledge will be required), there are no technical limitations on the location of this work.

The main tasks will be:

(i) collecting instrument anomalies identified by the instrument itself, the data handling system, or reported by the MOC
(ii) identifying unexpected instrument events reported in instrument HK TM
(iii) analysing trend data extracted routinely from instrument HK TM and calibration/scientific AOT products
(iv) periodically dumping instrument on-board memory for comparison with the expected image

In the event of an anomalous situation, the ICC will investigate the problem using data from the observation, previous observations, ground testing; instrument simulators or other software tools. In routine phase there will also be time to investigate problems using the instrument flight spare and/or specific diagnostic observations submitted to the satellite.

These routine monitoring activities will be carried out as a background task (i.e. there is no requirement to carry out the task each day) although monitoring should not lag behind data reception by more than a few days. Instrument anomalies will, of course, be dealt with as soon as possible after they have been detected and this may require the immediate suspension of instrument operations.

8.9 Scientific Performance Verification

Once the initial instrument calibration is established, the latter part of PV phase will be used to confirm the scientific performance of the instrument. To do this, observations of a standard set of sources giving a range of astronomical parameters e.g. point-like to extended, faint to bright, and low background to high background are selected before launch, placed in the PV phase plan, then, when approved, entered into the observation planning system and scheduled. These observations are then used to fully exercise each observing mode and its data processing. If this is found to be satisfactory, the ICC will then recommend the release of the observing mode to the HSC.

8.10 Scientific Validation of AOTs

Whenever an update to an observing mode or the IA system is made, the update will need to be checked for scientific validity. This is likely to be done via a standard set of observations. These observations will initially be performed in PV phase and the data from these observations will allow the ICC to recommend whether or not a particular observing mode should be released to the community.

9. ROUTINE

In operations the ICCs' main tasks are: monitoring instrument health, calibrating the instrument, and the provision of data reduction software. The ICC will also be expected to specify criteria for data quality checking and will be expected to investigate those observations which fail to meet these criteria.

9.1 Preparation of observations

9.1.1 General Observers

Astronomers will have a time allocated to use SPIRE from the HOTAC. Each astronomer will be responsible for planning their own observations using the PHS which will consist of tools supplied by the ICC and HSC (see section 8.1). The HSC is responsible for co-ordinating this process and they will provide an on-line environment for the users to plan and fill in the observation details of their accepted proposals. The HSC are also responsible for scheduling these observations.

The PHS user will be able to use the latest measured performance of the spacecraft and of the instruments which will be either determined in ground testing or in-flight. The ICC will provide an observation time estimator which will be made available on-line as part of the PHS and will be refined throughout the mission as additional experience is gained. This will allow observers to optimize their proposals, using their knowledge of background fluxes, stabilisation times, etc. Planning and Preparation of Calibration and Engineering Observations.

9.1.2 The ICC

For every nominal scheduling period the ICC will select and prioritise a set of observations based on its long-term calibration plan which is agreed with the HSC. These observations will include observations needed for calibration derivation, calibration monitoring, cross-calibration, plus, if necessary, problem diagnostics. It is the joint responsibility of the ICC and HSC to define and agree cross-calibration observations.

The ICC will verify that the selected observations are consistent and schedulable (e.g. using time estimators, visibility tools and the HSC mission planning tools) and handed over to the HSC for scheduling. The hand over mechanism is TBD but is likely to involve a transfer between the ICC copy of the HCSS database and the HSC copy. Specific scheduling constraints can be provided, such as 'schedule at the start of an operational day', 'schedule observation A 20 minutes after observation B', 'schedule at a specific absolute time', or 'use a specific S/C configuration'. Repetitive calibrations (e.g. to be carried out every Nth day/week) will be entered into the system as a series of independent observations submitted to the HSC for scheduling.

Normally, calibration and engineering observations are submitted at fixed times within the agreed nominal scheduling cycle. When warranted, e.g. by non-nominal instrument behaviour, a much shorter time scale (3 days – TBC) for the submission and planning of a calibration or engineering observation can be accommodated.

HSC personnel select the proposed calibration and engineering observations and insert them into the observation schedule in agreement with the specified scheduling constraints. The resulting schedule may or may not be a mix of calibration, engineering and normal observations. After submission of the observation schedule to the MOC, the calibration and engineering observations are carried out as normal observations and the resulting data are ingested into HCSS by the HSC according to normal operating procedures. Contrary to failed 'normal' observations, however, the HSC will not undertake to reschedule failed calibration or engineering observation without a specific request from the relevant ICC.

9.2 Processing & analysis of ordinary observations

The SPIRE data processing will be done via the interactive analysis system which is developed and maintained under the sole responsibility of the ICC. The HSC will make the IA package available to the astronomer via the HCSS and it will include the both the 'latest' agreed software and calibration tables i.e. the 'user' release (see section 9.5.1 for details). The HSC will use the IA to carry out the scientific data processing using the IA in the 'pipeline' SPG configuration. As a result of this pipeline processing a set number of reduced data products, as defined by the ICC, will be stored in the HCSS. The HSC will be responsible for providing the necessary support for data reduction to the community and will ensure that all observational data are systematically processed for quality control purposes.

It is expected, but not necessary, that most astronomers will start their data reduction of a particular observation with one of these high level SPG products. The IA packages will also allow any astronomer, who so wishes, to start their data processing process from the data frames stored in the HCSS and to facilitate this they will be able to access both the 'latest' software and associated calibration tables. Although the IA system is not yet defined it is baselined to be modular in terms of 'processing steps', with each processing step being run in either automatically or interactively.

9.3 Processing & analysis of calibration and engineering observations

Calibration and engineering observations are stored in the HCSS database and will be analysed to the maximum extent possible using the standard IA data reduction steps with further analysis being completed using specific calibration analysis tools developed by the ICC. For some engineering observations QLA may also be used. Although most calibration analysis will be carried out by members of the ICC, some calibration analysis might also be done by an instrument specialist at the HSC acting as a member of a specialist ICC team.

The analysis leads to an assessment of the instrument status and behaviour, and this will be reviewed on a regular basis by the entire ICC, either by ICC SODAG meetings or via tele- or video-conferencing. Also, if necessary, additional calibration sources may be selected for further observations or more information on available calibration sources may be sought (e.g. using additional observations of calibration sources using other Herschel instruments or ground-based facilities).

As a result of this review, the analysis, calibration trend tables, specific calibration parameters, or tables needed in data processing will be updated in the ICC database. It is also possible that it will be necessary to also update the processing software. Agreed updated parameters or tables will initially be made available to members of the ICC for testing purposes and the ICC database and processing software will support multiple versions (e.g. 'nominal' and 'test').

The results of this test period will again be reviewed and once the 'test' values for such parameters are accepted as new 'nominal' values. The development of IA is under the control of the ICC. The formal update mechanism in the HSC system is not yet agreed, although it is likely that for SPG at least, the HSC would prefer that the ICC and HSC review the planned update under the joint HSC/ICC SPR/CCB mechanism. The new tables are then made available through HCSS for general use, e.g. by the standard product generation software or, when relevant, by the scientific mission planning system.

The results of this analysis also flow back into the next cycle of calibration planning and data reduction. and if necessary the long term instrument calibration plan and strategy are adjusted.

Although calibration observations will normally be specifically requested, the ICC may use any observation for the sole and explicit purpose of calibrating the instrument without this being considered an infringement of proprietary rights. The status of the overall instrument calibration and health are added to the calibration status report, which is periodically produced by the ICC, Optimising observing modes/AOT parameters

Routine phase calibration observations and trend analysis will give an indication of the instrument behaves over the mission from PV phase onwards. Any changes in behaviour may result in the need to change an observing mode. Typical reasons for these changes include a change in internal calibrator behaviour, a change in detector sensitivity or pixels becoming 'dead', and a mechanism movement becoming sub-optimal. Investigations by the ICC into the best way to get the maximum scientific return from the instrument may lead to suggestions for a new observing mode.

If approved by the ICC (and instrument team?), a potential new observing mode will be tested on the instrument simulator and/or flight spare. During this process the changes needed to be made to S/W will be analysed. When a final decision is made by the ICC, a request for a change is made via the SCR system. The change will be formally approved by the CCB.

9.4 Optimising data processing

The ICC data processing is initially developed in the ILT and IST phases. In PV phase it is likely to be initially refined as a better understanding of the instrument is achieved and/or refinements are made to the observing modes.

During routine phase members of the ICC will continue to work on processing algorithms (and associated calibration files). Once a prototype algorithm and, if necessary, the associated calibration file, are ready, this is submitted to a regular meeting of the ICC for discussion. If approved, this will be coded to IA coding standards and enter the software update system described in section 9.5.1. Software maintenance

9.4.1 Software supplied to the HSC

The HSC and ICCs will share a large amount of S/W and a significant fraction of this (e.g. time estimators, command generators, instrument simulators, IA) is developed by the ICCs but used by the HSC as well. It is expected that the maintenance of all shared S/W will be managed in a centralised fashion. The current baseline is the existence of one joint Configuration Control Board (CCB), chaired by the Science Operations Manager (SCOM), with permanent members from the HSC and ICCs. Only the CCB will have the authority to approve/refuse and plan changes to the HSC/ICCs system that may have an impact on the Herschel science data.

To track changes there will be a centralised change control system accessible to all relevant parties plus centralised documentation and S/W configuration control systems which are used by all relevant parties. The CCB is expected to meet at regular intervals (e.g. weekly) to review the pending SPRs, SCRs and to disposition on their analysis, implementation, and installation. Because the different CCB members will not be on the same site, CCB meetings will normally be held via tele- or videoconference.

Note the status of IA within this system needs clarification. For software under the control of the ICC there will be an ICC CCB (possibly more than one CCB depending on the software), which will meet regularly (~ monthly) to discuss the status of the software. The IA may only be subject to the ICC CCB, although, in the case of the SPG, the joint HSC/ICC CCB could preside over a 'release'. The bug fixes can be in the HSC system without being live and there will also be a different areas in the SPR/SCR system.

9.5 Software Maintenance

It is expected that the HSC and the ICC will have SW maintenance teams in charge of implementing, testing and installing the SW changes as approved by the CCB for the SW falling under their responsibility.

Within the ICC there is likely to be SW maintenance teams with very different responsibilities e.g. IA/QLA, OBS, instrument simulators etc. No mechanism for the co-ordination of these teams has yet been baselined but this could be co-ordinated as a SODAG activity with the team leaders reporting progress to the SODAG. In the specific case of SPIRE it is also likely that some of this maintenance activity will be done by teams not located at one of the three ICC centres. The SW control and update mechanism may be different for each team i.e. the IA/QLA team may use an internal SPR/CCB system whereas another team may prefer to only use the HSC one.

For software updates in the HSC system, the different teams will need to co-ordinate their efforts on a day-to-day basis with the objective of meeting the work plan set by the CCB. Here, the HSC maintenance team leader may act as the co-ordinator. The co-ordination will be facilitated by the centralised change, documentation and configuration control systems, which are expected to be taken over from the development phase.

9.5.1 Internal IA/QLA Software Maintenance

This section describes the system envisaged for the QLA/IA SW, but may be appropriate for other SW under the ICC responsibility.

The ICC IAS/QLA software will be developed on a number of development sites. It is only at these development sites that changes to the system are performed and tested. Once an element is changed, verified and validated, the author of the change places it into an internal ICC configuration control system. This is likely to be an agreed ICC area of the HCSS system.

The author does not have to possibility to issue a new release of the system and new releases of the system are decided by the ICC CCB. The membership of the CCB is likely to be a small number of people for the developers' release (e.g. ~ one person from each development site) and a larger membership for the 'users' release. The SODAG will need visibility on this process and may also need to make the final ICC approval of a release (TBD). Releases to the development site can be rather frequent (typically a month but not less), and this internal CCB mechanism will ensure that the development site system is not chaotically evolving.

9.5.1.1 Development site:

Development site privileges are granted to any site – not necessarily one of the three ICC sites - participating in the development of the IA/QLA SW. The privilege of a development site is to always be able to access the latest version of the system. The duty of a development site is to (1) regularly contribute to the development by providing elements of the system, (2) follow the CC convention, (3) install all developers' releases, and (4) participate in the different test stages of a release.

9.5.1.2 Developers' releases:

To perform a release of the development site system (this is the test version), at a given date, CC is freezed (i.e. no more changes, except bug fixes, are allowed, elements under development have to be placed back in CC, even if incomplete) and the current version of all subsystems is released and tested (for a given period, e.g. 1 week). If these tests are good, then this is the new development site release. If not, we stay with the previous release and work out the bugs. On demand, the developers' release can be made available to consortium members. Current baseline for developers' release period is 4 weeks.

9.5.1.3 Users' releases:

Official or users' releases are much less frequent (6 months is the smallest period acceptable for software changes in routine phase). Their release process is no different from that of the development site except that the CC board is different, also there may be a further approval step with the PI led SODAG. Outside users may be frustrated by this slow process, but this minimizes the number of different versions of the system we are sending out, and thus the problems we will have to handle. For safety reasons, the users' release has to be identical to a developers' release.

9.5.2 On-board SW maintenance

It is expected that the need for OBS maintenance during routine phase will be minimal as each change will have an impact on the data processing and calibration of the instrument.

In the event that the on-board software needs to be changed, the ICC will use the OBS maintenance facility, provided by the ICC, to update the code or tables. The updated code will be used to generate memory images required to implement the change on board. The updated memory image will be tested on either the Flight Spare instrument or other instrument simulators before being made available to the Ground Segment.

An SPR/SCR will be raised and, when verified, the memory image(s) will be delivered to the HSC with a software release note describing the implications of the change, plus updated documentation reflecting the change. The HSC will validate the updated memory image using the satellite simulator and submit the change to the CCB for approval.

When agreed, the updated memory image will be submitted by the HSC to the MOC for uplink to the satellite. The whole memory image will be transferred to MOC and not only the parts of the memory image which have been modified (patches). It will then be up to MOC to generate the necessary patches to be uploaded to update the on board memory image in accordance with the one received from the HSC. MOC will also be in charge of verifying that the update has been successfully performed.
In the event, where an instrument on board memory needs to be analysed (e.g. following an instrument failure), the ICC may request MOC to dump partially or totally its memory image. The memory dump will be planned by MOC in co-ordination with HSC and the ICC. The resulting memory dump will then be transferred to the ICC via the HSC.

9.6 Monitoring of Instrument Health and Safety

The ICC will continue to monitor the instrument health and safety as described in section 7.6. For critical observations, e.g. investigations following an instrument failure, it may be necessary for parts of the ICC to revert to the setup for the commissioning phase, during which ICC personnel is physically present at the MOC, which is not normally the case during routine phase.

9.7 Quality control of data products

The IA system running in the pipeline configuration will produce 'quality control pipeline' products in addition to the scientific data products. The quality control data will be evaluated by the HSC and as a result of the evaluation, a quality flag will be assigned to each observation. This quality flag will reflect

(i) whether the observation has executed nominally
(ii) whether all data generated are available in the archive
(iii) whether quality control processing has completed without error messages having been generated
(iv) whether the corresponding quick-look output is available

Although it is assumed that the quality flag will be assigned automatically for most observations, it is expected that in some cases a deeper analysis by an ~~instrument~~ ICC specialist may be required and here it may be possible for the ICC to set criteria for observations it wishes to check.

During the operational phases it is not planned to store the products generated during quality control processing in the archive, with the exception of the quick-look product. Why not? If an observation has the final quality flag assigned as 'failed', it will be marked in the database to be considered by the scientific mission planning system to be rescheduled.

The above description of quality control processing highlights the fact that assignment of a 'good' value to the quality flag is a formal process which says little about the scientific validity of the output product from an observer's point of view.

9.8 Support to the HSC

The ICC will be required to support the HSC in several ways:

S/W maintenance:
See section 9.5.

Attendance at meetings:
It is likely that the HSC will hold regular operations meetings at which, participation by the ICC is expected.

Helpdesk enquiries:
Herschel observers will be able to make enquiries about their observations to the HSC via a helpdesk system. Any enquiries regarding SPIRE data, which can not be dealt with by the SPIRE expert at the HSC will be passed to the ICC for follow up. After investigating the problem the ICC will inform helpdesk the outcome.

Quality control follow up:
The HSC will provide quality control information to the ICC. If a set of criteria specified by the ICC are met or the SPG pipeline fails (e.g. because of partial TM loss) the ICC will investigate whether the observation will need re-scheduling and pass their recommendations back to the HSC.

Outreach:
The HSC is responsible for outreach activities but it may consult the ICC on suitable material to be used and it may require the ICC to aid in the preparation of publicity material.

10. POST-OPERATIONS PHASE

The Herschel post-operations phase consists of the rundown monitoring phase, mission consolidation phase, active archive phase, and the archive consolidation phase (when the transfer into the subsequent historical archive phase takes place), and is the final formal phase of the mission.The goal of this phase is, within the constraints of time and resources, to maximise the scientific return from the Herschel mission by facilitating continuing widespread effective and extensive exploitation of the Herschel data.

The operations and ground segment of Herschel are designed to provide 'seamless' transitions between the various mission phases and, many activities 'normally' associated with this phase will already be ongoing as part of the routine day-to-day activities in the preceeding phase. However, all these activities will (have to) be concluded, and finally 'wrapped up' for posterity in the historical archive. During this phase we would expect a run down of ICC manpower at all sites.

These ICC activities will include:

- finalisation of the understanding of the instrument behaviour (including calibration and cross-calibration) in orbit
- finalisation of data processing development.
- continuing to provide support to the HSC in supporting astronomical community in using Herschel data, by provision of not only of software, but also of expertise, and information

10.1 Calibration and Algorithm Development

Calibration tables needed for data processing will continue to be refined by the ICC in the post-operations and it is likely that emphasis will be placed on calibration issues which require a more in-depth investigation. It is likely that these will not have been completed due to operational constraints on the members of the ICC. Also this period allows a final derivation of any time dependent calibration tables.

10.2 Software Maintenance

Software maintenance is no longer required on operational systems such as the time estimator and QLA, however the CCB system will continue to be used for updates to the IA system. At certain points in the post-operations phase the HSC will undertake bulk reprocessing of data following updates to the IA system (e.g. on a yearly basis). The ICC may have to undergo a scientific validation exercise following these updates.

10.3 Support to the HSC

The HSC will continue to operate a helpdesk system and the ICC will be required to investigate/answer queries from SPIRE users via this system. Also all software updates will continue to be supported, including possible tele-attendance at CCB meetings. Regular ground segment meetings will continue and the ICC may also may be required to support the organisation of Herschel related conferences.

11. ARCHIVE PHASE

The historical archive 'phase' is actually outside the (funded) Herschel mission but could commence after the end of the post-operations phase. The user will see no difference from earlier phases, except that from the beginning of this phase onwards no further developments, and no updates of the contents, of the archive can be expected to take place. The duration over which the historical archive will be kept available is undecided, as is, its source of funding, location, and 'custodian', but it is foreseen to be an asset of great value to astronomy for a considerable length of time.