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Rosetta Science Operations Centre Design Specification (RSOCDS)

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20 Oct 2003

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CHANGE RECORD SHEET

Date	Iss.	Rev.	pp .	Description/Authority	CR No.
19 Oct 1999 - 06 Jan 2000	D	1 - 6		first draft	
13 Jan 2000		7		add ESOCs comments to viewgraphs	
14 Jan 2000		8		add comments after MPAE visit	
27 Jan 2000		9		add comments after lunch discussion with Claudia Alexander	
04 May 2000		10		updates according to recent changes, add description of team	
21 Aug 2000		11		updates after comments from ESOC (Elsa and Mark) and Raymond	
24 Aug/25 Aug 2000		12		Insert different planning process for nominal - preplanned observations.	
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11 Apr 2001		14		Incorporate final comments before Design Review	
18 Apr 2001		15		Update glossary, add testing	
07 Sep 2001		16	4	Extend definition of SAP	
			8	replace "... in AD17" with "... in an appendix to AD15"; replace "these could be used" with "these will be used"; delete "their usage will be discussed..." - this has happened!	
			9	Add " To ensure that, the Lander team (LCC) will forward the Lander Operations Plan (LOP), which is in a human-readable form, to the RSOC. The RSOC will use the LOP for planning. The Lander team generates the LOR file (which is not human-readable) from the LOP. Only after acceptance of the LOP will the LOR be passed on to the RMOC" to section about Lander interface (from Lander Science Interface Meeting, July 2001, ESOC)	
23 Sep 2001		17	8 9	update picture "RSOC interfaces" add conversion of Lander FOP to ITL add detailed description of long-, medium-, short-term planning, from outcome of RSOC Design Review.	
12 Oct 2001		18		add schedule of short-term planning	
			9	add image with Lander science planning	
5 Nov 2001				added " AD19: Experiment Interface Documents part B (EID-B) of all experiments and Lander Interface Document Part B (LID-B)" to applicable docs	
14 Jan 2002		19	11	Added the following sentence to 6.1.4.3, Lander delivery phase: ". After the Lander has landed, the principle science planning will follow a schedule as in the nominal short-term planning, however, the duration of the planning cycle will be as short as possible. Typically, a planning cycle of not more than one day is envisaged. The Lander requests a complete cycle time of max. 3 hours. This will be accommodated on a best-effort basis."	Meeting RLGS - RGS, 6 Dec 2001
28 Jan 2002		21	11	Modify the above paragraph	Lander meeting at DLR, Jan 2002

Date	Iss.	Rev.	pp .	Description/Authority	CR No.
			17	update Section 6.1.8, conflict solving, with more details	
08 Feb 2002		22	3	Add "One MSP will be generated per mission scenario." to description of MSP	clarification
			7	Insert Figure showing RSOC architecture in CVP	
			8	Add text at end of "interface to the PI teams" explaining the physical interface.	
			8	Expand section 5.4, Interface to the Lander, with an explanation about the Lander delivery	
			8	add " the Lander delivery phase" to the co-location of RSOC at ESOC	
			10	Add a sentence " It is envisaged that a slow transition between the "manual" approach using Flight Control Procedures and the automated approach with OIOR/LOR files will take place during the first cruise phases." to Section 6.1.1.	
			18	Add a section on s/w and database maintenance	ESOC request
			23	Update Section 10.21: " It is a mission preference that the Lander will be separated preferably before 3 AU while the comet is still relatively in-active. Therefore the Lander separation and relay scenarios have to be executed as soon as a landing site has been selected (Note that the Lander team baselines a delivery at 3 AU and not before)."	GSDR_0044
06 Oct 2003	1	-		Updates and extensions after further discussions Major changes: • Identify Scenario Definition and Master Science Plan • Clarify medium-term planning / training cycle • Clarify that the format of OIOR and LOP is ITL and the format of LOR is POR • Add information about the interfaces in chapter 5 • Add "Procedure how to update the RMIB" and "Procedure how to run experiment sequences on the spacecraft" • Update operational planning and mission phases for 67P/Churyumov-Gerasimenko	
20 Oct 2003				Editorials	

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 Scope

Rosetta is the third cornerstone mission of the ESA long term scientific program Horizon 2000 and will be launched at the end of February 2004 to comet 67P/Churyumov-Gerasimenko (C-G). The original mission plan was to launch in January 2003 to comet 46P/Wirtanen, but the launch had to be postponed due to problems with the Ariane 5 launcher.

To support the Rosetta Project Scientist, the Rosetta Science Operations Centre (RSOC) is being established. The formal, top-level requirements for the RSOC are laid down in AD4, the RSOC Requirements Specification. The present document was written in answer to AD4. It describes the way the RSOC shall look like, *i.e.* the "how is it done". The "how do we get there", *i.e.* the implementation, is described in AD12, the RSOC Implementation Plan. For historical reasons, all issues concerning archiving are dealt with in a separate document, see AD14.

The interface to the Rosetta Mission Operations Centre (RMOC) is described in the SOIA (AD3), which was written by ESOC. The interface to the experimenter teams (*i.e.* the orbiter PIs and the Lander Ground Segment) is described in AD15, the RSOC to Experimenter Interface Control Document.

1.2 Introduction

The RSOC interfaces with the RMOC on one side, with the PI and lander institutes (called "experimenters" in this document) on the other side. Its main tasks are the planning of the science operations schedule and the generation of co-ordinated operational sequences, the payload command sequences, for all Rosetta experiments and their onward transmission to the RMOC. The tasks of the RSOC are outlined on top level in AD1, the Rosetta Science Management Plan and are repeated in Section 3.

This document will first briefly address the interfaces. Then, the implementation of the different tasks will be discussed in sequence. In addition, this document defines the terminology used within Rosetta operations and data archiving.

1.3 Experiment Complement

Rosetta will be equipped with the following baseline Payload complement:

- Remote sensing experiments - ALICE, MIRO, OSIRIS, VIRTIS
- Dust analysis experiments - COSIMA, GIADA, MIDAS
- Volatiles analysis experiment - ROSINA
- Nuclear structure - CONSERT
- Plasma analysing experiments - RPC (ICA, IES, LAP, MAG, MIP)
- Radio science - RSI
- Rosetta Lander - SSP

1.4 Applicable Documents

Always the latest issue is applicable.

1.4.1 Higher-level documents

AD1	Rosetta Science Management Plan, ESA/SPC(94)37, 14 Oct 1994.
AD2	Mission Implementation Plan (MIP), RO-ESC-PL-5100, Issue 1.2, 29 Nov 2000.
AD3	Science Operations Implementation Agreement (SOIA), RO-ESC-IF-5005, Issue 2, Oct 2003.
AD4	RSOC Requirements Specification, RO-EST-RS-3003, Issue 1, Revision -, 09 Feb 2001.
AD5	Experiment Interface Document Part A (EID-A), RO-EST-RS-3001 (only Section 6).

AD6 Experiment Interface Documents Part B (EID-B) of all experiments and Lander Interface Document Part B (LID-B).
AD7 Experiment Interface Document Part C, Appendix to EID-A (AD5).
AD8 Ground Segment System Test Plan (GSSTP), RO-ESC-PL-5102, Issue 1, 30 Nov 2000.

1.4.2 Documents on the same level

AD9 Command Request Interface Document (CRID), RO-ESC-IF-5004, Issue B4, 24 Jun 2002.
AD10 Data Delivery Interface Document (DDID), RO-ESC-IF-5003, Issue B5, 27 Mar 2003.

1.4.3 Lower-level documents

AD11 Experiment Planning System (EPS) User Requirements, SOP-SSD-RS-001, Issue 1, Revision -, 08 Nov 2000.
AD12 RSOC Implementation Plan (RSOC IP), RO-EST-PL-3032, Issue 1, 15 Nov 2002.
AD13 Visual EPS User Requirements Document, SOP-SSD-RS-003, Draft 2, 10 May 2002.
AD14 ROSETTA Archive Generation, Validation and Transfer Plan, RO-EST-PL-5011/1.0, 16 May 2001.
AD15 RSOC to Experimenter Interface Control Document, RO-EST-IF-5010, Issue 1/a, 15 Apr 2003.
AD16 Rosetta Glossary, RO-EST-LI-5012/1g, 09 Oct 2003 (available online at http://www.rssd.esa.int/Rosetta/, navigate to "Glossary").
AD17 ORF Acknowledger User Requirements Document, SOP-SSD-RS-004, Issue 1, 14 Aug 2001.
AD18 RSOC to Flight Dynamics Team Interface, part of SOIA (AD3).
AD19 ECSS-040, Software Standard.
AD20 RSOC System-Level Test Plan, RO-EST-PL-5013, Issue1, Revision 0, 01 Jun 2003.
AD21 Rosetta Mission Calendar, RO-ESC-TN-5026, Issue 2, Jul 2003.
AD22 Rosetta: Consolidated Report on Mission Analysis Churyumov-Gerasimenko 2004, RO-ESC-RP-5500, Issue 5, Revision 0, Aug 2003.
AD23 Procedure on Handling Document Change Requests (DCRs), SOP-SSD-PR-003, Issue 1, 25 Sep 2003
AD24 EPS ICD File Syntax Definition, SOP-RSSD-IF-001, Issue 1, Revision -, 13 Mar 2003.
AD25 Procedure on handling Software Problem Reports, SOP-RSSD-PR-001/Da, 01 Oct 2002.

1.5 Reference Documents

RD1 D. Boden, W. Larson, Cost-Effective Space Mission Operations, Space Technology Series.
RD2 Experiment Planning System Software User Manual, SOP-SSD-UM-001/1b, 07 April 2003.
RD3 Mission scenarios - Close encounter, RO-EST-TN-3027, Draft 7, 21 Mar 2000.

2. Terminology used within the Rosetta science planning

This section explains the most important terminology used in this document. Note that an extensive explanation of terms and acronyms is given in AD16.

The **Science Operations Team** (SOT) consists of the staff constituting the RSOC.

Science Activity Plan: The *Activity Plan* or *Science Activity Plan* (SAP) is a top level schedule which outlines the science operations in a descriptive manner. Its main content is a time-ordered listing of *mission scenarios* within *mission phases*.

Mission phase: One of the major time divisions of a mission (see Rosetta Mission Phase Definition, Appendix B). Has a definite start and end date and a definite start and end event. Examples are Near comet drift phase, Comet low activity phase, ...

A **mission scenario** is a part of the mission fulfilling a certain set of science goals. It typically requires a dedicated trajectory (a trajectory can be part of an orbit, a complete orbit, or several orbits). Within one *mission phase*, different *scenarios* can be carried out and *scenarios* can be repeated more than one time, *e.g.* Map gravitational field, Close encounter, ...

A **Master Science Plan** (MSP) lists the experiment operations on a top level, *e.g. mode* level. It will also contain s/c pointing and slewing information. A *Master Science Plan* describes a *mission scenario*. One *MSP* will be created per *mission scenario*. In the Rosetta mission, it will be generated in the long-term planning process.

An **experiment mode** describes the operational state of the experiment. When the experiment is in a certain *mode* it can perform only the actions that belong to that *mode*. A *mode* creates the potential to perform a certain kind of operation. Examples are: "standby", "measurement", "software maintenance".

Experiment actions: The experiments are commanded by telecommands, which are stored in the RMIB. For the purpose of scientific operational planning, sometimes more details than the telecommands need to be modelled, sometimes (hopefully most of the time) less details need to be modelled. To allow this, so-called experiment *actions* are used in the planning process. The experiment actions are structured in a hierarchical order reflecting different levels of complexity.

The lowest level is level 3. *Level 3 actions* are the smallest possible actions, *e.g.* "open shutter", "expose", *etc.* Level 3 actions are assumed to have a constant power level and/or data rate generation.

Level 2 actions are a set of level 3 actions which perform a certain operation. As an example, "make image" could be a level 2 action which is composed of the level 3 actions "open shutter", "expose", "close shutter", "read out CCD", "transfer image to mass memory".

Level 1 actions are defined for a given scientific measurement. For example, we could have "colour imaging" as a level 1 action. It would be composed of the level 2 actions "set red filter", "make image", "set blue filter", "make image", "set green filter", "make image".

Pointing modes: To allow the definition of pointing requirements, the *following pointing modes* are defined. These have been communicated to DSS (except the limb pointing modes) and are used in the design of the Avionics system:

- inertially fixed pointing (INERT)
- slewing between two inertial positions (INSLW)
- nadir pointing (NADIR)
- nadir pointing with offset (NADOF)
- tracking a landmark on the comet surface (TRACK)
- tracking a feature in the cometary coma (TRCOM)
- limb tracking (LIMB)
- limb tracking with offset (LIMBOF)

Note that in principle all different *modes* are special cases of INSLW. *E.g.* INERT is INSLW with begin and end point being identical, *etc.* This division is used since it allows to state in one word what the pointing requirement implies. Also note that the spacecraft has certain limits. *E.g.* if a feature in the coma moves faster than the spacecraft can rotate, then the pointing request cannot be fulfilled.

The **Pointing Request file** (PTR) is used to specify times at which the s/c should be in a certain pointing mode. It is defined in detail in AD15.

The **Event File** (EVF) is a time-ordered listing of events like AT_PERICENTER. It will be provided by the ESOC Flight Dynamics team. The detailed format is defined in AD10, appendix H.

The **Project Test Bed** (PTB) is an environmental simulator which the SOT uses to model the Rosetta mission and to determine the environmental parameters like illumination conditions, distances to landmarks, *etc.* It is based on existing software at D/TOS.

The **Experiment Planning System** (EPS) is a software tool used by the SOT to perform the science operations planning. For more information, read the EPS User Manual (RD2).

The **Experiment Description File** (EDF) is an ASCII file describing the experiments. In it, the experiments are split up in different operational subunits, called "modules". The possible states of the modules are given. All possible actions are listed, together with required power, generated data rate, and constraints. The *EDF* is used by the *EPS* to "know" the behaviour and constraints of an experiment. It is described in detail in RD2.

The **Orbiter Instrument Operational Request** (OIOR) file is an ASCII file sent from the orbiter PIs to the SOT, listing the operations of their respective experiments. It follows the ITL syntax. It is defined in detail in AD15.

The **Payload Operational Request** (POR) file is the input file for the Mission Planning System at ESOC. Its format is defined in the CRID (AD9). The *EPS* will be able to generate the *POR* file. It is defined in detail in AD15.

The **Lander Operations Plan** (LOP) file is the same as the *OIOR* but coming from the lander team.

The **Lander Operational Request** (LOR) file is the same as the *POR* but coming from the lander team.

Operational Request File (ORF): This term is used for the operational request files that come from the experimenter teams, *i.e.* both the *OIOR* and the *LOP.*

The **Rosetta Mission Implementation Base** (RMIB) contains a description of all possible telecommands, TC parameters, calibration curves, limit sets, telemetry packets, TC sequences and TC sequence parameters on Rosetta. It is maintained by the RMOC at ESOC.

The **Rosetta System Data Base** (RSDB) was used for testing. It does not contain the TC sequences and TC sequence parameters. Note that the RSDB is consolidated in the RMIB.

The **Data Distribution System** (DDS) is implemented by the RMOC to distribute all relevant information to the experimenters.

3. Tasks of the RSOC

The Rosetta Science Management Plan (AD1) defines the tasks of the RSOC.

The RSOC will be responsible for:

(1) the definition of scientific operations for all mission phases with expert PI team support

(2) mission planning and implementation of experiment operation schedules

(3) supporting the PI teams in developing software for payload operations, *e.g.* generation of command sequences

(4) the co-ordination and pre-checking of command sequences generated by the PI teams for the operations of their payload before submission to the RMOC

(5) the analysis (with PI team support) of all mission critical science data necessary for spacecraft navigation and environmental hazard assessment. This includes processing and evaluation of the data from the navigation camera system

(6) the maintenance of a quick-look science data facility

(7) together with the PI teams, the creation of a summary of the main scientific results, at regular intervals or for mission highlights

(8) the preparation of guidelines for science data archiving and - supported by the PI teams - to create the Rosetta Data Archive

(9) make pre-processed data and the scientific data archive available to the scientific community in accordance with approval procedures and schedules as defined in the Experimenter Agreements.

The following matrix gives an overview about which bullet is discussed in which section of this document.

Table 1: Tasks of the RSOC and where they are described in this document.

Bullet no.	Section
(1) definition of science operations	6.1 Science operations
(2) mission planning	6.1 Science operations
(3) software for payload operations	6.1.9 Software tools used by RSOC
(4) command sequences pre-checking	6.1.6 Planning of comet observation phases (c)
(5) spacecraft navigation and hazard assessment	*tbd*
(6) quick-look science data facility	6.5 Quicklook
(7) summary of main scientific results	6.6 Data archiving and distribution
(8) prepare data archiving guidelines and create archive	6.6 Data archiving and distribution
(9) make data available	6.6 Data archiving and distribution

4. Overview over the implementation of the RSOC

4.1 Introduction

The RSOC is being developed by the Rosetta Project Scientist and his team, currently at ESTEC. The RSOC shall demonstrate its operational readiness by the end of 2004. The details of the implementation, *i.e.* how the state described in this document is reached, and the detailed work package descriptions, are given in the Implementation Plan (AD12).

To perform the tasks as outlined later in this document, the RSOC will be set up according to an architecture as shown in Figure 1.

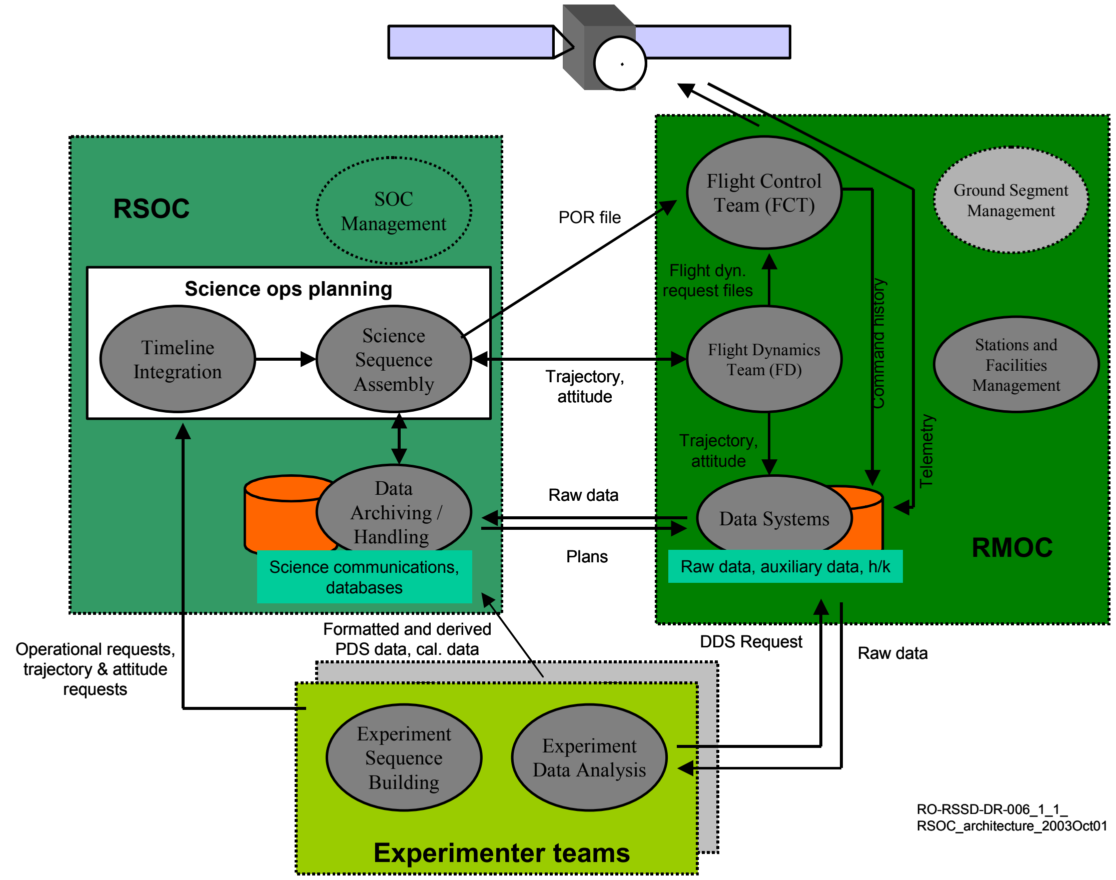


Figure 1: Architecture of the RSOC.

Note that in the commissioning phase, the operations of the experiments will be very interactive and the full structure as described in the above figure does not need to be in place. The RSOC will, however, perform some off-line planning tasks in order to ensure that it can function properly. It will be set up according to the reduced architecture shown in Figure 2.

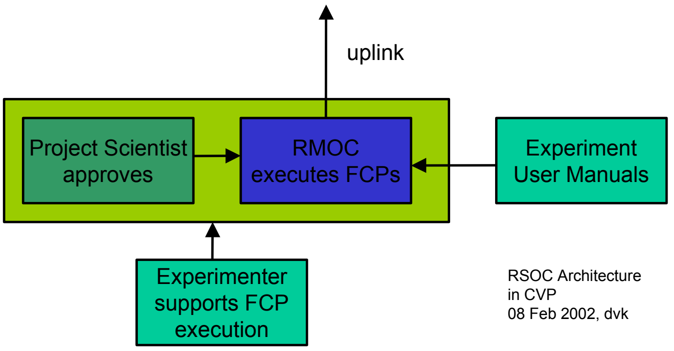


Figure 2: Architecture of the RSOC in the CVP.

4.2 The team

The team of the Rosetta Project Scientist, called "Science Operations Team (SOT)", consists of the Project Scientist, three Supernumerary positions, one staff (shared with other projects) and contractors and/or D/TOS personnel.

Their tasks are:
(a) Project Scientist: overall responsibility, team management, interface to Project team, interface to orbiter experiments, science communications and outreach
(b) Deputy Project Scientist: interfacing to lander experiments, ground-based observation co-ordination
(c) Science Operations Manager: camera interface, interface to Mission Operations team, define science operations, perform planning tasks
(d) Science Operations Support, Test/AIV support, perform planning tasks
(e) Data Archiving/Handling Manager: handles all data interfaces and is responsible for setting up the science data archive, quicklook, databases and mirrors
(f) Contractors, D/TOS: AIV support, development of software, general support

The team has overlapping experience, so that tasks can be shared and the know-how is preserved over the long time span of the mission.

4.3 Location

The Rosetta Science Operations Centre will be co-located with the RMOC at ESOC in Darmstadt during the following phases:

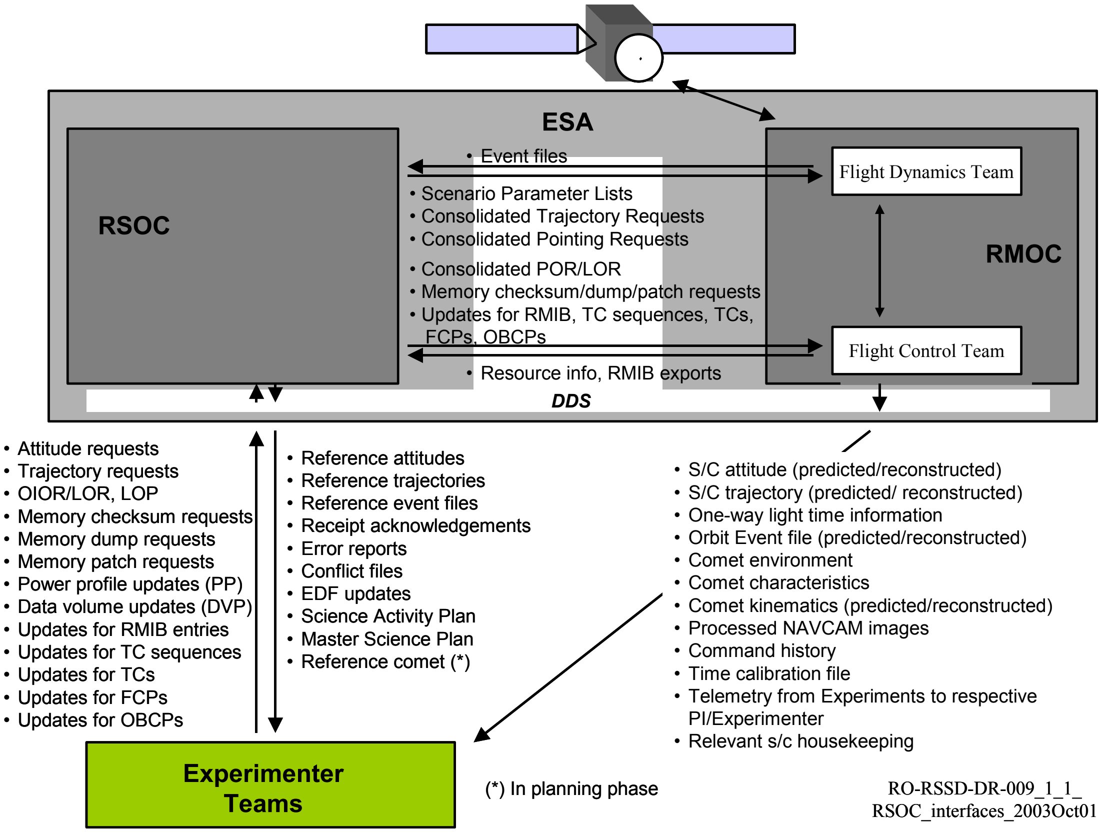
- commissioning phase (CVP)
- planetary swing-by phases (EAR1/2/3, MARS)
- asteroid fly-by phases (ASTA, ASTP) - at least one asteroid fly-by will be scheduled depending on the propellant budget
- wake-up operations
- comet approach phase (APPR)
- lander delivery phase (SSP)
- beginning of the comet escort phase (ESCO)

During the other phases, the Science Operations Team will be located at ESTEC, Noordwijk. There will be regular communication with the RMOC and the PI teams via email, fax, and telephone.

5. Interfaces

5.1 Introduction

The RSOC has two major interfaces: one to the RMOC, located at ESOC in Darmstadt, and the other one to the PI and Lander institutes. These are described on a top level in the following sections. The relevant documentation for the detailed definition is given. An overview over the interfaces is given in Figure 3.



(*) In planning phase

RO-RSSD-DR-009_1_1_
RSOC_interfaces_2003Oct01

Figure 3: RSOC interfaces.

5.2 Interface between RSOC and RMOC

The overall management interface between RSOC and RMOC is defined in AD3, the Science Operations Implementation Agreement. Additionally, this document describes the physical format of at least the email interfaces between RSOC and RMOC as outlined in the following sections.

5.2.1 Exchanged files

For the technical interfaces down to file format level, several documents are available:

When preparing the science operations, the RSOC will interface mainly with the Flight Dynamics Team (FDT) at ESOC. Requests for spacecraft trajectory and spacecraft pointing will be passed to the FDT via so-called "Scenario Parameter Lists (SPL)". The SPLs are tabular listings of items like illumination angle requirements, visibility requirements, maximum distances to a target, *etc.* These are defined in the SOIA (AD3).

When the experiment operations are planned in more detail, computer files will be generated by the RSOC with pointing requests, so-called "Pointing Request Files (PTR)". These will also be used as a formal interface to the FDT. They will also be defined in the SOIA (AD3).

The FDT will answer to the SPLs and PTRs from the RSOC using "Event Files (EVF)". The EVFs contain time-ordered listings of events. Their definition is in the DDID Appendix H (AD10).

During the long-term planning, RSOC will generate the Science Activity Plan (SAP) a few months prior to each mission phase. During the short-term planning, the RSOC has to give a consolidated scientific operations timeline to the Flight Control Team (FCT) at RMOC. It will be generated by the Experiment Planning System (EPS), a software tool to generate the timeline from the inputs of the experimenters. The file to be given to ESOC is called POR (Payload Operational Request) and will follow the format defined in the CRID (AD9).

To constrain the science operations of the individual experiments, resource files are passed from FCT to the RSOC. The resource files are: data rate file, power, number of allowable mission timeline commands.

After the end of the commissioning phase, all updates to the Rosetta Mission Implementation Base (RMIB) will be done via the RSOC, *i.e.* RSOC has to forward requests for changing Telecommands, Telecommand Sequences, plus associated parameters, to the RMOC. In return the RMOC sends an export of the updated RMIB to the RSOC, which the RSOC imports into the EPS.

5.2.2 Physical interfaces

The distribution of data from the RMOC to the RSOC will be done via two different ways: the Data Distribution System (DDS), or via an email interface.

(a) Using the DDS works similar to the distribution to the experimenter teams. The detailed description of this interface is the DDID (AD10). RSOC will retrieve files from the DDS just as any experimenter team, *e.g.* the Event Files (EVF).

(b) A number of files are sent from the RMOC to the RSOC via e-mail. This interface will be used for the resource files coming from the Flight Control Team (*i.e.* the data rate, power, and mission timeline entries available to the payload). An e-mail template with specific subject lines is defined in the SOIA (AD3).

From RSOC to RMOC, the same two interfaces exist:

(a) RSOC can ingest files into the File Transfer System (FTS) at RMOC by putting them in a dedicated directory of the RSOC machine at ESOC (“rofta/roftb”, see Figure 4). Depending on the file type, they will be forwarded by the FTS to the computers of *e.g.* Flight Dynamics or the Flight Control Team. This transfer mechanism applies to the POR, SPL and PTR files.

(b) For items which are not time critical, an e-mail interface is used as described in the SOIA (AD3), *e.g.* for the delivery of the Science Activity Plan or change requests to the database (TC sequence changes, TC changes).

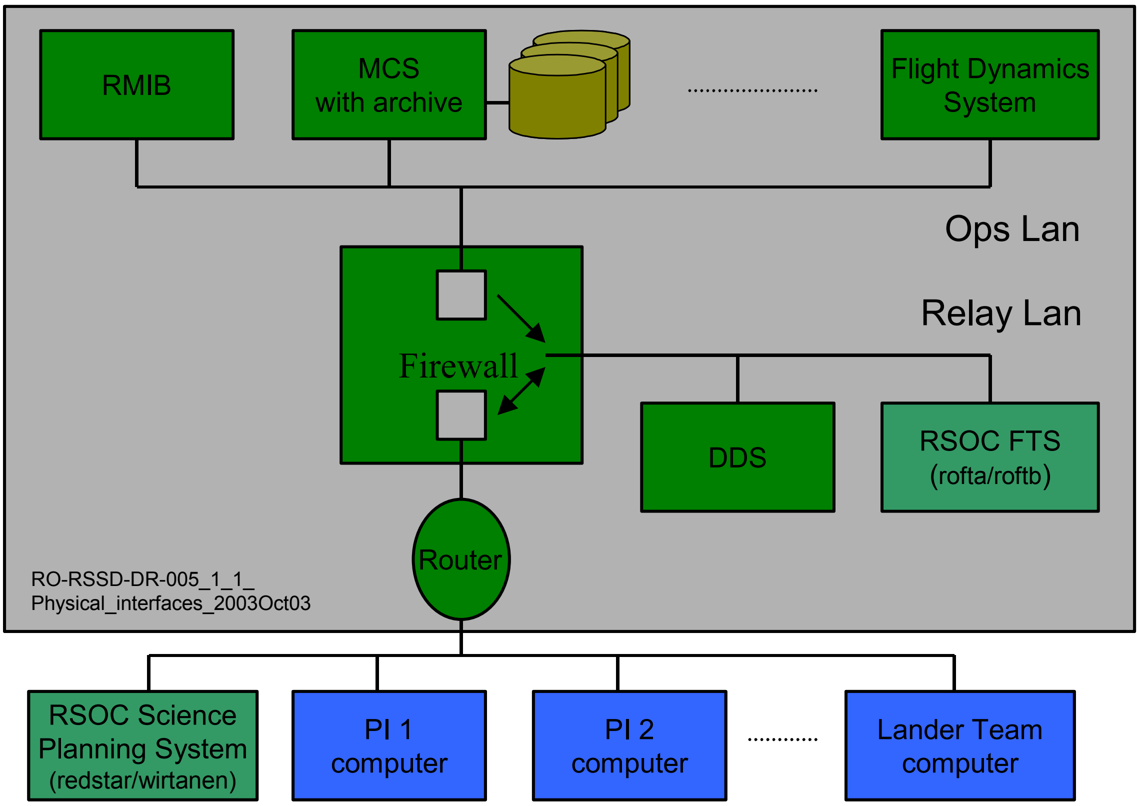


Figure 4: Physical interface setup between RSOC, RMOC, and the PIs.
The grey box indicates ESOC. RSOC has a dedicated computer at the ESOC relay lan, called rofta/roftb. This machine can be accessed via a secure connection from redstar (physically located at ESTEC).

5.3 Interface between RSOC and the PI teams

5.3.1 Exchanged files

For the actual science operations, the PI teams will need to send their Operational Request Files (ORF) to the RSOC. In the case of the Orbiter experiments, the ORF is called Orbiter Instrument Operational Request (OIOR) file. The format must follow the syntax of the "Input Timeline (ITL)" file. This is identical to the POR from a functional point of view, but better readable.

The experimenters also can provide Pointing Request Files and trajectory requests. Note, however, that the current assumption is that detailed formal Pointing Request Files and trajectory requests will mainly be produced by the RSOC, based on PI input.

All of these interfaces are described in more detail in the RSOC to Experimenter ICD (AD15). In addition, AD15 provides definitions for interfaces like sequence updates, resource requirement updates, *etc.*

The RSOC computer will run a software called "ORF Acknowledger" that registers incoming files from the experimenter teams (including the Lander) and performs a first check of the file name and, if applicable, does a syntax check of the file. It will notify the sender and the SOT of its results. AD17 describes the ORF Acknowledger in more detail.

5.3.2 Physical interfaces

The physical interface between experimenter and RSOC will be via the DDS located at the RMOC at ESOC in Darmstadt, *i.e.* all experimenters will ftp their files to the same machine as their requests for *e.g.* telemetry. The PI teams will put the files in a directory called “requests_to_RSOC”. The so-called File Transfer System (FTS) running at the RMOC will forward these files to a machine of the RSOC called “rofta” (backup machine is “roftb”). This machine is physically located at ESOC, but can be remotely accessed from ESTEC via a secure connection from one computer (“redstar”). Via this connection, the files can be transferred safely to the RSOC. This transfer mechanism is used for OIOR files, trajectory and pointing requests, sequence updates and resource requirements updates. E-mail is used for messages from the experimenters to RSOC that are not part of the nominal planning process.

The distribution of data from the RSOC to the PI teams happens via the DDS. RSOC ingests files in the DDS by putting them in a dedicated directory on “rofta/roftb”, where they are collected by the FTS and put into the archive of the DDS. Then the PI teams can request them via an XML request by ftp or the Internet. They can also request a “push” setup, where files are pushed onto their machines automatically. Documents are available from the RSOC documentation server at the web site http://www.rssd.esa.int/livelink.

5.4 Interface between RMOC and the PI teams

The RMOC will distribute operational information to the PI teams via the DDS. This is a file server from which data can be requested via XML files or the internet. This interface is described in the DDID (AD10).

Before the end of the commissioning phase, the RMOC will also interface with the PI teams directly to populate the Rosetta Mission Implementation Base (RMIB) containing all telecommands, telecommand sequences, telemetry values, Flight Control Procedures, and the respective parameters and calibration curves. RMOC expects official input via the User Manuals. Direct iterations happen with the teams via e-mail and telecons. RSOC expects to be copied on all input, as database changes will also affect the science planning.

Note that after the commissioning review, this interface will go via the RSOC.

5.5 Interface to the Lander

5.5.1 Lander delivery

The ESOC Flight Dynamics Team (FDT) is responsible for the successful delivery of the lander onto the comet. The delivery will be prepared and executed in close cooperation with the SONC. Both FDT and SONC will plan the delivery. SONC will provide their inputs via a modified version of the Scenario Parameter List (SPL). The detailed format of the SPL is *tbd* by SONC. For an example, see AD15 (RSOC to Experimenter ICD), Appendix F.

5.5.2 Nominal science operations

There will be only one interface to the complete lander. The formal interface to the lander is via the Lander Control Centre (LCC) at DLR in Cologne. Note that the SOT needs full transparency on the science activities of all lander experiments (prepared by the SONC at CNES) in order to be able to coordinate science activities with other experiments. To ensure that, the lander team (LCC) will forward the Lander Operations Plan (LOP) in ITL format to the RSOC. The RSOC will use the LOP for planning. The lander team will also generate the LOR file (which is not human-readable) from the LOP and send it to the RSOC. Only after acceptance of the LOP the RSOC will pass the LOR on to the RMOC.

A graphical overview over the lander planning process is given in *Figure 5*.

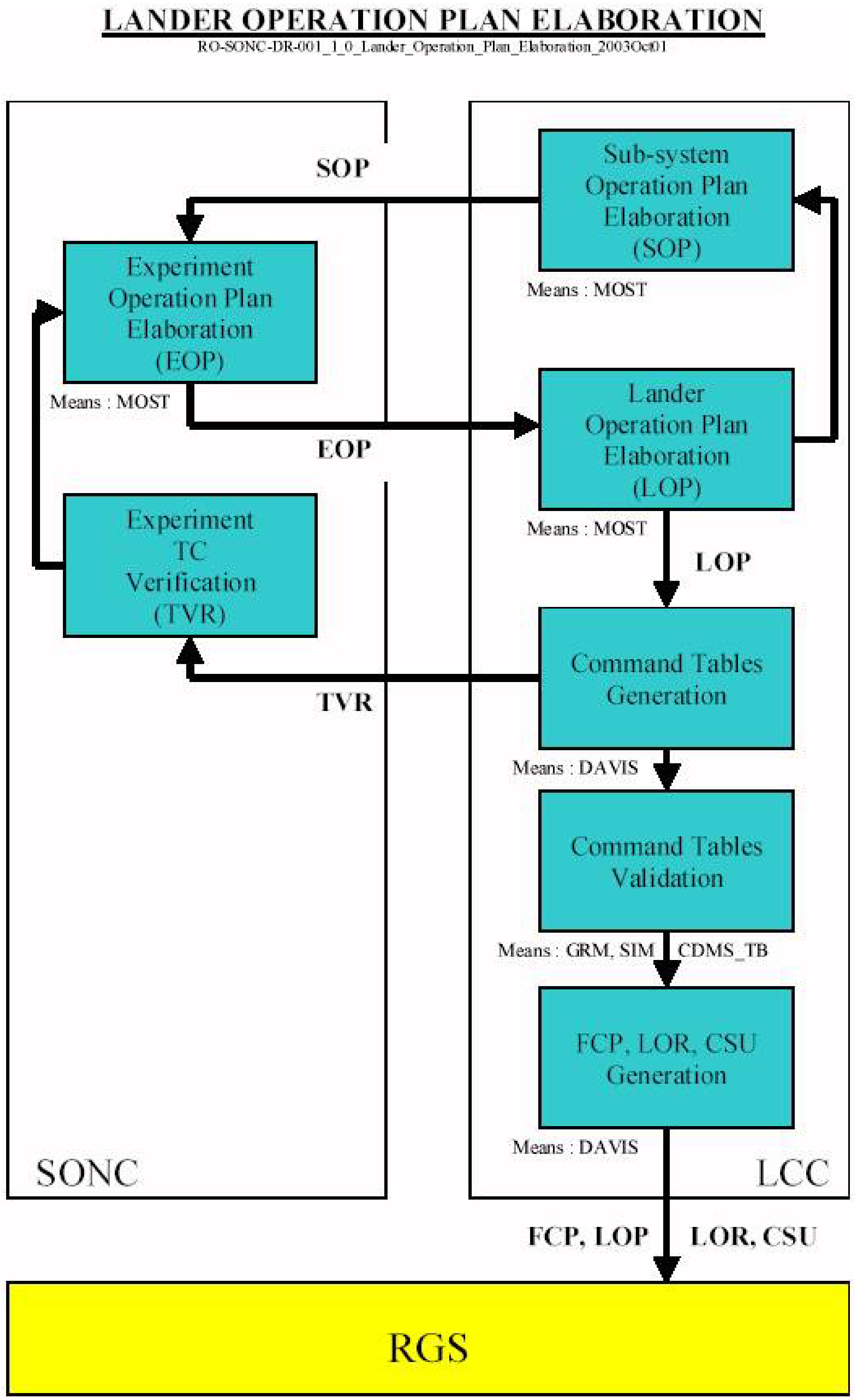


Figure 5: Lander operations planning and the interface to the RSOC.

6. Activities of the RSOC

6.1 Science operations

6.1.1 General overview

The basics for the Rosetta mission operations are laid down in the Mission Implementation Plan (AD2). Here, those parts concerning the science planning are expanded and detailed.

We distinguish between three different ways of performing science operations:

(a) Critical operations (Category 1 in MIP terminology) - these include payload commissioning, planetary swing-bys, asteroid fly-by(s), wake-up operations, lander delivery and relay - co-location at ESOC required
(b) Other pre-plannable operations (Category 2 in MIP terminology) - no co-location required
(c) Near-comet operations - co-location required only at the beginning

Both (a) and (b) will be handled in a "manual" approach using the traditional "timeline". For the near-comet operations (c), a planning process with three planning cycles (long-term, medium-term and short-term) will be implemented. The major rationale behind this distinction is the fact that there is a relatively long period from launch to comet encounter, which means *e.g.* that the RMOC will only have their electronic planning system ready many years after launch.

A transition between the "manual" approach using Flight Control Procedures and the automated approach with OIOR/LOP files will take place during the third commissioning phase. It is planned to execute the Pointing and Interference Scenarios already using TC sequences and a POR file generated at the RSOC based on ITL files.

6.1.2 Structuring the mission

The Rosetta mission is divided into so-called *mission phases*. Each mission phase has a defined start and end date or event. Examples for mission phases are commissioning, Earth swing-by, *etc.* A listing of the phases can be found in the EID C (AD7).

Within a mission phase, different *mission scenarios* are possible. A mission scenario is a time in the order of days to weeks, linked to a given set of science goals. Examples for mission scenarios are "Close encounter (CLOSE)" or ”Gas/dust jet sampling (JET)". For "Gas/dust jet sampling" the corresponding science goal would obviously be "Sample gas and dust in a jet and analyse it". For each mission scenario, a certain number of experiments would be on in a certain operating mode. Mission scenarios can be performed several times per phase, *e.g.* in the "Comet low activity phase (LOW)" there could be several scenarios called "Close encounter". Each scenario can have a "priority experiment" which can drive the trajectory and pointing requests. This does not mean, however, that other experiments are not on. All it means is that this experiment (or set of experiments, *e.g.* remote sensing) are planned first. The description of the experiment operations in a mission scenario together with the associated s/c trajectory and pointing information is called *Master Science Plan* (MSP).

The mission scenarios per phase are proposed by the SOT and discussed and confirmed by the SWT. They can be seen like "puzzle pieces" or modules that can be prepared in advance and used when required. The currently defined scenarios are listed in Appendix B.

The RMOC expects before each mission phase a so-called *Science Activity Plan* (SAP) for this phase. The SAP is a time-ordered listing of mission scenarios, describing on top level what should be done when.

6.1.3 Preparational work

To prepare the different planning phases, the Science Working Team (SWT) will identify a set of mission scenarios that will contribute to the realisation of the required science goals. This will be initiated by the SOT even before the launch. The SOT will prepare operational timelines for the different scenarios and discuss them in so-called "scenario working groups". A reasonable time before the comet approach, a SWT/SOWG meeting will be held to finalize the proposed scenario timelines.

Operational constraints of the experiments will be documented using the Experiment Description Files (EDFs) for each of the experiments. They allow to formulate constraints using a special syntax (defined in AD24, the EPS ICD File Syntax Definition). The Experiment Planning System (EPS) will check whether these constraints are respected or violated. The RSOC, together with the help of the experimenter teams, has the task to identify constraints and document them in the EDFs. There will be one master EDF for each experiment, which shall be updated regularly via a controlled "Software Change Request". The Software Change Request shall have to be approved by the respective PI. Since it is expected that many constraints will be found during the commissioning phase (CVP), the configuration control of the EDFs shall be implemented after some consolidation phase after CVP.

6.1.4 Planning of critical operation phases (a)

6.1.4.1 Commissioning phase

In the commissioning phase, a manual approach to planning will be used, using the traditional timeline. The experimenter teams will provide their Flight Control Procedures (FCP), typically in the User Manual, to the RMOC. The Project Scientist or his/her representative will formally endorse the FCPs before execution. It is expected that the PI/Lander Lead Scientist with his team is available at the RMOC in ESOC to allow quick and easy conflict solving. Also, the SOT will be co-located with the RMOC.

Any overall changes in the allocated time slots during the commissioning phase will need to be coordinated by the SOT.

To test and verify the planning concept, the Pointing scenario (POINT) and the Interference scenario (INTERFER) will be planned using Operational Request Files and running them through the planning tools (EPS/PTB) at the RSOC.

6.1.4.2 Planetary and asteroid fly-bys and wake-up operations

Again, the manual approach with Flight Control Procedures will be used. However, due to the short duration of the fly-by, the detailed operations will be defined well in advance of the fly-by. Timelines will be prepared during workshops at SOWG meetings and endorsed in a SWT/SOWG meeting. The experimenter teams will provide their Flight Control Procedures (FCP), typically in the User Manual. The SOT will check them for conflicts and iterate them with the RMOC and the experimenter teams. The final plan will be endorsed by the SWT before the start of the fly-by phase. Deadlines and other schedule items are still *tbd*.

To ensure conflict-free operations, the SOT will implement the FCPs in OIOR/LOP files (with the help of the experimenters) and check them with the planning software EPS/PTB.

It is expected that the PI/Lander Lead Scientist with his team is available at the RMOC in ESOC to allow quick and easy conflict solving. Also, the RSOC will be co-located with the RMOC.

6.1.4.3 Lander delivery phase

In this phase, the lander is given priority. The lander team will prepare FCPs which are checked by the SOT and iterated with the RMOC. It is envisaged that a close cooperation between the RMOC and the SONC is performed. Note, however, that the RSOC stays the formal interface to the lander in all cases. After the lander has landed, the principle science planning will follow a schedule as in the nominal short-term planning, however, the duration of the planning cycle will be as short as possible. Typically, the planning cycle shall be 3 hours (tbd).

6.1.5 Planning of other pre-plannable mission phases (b)

The experimenter teams will provide FCPs, which are checked by the SOT and iterated, if necessary, with the RMOC and the experimenter teams. The final plan will be endorsed by the SWT before the start of the respective mission phase. In long cruise phases, additional planning cycles might occur on ca. 6-month-intervals.

There is no co-location requirement for the other pre-plannable mission phases (b).

6.1.6 Planning of comet observation phases (c)

6.1.6.1 Introduction

The comet observation phases will be planned via three cycles, long-term, medium-term and short-term planning. The long-term planning cycle covers all long-term planning aspects, in particular the development of mission scenarios and the development of the Science Activity Plan, *i.e.* a time-ordered listing of mission scenarios, for each mission phase. The medium-term planning cycle is a training period starting about 2 years before comet encounter. During the medium-term planning cycle, the complete planning process down to the lowest level (the POR files) is performed using a model comet in order to exercise the planning process and to develop an operations baseline. The short-term planning covers the quasi real-time planning process performed when at the comet.

The following text first gives an overview over goals, activities and schedule of the planning cycles in bullet form. After that, one dedicated section describes the activities in more detail.

Long-term planning:

- Goal: A baseline SAP and scenario descriptions shall be available before each mission phase.
- Activities:
    - Scenario development (scenario description, *i.e.* Master Science Plan (MSP))
    - Science Activity Plan (SAP) development
- Schedule: Has started already. Covers the complete mission.
- Output:
    - Mission scenario documents, containing a scenario description, *i.e.* Master Science Plan (MSP), for each scenario, with pointing and trajectory information and operations at least down to mode level
    - SAP (a time-ordered listing of the mission scenarios)

Training:

- Goal: Ensure that the planning process was done at least once in all detail. Exercise the planning process and develop an operations baseline.
- Activities:
    - For each mission scenario, generate baseline POR file (based on baseline MSP, baseline scenarios).
    - Build up a “library” for operations.
- Schedule: Ca. 2 years before the Comet Acquisition Point is reached. Covers the comet phases.
- Output:
    - Detailed planning (POR file, pointing, trajectory) for each mission scenario, based on dummy comet.

Medium and Short-term planning:

- Goal: Actually perform the science operations at the comet.
- Activities:
    - Generate requests to flight dynamics (SPLs and PTRs)
    - POR file generation
    - Update SAP and MSPs only if needed.

- Schedule: After Comet Acquisition Point is reached, until end of mission. Typically one medium-term planning input is provided per month, one short-term planning period will cover one week.
- Output:
  - Detailed planning (POR file, pointing, trajectory) for each scenario, based on the real comet.

6.1.6.2 Long-term planning

The goal of the long-term planning cycle is to construct a baseline Science Activity Plan (SAP) and scenario descriptions before each mission phase. To do this, two main activities have to be performed:

(a) Scenario development (scenario description, *i.e.* Master Science Plan)
(b) Science Activity Plan (SAP) development

A graphical representation of the tasks during the scenario development are given in Figure 6.

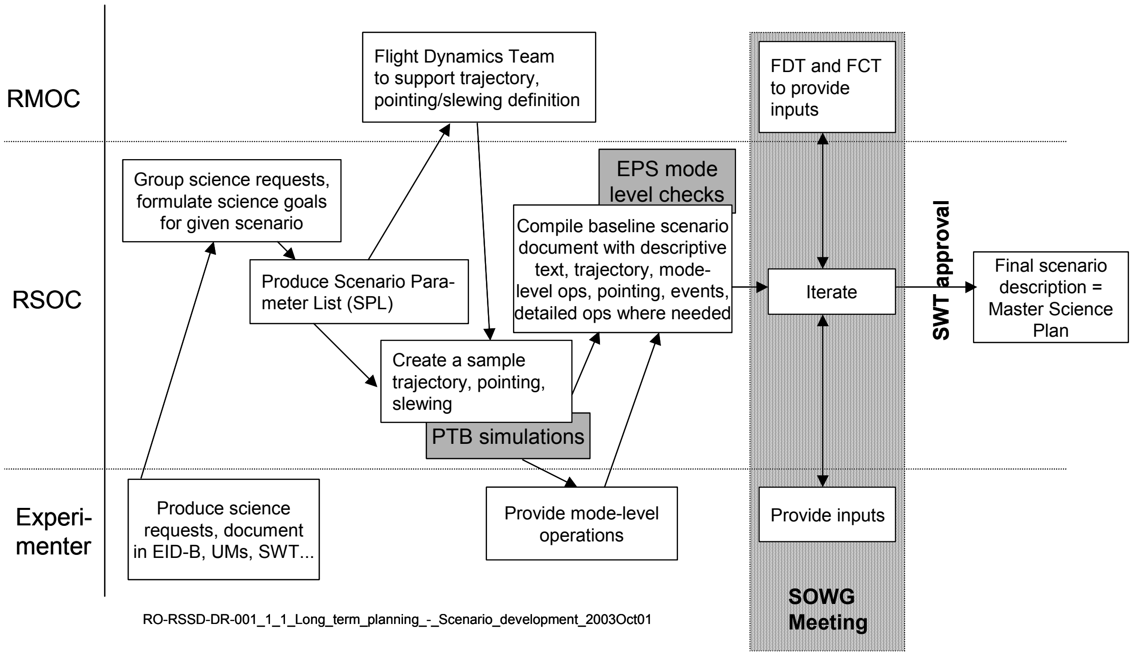


Figure 6: Graphical overview over the long-term planning cycle - Scenario development.

The long-term planning process starts with the formulation of the top-level science goals and their derived observation requirements. These have first been documented in the EID-Bs of the experimenter teams, and are repeated in the User Manuals. Additionally, top-level operational requests are communicated to the SOT via e-mail, fax, or during SWT/SOWG meetings.

The SOT will group the science requests by science disciplines, *e.g.* remote sensing, or scientific phenomena, *e.g.* cometary outbursts. *E.g.* there might be individual requests to fly through a cometary jet, from both gas and dust sampling experiments. It is obvious that these can be grouped and performed during one given trajectory around the comet. The SOT will define a mission scenario for this, *e.g.* "gas/dust jet sampling". It will require a certain trajectory and pointing/slewing profile. Constraints, *e.g.* on the downloadable data volume, available power and interference between the different instruments, must be taken into account.

The SOT will produce Scenario Parameter Lists (SPLs) which define the interface between the SOT and the Flight Dynamics Team (FDT). The SPLs define items like illumination conditions, required distances to landmarks, pointing/slewing patterns, *etc.* In addition, the SOT will already generate draft mode-level experiment operations in order to check that the constraints are observed.

The SOT will develop a trajectory and pointing/slewing profile using its planning software (the Rosetta PTB = Project Test Bed). It will also generate a "reference event file" which can be used for the first planning steps in case no event file is yet available from the Flight Dynamics Team (FDT) of ESOC.

The FDT will check the SPLs and support the development and comment on the trajectory and pointing/slewing profiles and ensure that no major problems can occur.

The resulting profile will be filled out by the SOT and the experimenter teams with at least mode-level operations of the experiments, while the constraints will be observed. The mode-level operations will be checked for potential conflicts using the Experiment Planning System (EPS).

The SOT will compile from this information a baseline scenario document (Master Science Plan) with

- a descriptive text,
- a trajectory request (included in the Scenario Parameter List) and a reference trajectory file,
- a pointing request file and a reference pointing file,
- a reference event file, or the baseline event file from FDT,
- at least mode-level operations of the experiments.

The SOT will iterate each scenario with the experimenters and the RMOC. Typically this is done in a workshop organised during an SOWG meeting (*e.g.* the workshops on the "interference scenario" and the "pointing scenario" conducted during SOWG #5 and SOWG #6). The final MSP needs to be approved by the SWT.

The second part of the long-term planning process is performed in parallel, the Science Activity Plan development. A graphical overview is given in Figure 7.

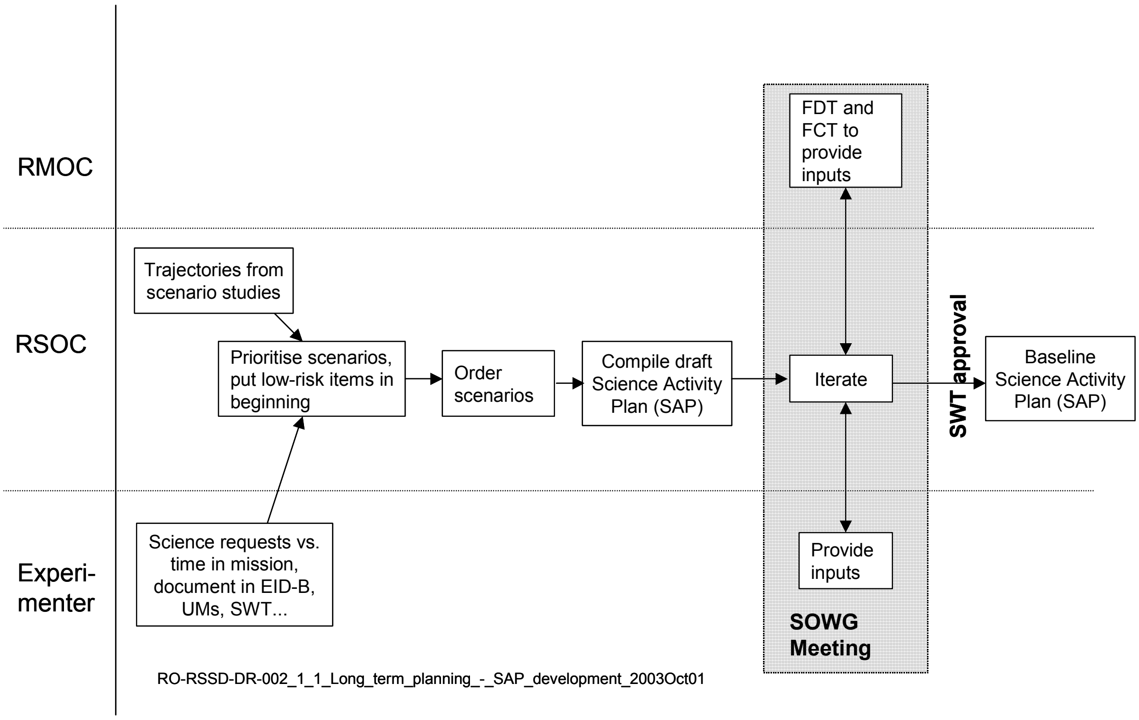


Figure 7: Graphical overview over the long-term planning cycle - SAP development.

One of the inputs for the SAP development is some baseline information on the trajectories of the individual mission scenarios. The reason is that the spacecraft trajectory has to fit together in a reasonable way. For example, it would take a lot of fuel to go directly from an equatorial orbit into a polar orbit.

Also, the scenarios will be sorted somehow as a function of comet activity. Obviously, the sampling of a jet may not be possible in the beginning of the mission if no jets are active yet.

Thus, the activities during the SAP development can be summarised as follows:

From the top-level science inputs documented in the experimenter teams' documentation (EID-Bs, User Manuals, e-mails) and the preliminary information on trajectories, the SOT will prioritise the scenarios. Those which impose the lowest risk on the spacecraft and/or experiments will be done in the beginning. In addition, the scenarios will be ordered according to its requirements concerning comet activity.

The SOT will produce a draft SAP, which will be iterated with both the RMOC and the experimenter teams, typically in working group meetings during a SOWG meeting. The final SAP needs to be approved by the SWT. The outcome will be one Science Activity Plan for each mission phase.

6.1.6.3 Training phase

The goal of the training phase is to ensure that the complete planning has been exercised at least once. It will take place in the time span from about 2 years before comet acquisition until the short-term planning starts. Based on the scenarios and the SAP developed during the long-term planning process and using a sample comet, the planning for each scenario will be detailed down to POR level. The result will be a library of planning modules that can be quickly adapted to the real comet once its properties have been measured. A graphical overview over the medium-term planning cycle is given in Figure 8.

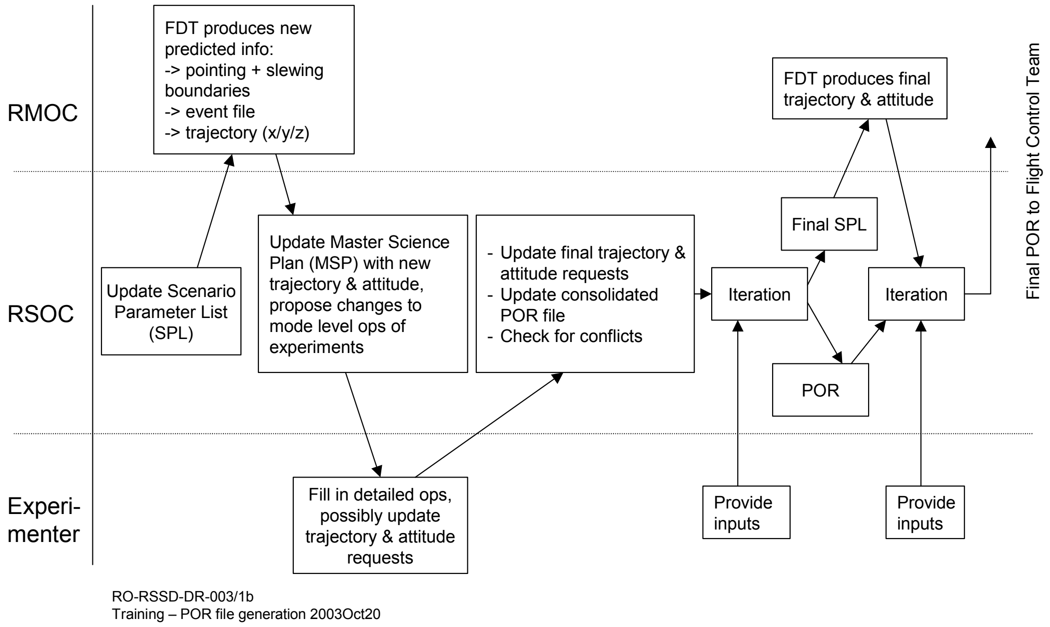


Figure 8: Graphical overview over the medium-term planning cycle - POR file generation.

The SOT will start from the scenarios as defined during the long-term planning cycle. The first step will be to confirm or update the SPLs and PTRs to take into account new knowledge about the requirements from the experimenter teams. These will be given to the FDT, who will produce new predicted trajectory files (x/y/z position), pointing/slewing profiles (quaternions) and event files (EVF files).

Using this information, the SOT will go through the scenario documents (Master Science Plans) and propose updates and changes in the mode-level operations to the experimenter teams. These will update the mode-level operations and fill in detailed operations down to the level of telecommand sequences. If required, they will also update or add trajectory and pointing requests.

The SOT takes this information and compiles it to generate a consolidated POR file and final trajectory and pointing/slewing requests (PTR files). Using the EPS software, the SOT will check for conflicts and, if required, iterate with the experimenter teams. The final SPL/PTR will be given to the Flight Dynamics Team. The FDT will generate a final trajectory and pointing/slewing profile. The SOT will iterate the operations of the experiments, based on this trajectory and pointing/slewing profile, with the experimenter teams and the FCT. The final outcome will be one or several POR files for each scenario.

6.1.6.4 Medium and Short-term planning

The medium and short-term planning cycle will start as soon as the real comet is known, *i.e.* after the Comet Acquisition Point was reached. The medium-term planning comprises the generation of input for Flight Dynamics and its iteration. This will happen on a monthly basis. The short-term planning comprises the actual generation of POR files. It will happen on a time scale of several days to one week. The process itself is similar to that performed during the Training cycle. However, it is expected that the time for iterations will be less. Also, the measured comet parameters will be used. A graphical overview is given in Figure 9. The dashed boxes indicate that it is expected that only limited time will be available to perform these tasks.

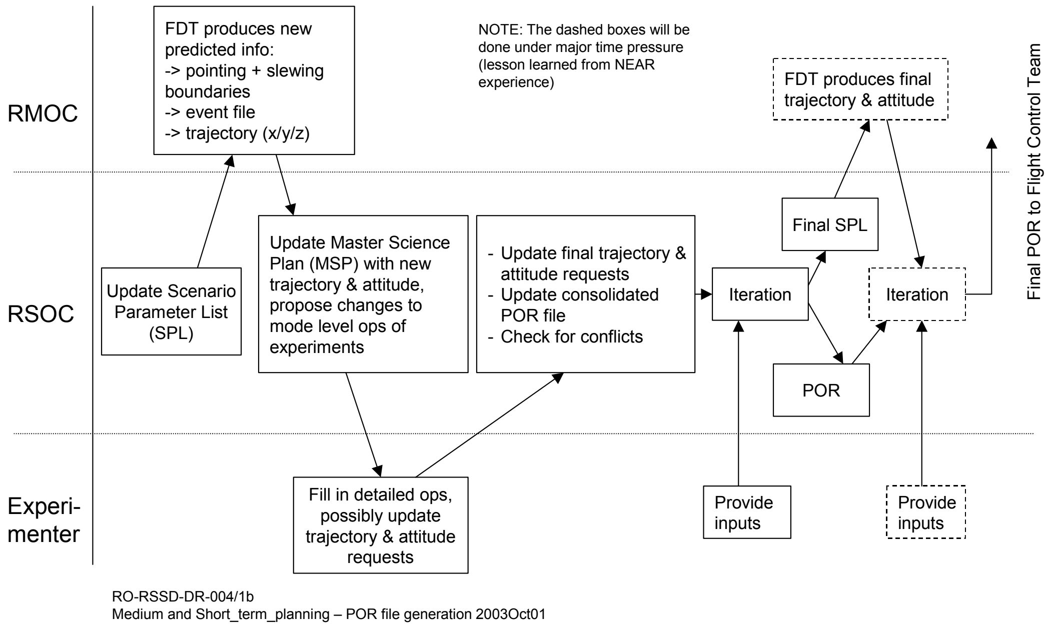


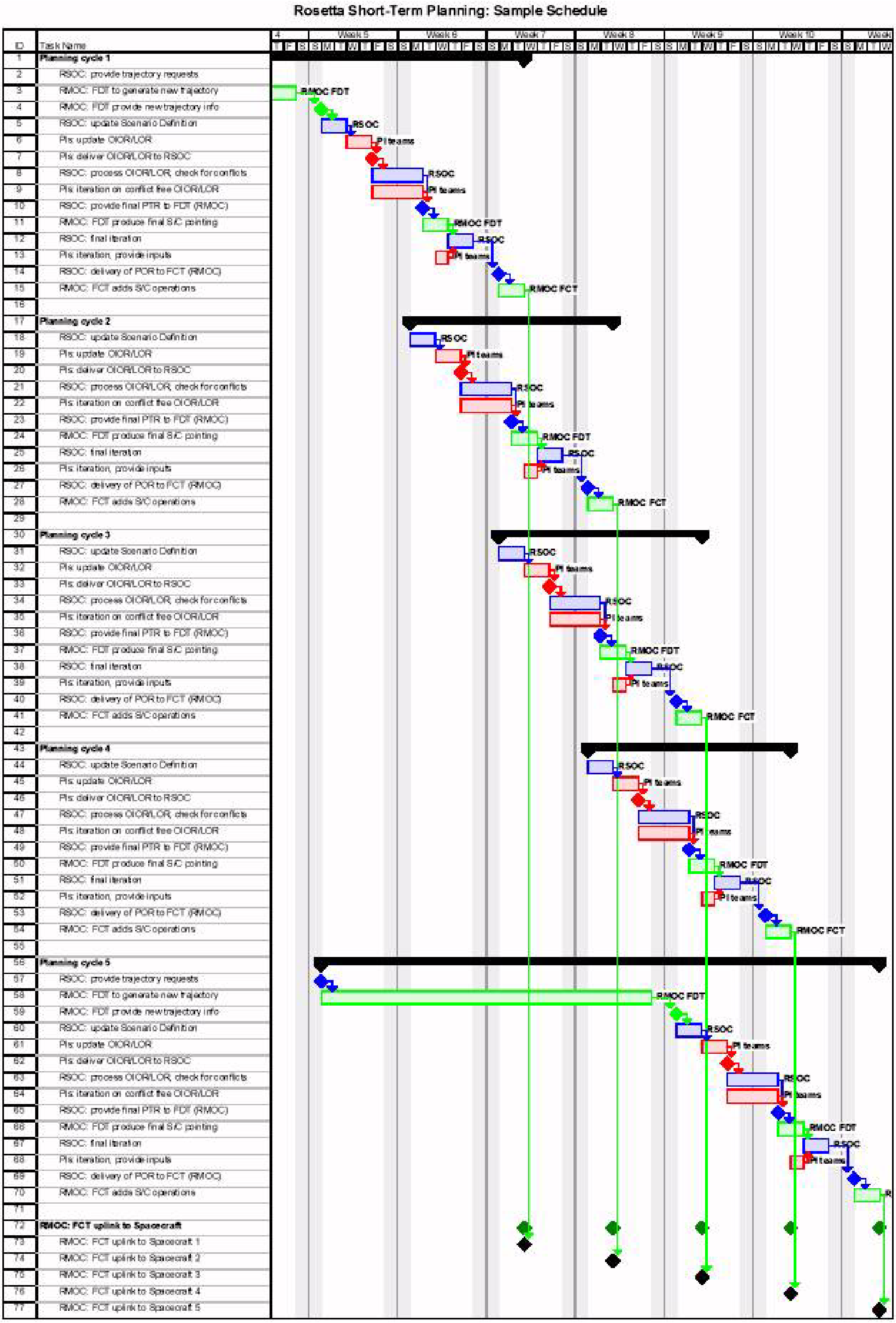
Figure 9: Graphical overview over the medium and short-term planning cycle - POR file generation.

Depending on the physical parameters and activity profile of the comet, the scenarios and possibly even the Science Activity Plan have to be redefined. If this is the case, the activities as shown in Figure 6 and Figure 7 will be performed again.

The short-term planning process will be organised in so-called "planning cycles". These will have consecutive numbers. Each one of them will have deadlines for the different interfaces defined. These are indicated in Figure 10, where the above block diagram is depicted as a bar chart. It is assumed that the uplink of the Mission Timeline is done on a Wednesday morning. It is also assumed that the covered time span of this planning will be one week, *i.e.* uplinking is performed every week. Note that due to the limited capacity of the MTL it is expected that more than one upload will be necessary to cover the one week.

Calculating backwards, the first deadline, when the experimenter teams have to send their Operational Request File (OIOR or LOP/LOR) and possibly a Pointing Request file (PTR) to the

RSOC, would be on the Friday morning, nearly two weeks earlier. The receipt of these files will be acknowledged by the ORF-A software, within a few minutes. The RSOC requires one and only one file of each type (*i.e.* one OIOR, one PTR) from each experimenter team, covering the complete week of the planning cycle. It will then perform the planning as depicted in Figure 9, including iterations with the experimenter teams, Flight Dynamics and the Flight Control Team.



Rosetta Short-Term Planning: Sample Schedule

ID	Task Name
1	**Planning cycle 1**
2	RSOC: provide trajectory requests
3	RMOC: FDT to generate new trajectory
4	RMOC: FDT provide new trajectory info
5	RSOC: update Scenario Definition
6	PIs: update OIOR/LOR
7	PIs: deliver OIOR/LOR to RSOC
8	RSOC: process OIOR/LOR, check for conflicts
9	PIs: iteration on conflict free OIOR/LOR
10	RSOC: provide final PTR to FDT (RMOC)
11	RMOC: FDT produce final S/C pointing
12	RSOC: final iteration
13	PIs: iteration, provide inputs
14	RSOC: delivery of POR to FCT (RMOC)
15	RMOC: FCT adds S/C operations
16	
17	**Planning cycle 2**
18	RSOC: update Scenario Definition
19	PIs: update OIOR/LOR
20	PIs: deliver OIOR/LOR to RSOC
21	RSOC: process OIOR/LOR, check for conflicts
22	PIs: iteration on conflict free OIOR/LOR
23	RSOC: provide final PTR to FDT (RMOC)
24	RMOC: FDT produce final S/C pointing
25	RSOC: final iteration
26	PIs: iteration, provide inputs
27	RSOC: delivery of POR to FCT (RMOC)
28	RMOC: FCT adds S/C operations
29	
30	**Planning cycle 3**
31	RSOC: update Scenario Definition
32	PIs: update OIOR/LOR
33	PIs: deliver OIOR/LOR to RSOC
34	RSOC: process OIOR/LOR, check for conflicts
35	PIs: iteration on conflict free OIOR/LOR
36	RSOC: provide final PTR to FDT (RMOC)
37	RMOC: FDT produce final S/C pointing
38	RSOC: final iteration
39	PIs: iteration, provide inputs
40	RSOC: delivery of POR to FCT (RMOC)
41	RMOC: FCT adds S/C operations
42	
43	**Planning cycle 4**
44	RSOC: update Scenario Definition
45	PIs: update OIOR/LOR
46	PIs: deliver OIOR/LOR to RSOC
47	RSOC: process OIOR/LOR, check for conflicts
48	PIs: iteration on conflict free OIOR/LOR
49	RSOC: provide final PTR to FDT (RMOC)
50	RMOC: FDT produce final S/C pointing
51	RSOC: final iteration
52	PIs: iteration, provide inputs
53	RSOC: delivery of POR to FCT (RMOC)
54	RMOC: FCT adds S/C operations
55	
56	**Planning cycle 5**
57	RSOC: provide trajectory requests
58	RMOC: FDT to generate new trajectory
59	RMOC: FDT provide new trajectory info
60	RSOC: update Scenario Definition
61	PIs: update OIOR/LOR
62	PIs: deliver OIOR/LOR to RSOC
63	RSOC: process OIOR/LOR, check for conflicts
64	PIs: iteration on conflict free OIOR/LOR
65	RSOC: provide final PTR to FDT (RMOC)
66	RMOC: FDT produce final S/C pointing
67	RSOC: final iteration
68	PIs: iteration, provide inputs
69	RSOC: delivery of POR to FCT (RMOC)
70	RMOC: FCT adds S/C operations
71	
72	**RMOC: FCT uplink to Spacecraft**
73	RMOC: FCT uplink to Spacecraft 1
74	RMOC: FCT uplink to Spacecraft 2
75	RMOC: FCT uplink to Spacecraft 3
76	RMOC: FCT uplink to Spacecraft 4
77	RMOC: FCT uplink to Spacecraft 5

Figure 10: Detailed schedule of 5 planning cycles during the nominal short-term planning process.

Obviously, several of these planning cycles will be going on in parallel.

The progress of the short-term planning can be followed by monitoring the files that are exchanged via the DDS. *I.e.* on a Tuesday morning one should find a final PTR from RSOC on the DDS and so on.

The acceptance of an OIOR or LOP/LOR file from the experimenter teams for the planning is implicitly given when the final POR file is put on the server.

6.1.7 Contingency handling

Procedures for contingency handling within an experiment must be provided by the experiment teams. In case that telemetry indicates a problem with an experiment, the RMOC will contact the respective PI and the RSOC to find a solution. The RSOC will archive the relevant information.

If measurements cannot be performed due to problems with the s/c or an experiment, the main priority will be to continue with the next scenarios. It will *not* be priority to recover the measurements. An example: Assume that a "close encounter scenario" was planned for 5 - 12 March, to investigate in detail the surface profile of an active area using the remote sensing experiments. On 13 March, a "gas/dust jet sampling scenario" was supposed to start. If on 10 March problems with the measurements of one of the remote sensing experiments occur and cannot be recovered until 13 March, the priority will be given to the start of the "gas/dust jet sampling scenario". It will *not* be attempted to repeat the measurements of the close encounter scenario. The reason is that the scenarios are closely linked to the s/c trajectory. Repeating a scenario or trying to recover lost measurements would mean a complete re-planning of the future trajectory. This will be avoided whenever possible.

6.1.8 Conflict solving

Conflicts will be found in the planning process when the EPS is used to analyse the consolidated planning files (OIOR/LOP files, PTR files). Conflicts are generated whenever certain constraints are violated. These constraints are defined in the Experiment Description Files (EDFs), which act as a database to model the experiments. For example: In the EDF of MIDAS, there might be a constraint describing that MIDAS should not be in Scan mode whenever the VIRTIS cooler is on. The EPS will check for this constraint. If it finds out that it is violated it will write a corresponding message into the conflict (CONF) file.

If the EPS flags a conflict, the Science Operations Team will propose changes to the input timelines of the concerned teams and iterate a conflict-free timeline with them. After the iteration, the experimenter teams will provide an updated OIOR/LOP file to the RSOC. If no solution is found during this iteration, the issue will be discussed with the SWT, provided that there is enough time. The final decision authority (also to reject a timeline) is with the Project Scientist.

To avoid conflicts to appear based on invalid constraints, the EDFs used by the RSOC for the planning process will be approved by the PI or Lander Lead Scientist. The EDFs will be under configuration control.

The SOT will prepare a proposal for rules to solve conflicts during the planning sufficiently enough before the first asteroid flyby. This proposal will be discussed and approved by the SWT.

6.1.9 Software tools used by RSOC

6.1.9.1 The Operational Request File Acknowledger (ORF-A)

The ORF-A is a software tool which runs on the RSOC computer at ESOC ("rofta", "roftb"). It registers incoming files from the experimenter teams (OIORs, LOPs, LORs, PTRs, Command Sequence requests, …). It performs a first check of the file name. For the files that can be checked with EPS, namely the OIOR, LOP, and PTR files, it performs a syntax check. It notifies the sender and the SOT of its results. This is done by putting a file on a server to be defined by the experimenter teams via ftp. This is an ASCII file in XML format describing the receipt and possible results of a syntax check. The detailed definition of this confirmation can be found in AD15. AD17 defines the user requirements of the ORF-A.

The ORF-A has been developed according to AD19.

6.1.9.2 The Experiment Planning System (EPS)

The EPS is a software tool which is developed by the SOT with the help of TOS/EMM. It accepts as inputs the operational requests from the experimenters (the OIOR/LOP files). The EPS also reads in the Event Files (EVF) if the OIOR/LOP files use events as time markers.

The experiments are modelled in a simplified way in the so-called Experiment Description Files (EDFs). The EDFs model items like power values, data rates, constraints.

Running the EPS produces a consolidated POR file as output. Note that the software can read/write files either in the syntax of the POR file or in the native ITL (Input Timeline) syntax. The experimenter teams are required to deliver their OOIR/LOP files in the ITL syntax, as this is human-readable.

The requirements for the EPS software are documented in AD11. The EPS User Manual (RD2) gives the necessary information to successfully use the tool for science operations planning.

The EPS has been developed according to AD19.

6.1.9.3 The Payload Test Bed (PTB)

The PTB is a software tool that allows to perform real-time simulations of the spacecraft behaviour and the spacecraft environment. It is developed by ESTEC, TOS/EMM. A simulation of Rosetta and the cometary environment was set up. This tool is used by the SOT to simulate the mission scenarios and get a first idea of possible orbits and timelines. It can read in trajectory files provided by the Flight Dynamics Team of the RMOC or model Keplerian orbits. It can read in Pointing Request files (PTR) to model the attitude of the s/c. It generates as output Event Files (EVF) in the format defined by the RMOC in AD10.

Note that the final environmental conditions will be determined and distributed by the RMOC, the PTB will only be used for internal planning purposes at the RSOC.

The Rosetta PTB has been developed according to AD19.

6.2 Procedures how to update the RMIB

6.2.1 Introduction

The following Section describes the procedures used on how to update the contents of the RMOC operational database, called RMIB, i.e. Flight Control Procedures, TC sequences, etc. This is detailed information, which may be moved to another document in a future version of this Design Description.

The operational database at RMOC will be maintained in Oracle Version 8, installed on a Compaq XP1000 computer running the Unix operating system. The Rosetta Mission Control System will provide Rosetta-specific database editors to maintain the contents of the operational database.

The RMOC is responsible for maintaining the RMIB. RMOC will perform validation checks on the contents of the database change requests coming from the SOT; for Command Sequences, the operational correctness of the new or updated sequence will be checked at RMOC. The SOT is responsible to provide inputs of ESOC for updating the operational database to satisfy the science operations requirements of the PIs. Making sure that consistent inputs are provided to RMOC when a database update is requested is SOT responsibility.

6.2.2 Naming convention

The Rosetta Flight Operations Plan (FOP) is a document containing

- Flight Control Procedures (FCP) named XX-FCP-nnn (XX = abbreviation for the experiment, nnn = number),
- Commissioning Procedures named CV-FCP-nnn,
- Dedicated Sequence Procedures named XX-SEQ-nnn.

The Rosetta Mission Implementation Base (RMIB) is a database containing all the procedures described in the FOP. The Dedicated Sequence Procedures of the FOP correspond to the telecommand (TC) sequences of the RMIB.

A TC sequence is named AXXSnnnZ (XX = abbreviation for the experiment, nnn = number, Y = letter used to distinguish different TC sequences in the same Dedicated Sequence Procedure). The TC sequence lists telecommands with timing and assigns values to the parameters of these TCs. In EDF format the timing of a TC is specified either as an absolute time from the start of the TC sequence or an offset time from the previous TC.

The experimenter may define TC sequence parameters named VXXYnnnn (XX and Y are identical to the letters used in the TC sequence, nnnn = last four digits of the number contained in the TC parameter name to which the TC sequence parameter is linked), so that he can later give values to the TC sequence parameters when calling the TC sequence. TC sequence parameters are linked to TC parameters. Without TC sequence parameters, all TC parameters in the sequence are fixed. TC sequence parameters should not create mayor changes in power, data rate or constraints for the experiment. Note that the names will be co-ordinated with RSOC and RMOC.

FCPs / Commissioning Procedures are similar to TC sequences, but also contain telemetry (TM) checks.

This section explains how the experimenters can add or change TC sequences and FCPs / Commissioning Procedures in the RMIB. The detailed interfaces down to the formats of the exchanged files are described in the following documents: the RSOC to Experimenter ICD (AD15) refers to the interfaces between the experimenters and the RSOC, the Science Operations Implementation Agreement (AD3) applies to the interfaces between RSOC and RMOC, and the Data Delivery Interface Document (AD10) deals with the interfaces between the experimenters and the RMOC.

6.2.3 TC sequence update

An experimenter wants to add a new TC sequence or change an existing TC sequence, *e.g.* add a TC or change the value assigned to a TC parameter. The following procedure applies:

1. The experimenter generates the new TC sequence following the format used in the EDFs, or he modifies an existing TC sequence. He also completes the Database Change Request form. The experimenter sends this new or changed TC sequence file accompanied with the Database Change Request to the RSOC and copies to the RMOC.

2. The RSOC uses the Experiment Planning System (EPS) to check if all TCs and TC parameters in the TC sequence are defined. If yes, the RSOC converts the TC sequence file to an EXCEL file and sends it to the RMOC.

3. The RMOC imports this EXCEL file describing the new or changed TC sequence into the FOP and updates the RMIB. The FOP is re-issued. The RMOC also sends an export of the updated RMIB to the RSOC.

4. The RSOC imports this RMIB export into its Experiment Planning System (EPS). The EPS updates the file `<experiment>_seqs.edf` containing the TC sequences for the experiment. The file `<experiment>_seqs.edf` is included in the Experiment Description File (EDF) `<experiment>.edf`, which models the experiment. The `<experiment>.edf` file also comprises the file `<experiment>_cmds.edf` containing the TCs for the experiment. In addition, the `<experiment>.edf` file includes information concerning

modes and constraints for the experiment. The updated `<experiment>.edf` file is sent to the PI.

5. The experimenter can then check the TC sequence updates in `<experiment>_seqs.edf`. In this context the `<experiment>.edf` file is provided for information purposes only. Updates to `<experiment>_cmds.edf` and `<experiment>_seqs.edf` are not allowed and cannot be taken into account, because these files are an output of an RSOC database and the original database is located at the RMOC.

6.2.4 FCP / Commissioning Procedure update

An experimenter wants to add a new FCP / Commissioning Procedure or change an existing procedure, *e.g.* add a TC or change the value assigned to a TC parameter. Before the results of the commissioning phase are analysed and implemented, the following procedure should be used:

1. The experimenter updates his FOP document with the required change. He also completes the Database Change Request form. He sends this updated FOP document and the Database Change Request to the RMOC and copies to the RSOC.
2. A RMOC engineer generates a Procedure Change Request and attaches the changed pages to it. This is signed by the Spacecraft Operations Manager. For an update of an existing FCP / Commissioning Procedure, the engineer opens the corresponding FOP procedure using the Mission Operations Information System (MOIS), effects the changes and saves the procedure under a new version number. Otherwise a new FOP procedure is created. The updated or new FOP procedure is printed and the print-out sent to the PI.
3. The PI confirms that the new or changed FOP procedure is o.k.
4. The RMOC updates the RMIB with the new or changed FOP procedure. The FOP is re-issued. The RMOC also sends an export of the updated RMIB to the RSOC.
5. The remaining steps are the same as for the TC sequence update in section 6.2.3 above.

After the results of the commisioning phase are analysed and implemented, FCPs should only be updated in exceptional cases. At that time the experimenters are required to send their FCP update requests to the RSOC, which forwards them to the RMOC. The experimenters may send their FCP update requests via the RSOC even before. The FCPs may be described in EDF syntax similar to the telecommand sequences. However, when the RSOC converts this file to EXCEL, the telemetry checks are lost (sequences cannot have telemetry checks). Thus the additional description in the FOP document is needed for FCP updates.

6.3 Procedure how to run experiment sequences on the spacecraft

1. The experimenter creates an ITL file, which calls the TC sequences to be run. Values can be assigned to the defined TC sequence parameters. If no values are assigned, the default values will be used. The assigned values must be consistent with the calibration curve linked to the corresponding TC parameter. The execution time is given as an absolute time or relative to a Flight Dynamics event in the Event File (EVF). Only the TC sequences defined in the RMIB may be used. These sequences are documented in the Flight Operations Plan (FOP) and the Experiment Description File (EDF), or more precisely the subfile `<experiment>_seqs.edf`, for the experiment. TCs must not be used in an ITL file. The ITL file is sent to the RSOC.
2. The RSOC uses it Experiment Planning System (EPS) to generate the Payload Operational Request (POR) file from the received ITL file. The EPS also checks for constraints and conflicts. The consolidated POR file is sent the RMOC.
3. The RMOC loads this POR file into its Scheduler which expands the sequences into telecommands with their parameters and timetags. The output of the Scheduler is uplinked to the Mission Timeline (MTL) on board the spacecraft.

4. On the spacecraft, the MTL runs and the activities defined in the ITL file are performed.

6.4 On-board software maintenance

RSOC will collect the requests of the experimenters for on-board software maintenance (patching, dumps, checksum requests) and forward them to the RMOC. In certain cases, planning models will need to be provided by the experiment teams (*e.g.* whenever OSIRIS wants to upload a new User Defined Procedure (UDP), they will need to provide a model in ITL syntax which RSOC can add to the OSIRIS Experiment Description File used in the planning process). All file formats are defined in AD15 and AD3.

6.5 Quicklook

The intention of a quicklook system is to collect, visualise and analyse data in a quick way for the purpose of releasing important information or results contained in those data. This implies that no major processing or calibration work should be applied to the data. Quicklook data will be used to fine tune the science operations planning and for Public Relations. It is envisaged that the experimenter teams contribute to the quicklook facility significantly. Details will be discussed and defined in collaboration with the experimenter teams about one year before comet detection for the comet observation phase.

For the Commissioning phase the data will be visualised and analysed using the SCOS-2000 system and the EGSEs of the experimenter teams.

6.6 Data archiving and distribution

The Rosetta data archive will be part of the Planetary Science Archive (PSA) implemented by ESA/RSSD. It builds on the JAVA architecture of the existing data archive of ESA's Infrared Space Observatory (ISO). As other ESA missions (XMM Newton, Integral) will also make use of this architecture for archiving their data, a long-term archive with continuous development is ensured. The PSA aims for online ingestion of logical archive volumes and data delivery in the form of direct or FTP download of data products, linked files and data sets. It will offer additional online services to the scientific user community and science operations teams, e.g. graphical data preview and search queries across instruments, missions and scientific disciplines.

The data archiving of Rosetta will follow the standards of the Planetary Data System (PDS), which was created for archiving the science data returned by the NASA planetary missions. It will be implemented together with the Small Bodies Node of the PDS at the University of Maryland (UoM). A copy of the Rosetta archive at ESA/RSSD will be maintained at the UoM. Details are documented in the Rosetta Data Archive Plan, AD14.

For special occasions and in regular intervals, the SOT will prepare summaries of the main scientific results. During the mission, the SOT will prepare summaries in a form suitable as press releases at least at the following points:

(a) at the end of the mapping scenario - the complete map of the comet, quicklook on mineralogical composition, results of gravitational mapping, other items of interest,
(b) after lander delivery - first images of the surface,
(c) a few days after lander delivery - overview over measured nucleus properties,
(d) other occasions to be defined.

6.7 Foreseen meetings

The following table gives a first idea on the planned meetings concerning science operations. Note that to reduce travel costs, it is foreseen to use modern technology as video conferencing and the web as support media. In particular, for the monthly planning meetings the necessary information will be available on the web so that people can participate via telephone or video and have the documentation (*e.g.* the Science Activity Plan under discussion) available at their location. The short-term planning meetings will be done at a time where it allows the US Co-Is to participate remotely, *e.g.* at 16h ESOC time.

Table 2: Planned meetings with approximate dates.

Name	Purpose	Time
SWT	Normal SWT agenda plus mission scenario definition	Jan 2013
SWT	Long-term planning meeting	Jun 2013
more to come	more to come	
MTPM	Medium-term planning meeting	monthly
STPM	Short-term planning meeting	in ESCO: daily in the beginning, weekly later on.

7. Testing and training

Extensive testing of the software and the interfaces is performed to ensure the successful implementation of the RSOC. Details of the tests can be found in AD20 and AD8.

In the commissioning phase, the Pointing scenario will be planned using the concept as defined for the comet phase, *i.e.* with the medium-term and short-term planning cycles and using the complete set of software tools.

After the commissioning phase, updates will be performed to the software and, if required, to the interface concepts, to incorporate "lessons learned".

Before each fly-by, test and training sessions will be scheduled together with the RMOC. Around one year before the comet detection, test and training sessions will be scheduled to bring all involved parties up to speed again.

8. Security

The RSOC planning software (EPS, PTB) currently runs on one SGI O2 workstation. In addition, the EPS and PTB will be installed on several laptops, which guarantees the necessary redundancy in case of failure of a machine.

For all time critical interfaces to the experimenter teams, the Rosetta DDS will be used. It will be the entry point for all file transfers, making use of all security items taken into account in its design. A dedicated RSOC computer, called RSOC FTS, will be available there. It will be monitored 24h a day, 7 days per week. A cold-redundant backup machine is available in case of failure of the main machine. The Science Operations Team will have secure ftp access and rlogin access to this machine from the RSOC planning computer.

Note that during critical phases the experimenter teams are asked to be physically located at the RMOC. No public internet will be used in those phases, since the PI Support Area is inside the ESOC LAN.

9. Configuration control

Two different levels of configuration control are implemented. For documents describing interfaces to external parties, *e.g.* the RSOC to Experimenter ICD, a formal change procedure is used: Once it has formally been released, it will be put under configuration control. A Document Change Request (DCR) has to be filled out and approved by the involved parties for each subsequent change. The involved parties are: the initiator of the change request; the author of the document; the approvers of the document (normally the Project Scientist, for interface documents all interface partners). The approvement (or rejection) is done in a meeting of the involved players, called a Configuration Control Board (CCB) meeting.

A form sheet for the DCR is provided on the RSOC documentation server. All DCRs shall be archived on the RSOC documentation server in pdf format.

Details on DCRs are found in AD23.

For documents which do not describe interfaces and thus don't have an impact on external resources, a formal release has to be approved per signature by the Science Operations Manager or the Project Scientist. The same is true for any updates.

For all software tools which are in the path of operational files, a strict configuration control similar to the one described for documents describing interfaces to external parties. This is currently the case for ORF-A, EPS, and TCSCT. The form sheet to be used for changes is called SPR (Software Problem Report). The procedure is described in AD25.

All software source code and planning files, will be stored in a repository on the planetary science operations computer 'gorilla' using the Concurrent Versioning System (CVS).

In particular, the Experiment Description Files used in the science planning shall be put under configuration control after some consolidation time after the end of the Commissioning phase.

10. Appendix A - Mission phase definition

10.1 Introduction

The table at the end of this appendix gives an overview of the mission phases as defined in the EID-C (AD7), AD21 and AD22. Here, we give a short description of the activities in each of the phases.

10.2 Launch phase

Rosetta will be launched by an Ariane 5/G+ in a dedicated flight (single launch configuration) from Kourou on 26-Feb-04. After burnout of the lower composite, the upper stage L9.7 together with the spacecraft remains in an eccentric coast arc for nearly 2 hours. Then the upper stage performs delayed ignition and injects the Rosetta spacecraft into the required escape hyperbola defined by an excess velocity of 3.545 km/s and a declination of the asymptote of -2.0°. The spacecraft will encounter the Earth again about one year after launch.

After spacecraft separation from the upper stage, Rosetta acquires its three axes stabilised Sun pointing attitude and deploys the solar arrays autonomously. Ground operations will acquire the down-link in S-band using the ESA network and control the spacecraft to a fine-pointing attitude with the HGA pointing towards Earth using X-band telemetry. Tracking and orbit determination are performed, the departure trajectory is verified and corrected by the on-board propulsion system of the spacecraft.

10.3 Commissioning parts 1 and 2

Commissioning starts three days after launch following the first trajectory correction manoeuvre. DSM1 of 173 m/s is executed at perihelion.

Commissioning will be done in two parts, as the NNO ground station must be shared with Mars Express and cannot be used by Rosetta from June to mid-September 2004. Commissioning finishes at the end of NNO full passes availability in November 2004. All spacecraft functions needed during the cruise to the comet, in particular for hibernation, will be checked and the scientific payload will be commissioned.

10.4 Cruise phase 1

The scientific instruments are switched off while ground contact is not available.

10.5 Earth swing-by 1

The actual Earth swing-by will take place on 2-Mar-05. The perigee altitude is 4290 km. The relative approach and departure velocity is 3.9 km/s.

The phase ends one month after the swing-by, where any subsequent navigation manoeuvres are executed and the spacecraft is prepared for the next cruise phase to Mars.

There will be a high overlap with Mars Express at the NNO ground station, and peak science operations of the Huygens mission will make use of ESOC facilities. Therefore no science operations can be supported during the first Earth swing-by.

10.6 Cruise phase 2

After leaving the Earth, the spacecraft makes one revolution around the Sun, and in the second arc from perihelion to aphelion makes a swing-by of Mars. There is a solar conjunction for almost one month in April 2006.

Two passive check-outs with non-interactive instrument operations for about 5 days are scheduled during the cruise to Mars.

10.7 Mars swing-by

The mission phase begins one month before DSM2 of 65 m/s, which is performed near perihelion.

The actual Mars swing-by will take place on 27-Feb-07. The minimum altitude with respect to the Martian surface is 200 km. The relative approach and departure velocity is 8.8 km/s.During the swing-by a communications black-out of approximately 14 min is expected due to occultation of the spacecraft by Mars. Furthermore the spacecraft is expected to be in eclipse for about 24 min.

The phase ends one month after the swing-by. Science operations will be supported on a non-interference basis with spacecraft operations.

10.8 Cruise phase 3

No check-outs are scheduled during the short cruise to Earth.

10.9 Earth swing-by 2

Daily operations start again around two months before Rosetta reaches Earth with tracking and navigation manoeuvres.

The actual Earth swing-by will take place on 15-Nov-07. The perigee altitude is 13890 km. The relative approach and departure velocity is 9.3 km/s.

The phase ends one month after the swing-by. Again there is the possibility for scientific observations, but mission operations have priority.

10.10 Cruise phase 4

In this phase the spacecraft makes one revolution around the Sun. DSM3 of 129 m/s is scheduled near the aphelion of this arc in order to obtain the proper arrival conditions at the Earth. A solar conjunction will take place in January 2009, together with another two conjunctions of the Earth-spacecraft-Sun angle (Sun-Earth conjunction as seen from the spacecraft).

Three passive check-outs are scheduled during this cruise phase.

10.11 Earth swing-by 3

Operations are essentially the same as for the Earth swing-by 3. The actual Earth swing-by will take place on 11-Nov-09. The perigee altitude is 300 km. The relative approach and departure velocity is 9.9 km/s.

10.12 Cruise phase 5

Two passive check-outs are scheduled during this cruise phase.

10.13 Deep Space Manoeuvre 4

The deep space manoeuvre is carried out when the spacecraft has reached a distance from the Sun of 4.4 AU on 10-May-11. The required ΔV is 533 m/s.

One passive check-out is scheduled during this phase.

10.14 Cruise phase 6

The whole period will be spent in deep-space hibernation mode. Maximum distances to Sun and Earth are encountered during this period, i.e. 5.3 AU (aphelion) and 6.3 AU, respectively.

10.15 Near comet drift (NCD) phase

The spacecraft reaches the comet on 23-May-14 at a distance of 4.0 AU from the Sun. A sequence of four rendezvous manoeuvres within 26 days will reduce the relative velocity with respect to the comet from 780 m/s to 50 m/s. The spacecraft is in active cruise mode.

During this phase Rosetta approaches the comet without observing the comet with the navigation camera (NAVCAM). The comet orbit is determined by a dedicated ground-based astrometric observation campaign. The errors in the estimated position of the comet can still be several tens of thousand km.

The final point of the NCD phase is the Comet acquisition point (CAP) at 100000 km distance from the comet. The selection of this position depends on two factors: avoiding cometary debris (assuming there is any), and achieving good comet illumination conditions.

10.16 Approach phase

10.16.1 Far approach trajectory (FAT)

Far-approach trajectory operations start at CAP. During this phase the first images of the comet are obtained with the optical measurement system (NAVCAM, OSIRIS). After detection, knowledge of the comet ephemeris will be drastically improved by processing the on-board observations. Image processing on the ground will derive a coarse estimation of comet size, shape and rotation. The first landmarks will be identified.

The approach manoeuvre sequence will reduce the relative velocity in stages down to 3.1 m/s after 34 days. The manoeuvre strategy will be designed to:

- retain an apparent motion of the comet with respect to the star background,
- retain the illumination angle (Sun-comet-spacecraft) below 70 degrees,
- avoid the danger of impact with the cometary nucleus in case of manoeuvre failure.

The FAT ends at the Approach transition point (ATP), which is located in the Sun direction at about 1000 comet nucleus radii from the nucleus. During this phase the spacecraft is in active cruise mode with the navigation camera and some orbiter payloads switched on.

10.16.2 Close approach trajectory (CAT)

Close approach trajectory operations start at ATP and take 17 days. The spacecraft distance to the comet is decreased to 40 nucleus radii and the relative velocity falls below 1 m/s. The final point of this phase is called the Orbit Insertion Point (OIP) and is the point where the spacecraft starts orbiting the comet. The injection is performed by means of a hyperbolic orbit.

Lines of sight to landmarks are processed together with on-ground radiometric measurements in order to estimate the spacecraft's relative position and velocity, the comet absolute position, attitude, nucleus angular velocity, gravitational constant and location of landmarks.

10.16.3 Transition to global mapping (TGM)

The transition to global mapping starts at OIP. A hyperbolic arc is used down to a distance to the comet of about 10-25 comet radii where a capture manoeuvre will close the orbit. The plane of motion is defined by the comet spin axis and the Sun direction. This plane is rotated slightly in order to avoid solar eclipses and Earth occultations.

10.16.4 Global mapping phase (GMP), Close observation phase (COP)

Mission scenarios have the objective of completing a science goal and require a trajectory and attitude profile which is driven by experiments selected to have priority in achieving this goal. The first scenario is the mapping scenario, during which at least 80 % of the comet surface will be observed from a circular orbit with a radius in the range of 10-25 comet radii and the comet model will increase in accuracy by evaluating the scientific results. The second scenario is the close encounter scenario, in which detailed observations will be made of up to five potential landing sites for the Rosetta lander from a distance of less than 1 nucleus radius.

10.17 Lander delivery and relay phase

The priority of this phase is the successful delivery of the lander to the surface of the comet. After the landing, the Rosetta orbiter will be brought into a trajectory which is optimised such that the orbiter can act as a relay for the lander – ground communications. Note that the other experiments will also be operating during this phase, regular science planning will be performed. However, the operations of other experiments cannot interfere with the lander operations.

10.18 Escort phase

10.18.1 Comet activity: low activity (LOW)

Starting from 3.5 to 3.3 AU the comet develops a measurable coma. At this point spacecraft resources limit the on-board orbiter experiments to be fully operational and time-sharing by choosing priorities determines the operations. Over the interval of 3.3 to 2.6 AU the activity is low and more or less constant, but occurrences of outburst are possible. The nominal start of the scientific mission is 3.25 AU and spacecraft resources are capable of supporting full experiments operations.

It is a mission preference that the lander will be separated preferably before 3 AU while the comet is still relatively in-active. Therefore the lander separation and relay has to be executed as soon as a landing site has been selected. (Note that the lander team baselines a delivery at 3 AU and not before.)

10.18.2 Comet activity: moderate increase (MINC)

The overall activity is expected to show a steady and moderate increase. The completion of the science objectives drive the selection of the mission scenarios for this phase.

10.18.3 Comet activity: sharp increase (SINC)

A sudden and steep increase in activity together with a change in outgassing conditions are expected for this phase from previous observations. Special orbit requirements, like dust/gas jet crossings, are possible for mission scenario selection.

10.18.4 Comet activity: high activity (HIGH)

The production rate of gas and dust is expected to have a steep increase indicating a distinct change in outgassing conditions. The thermal conditions of the spacecraft for distances smaller then 1.4 AU may influence the science operations capabilities and time-sharing of the payload operations may be necessary.

10.19 Near perihelion phase

This phase is likely to show a steady increase of overall activity.

10.20 Extended mission

Nominally, unless a mission extension is agreed and if the spacecraft survives in the cometary environment, the mission ends at the perihelion pass after 11.5 years. If possible, however, the mission will be continued. More risky or more time consuming scenarios may be executed.

10.21 Asteroid fly-by(s)

At least one asteroid fly-by will be accomodated in the mission plan depending on the propellant budget.

10.21.1 Asteroid approach

Fly-by operations start 1-2 months before the fly-by. In parallel with the daily tracking with orbit determination and corrections, the scientific payload is checked out. The relative asteroid ephemeris will be determined by spacecraft optical navigation. The aim is to pass the asteroid on the sunward side. The cameras and scientific payload will point in the direction of the asteroid until after the fly-by. Science data will be recorded in the mass memory.

10.21.2 Asteroid post fly-by

After the actual fly-by, when the Earth link via the HGA is recovered, the data recorded in the mass memory will be transmitted to Earth. Orbit correction manoeuvres required to put the spacecraft on course will be performed.

Table 3: Rosetta Mission Phase Definition (Draft 1)

	Name	Abbrev.	Time from launch days	Start date d-m-y	Durat. days	Sun dist. AU	Earth dist. AU	Typ. total downlink rate kbit/s	Mission phase start event	Mission scenarios	Comments	Comet dist. km	Phase angle deg
	Launch	LEOP	0	26-Feb-04	3	1	0	22	Launch		Launch window open from 26-Feb-04 to 17-Mar-04		
	Commissioning 1	CVP1	3	29-Feb-04	99			22	Completion of first trajectory correction manoeuvre		S/C Commissioning, P/L Commissioning Slot 1 (9 h daily P/L ops, full pass) and Slot 2 (5 h daily P/L ops), DSM1 on 25-May-04		
	Cruise 1	CR1	102	7-Jun-04	105			22	End of NNO availability				
	Commissioning 2	CVP2	207	20-Sep-04	45			22	Start of NNO full passes availability	Pointing (POINT), Interference (INTERFER)	P/L Commissioning Slot 3 (6 h daily P/L ops, full pass)		
	Earth swing-by 1	EAR1	252	4-Nov-04	150	1	0	22	End of NNO full passes availability		Phase ends 1 month after swing-by, Earth on 2-Mar-05, see note 5		
	Cruise 2	CR2	402	3-Apr-05	537			22	End of data downlink from Earth swing-by				
	Mars swing-by	MARS	939	22-Sep-06	187	1.4	2.1	22	Wake up spacecraft to prepare swing-by		Phase starts 1 month before DSM2, ends 1 month after swing-by, DSM2 on 21-Oct-06, Mars on 27-Feb-07		
	Cruise 3	CR3	1126	28-Mar-07	172			22	End of data downlink from Mars swing-by				
	Earth swing-by 2	EAR2	1298	16-Sep-07	91	1	0	22	Wake up spacecraft to prepare swing-by		Phase starts 2 months before swing-by, ends 1 month after, Earth on 15-Nov-07		
	Cruise 4	CR4	1389	16-Dec-07	636			22	End of data downlink from Earth swing-by		DSM3 on 15-Mar-09		
	Earth swing-by 3	EAR3	2025	12-Oct-09	91	1	0	22	Wake up spacecraft to prepare swing-by		Phase starts 2 months before swing-by, ends 1 month after, Earth on 11-Nov-09		
	Cruise 5	CR5	2116	12-Dec-09	395				End of data downlink from Earth swing-by				
	Deep Space Manoeurve 4	DSM4	2511	11-Jan-11	181	4.4	3.4				Phase starts 4 months before DSM, ends 2 months after, DSM4 on 10-May-11		
	Cruise 6	CR6	2692	11-Jul-11	928	5.3	6.3				Spacecraft hibernation		
	Rendezvous	RV	3620	24-Jan-14	119	4.5	5.3				Preparation for series of rendezvous manoeuvres starts 4 months before		
	Near comet drift	NCD	3739	23-May-14	26	4.00	3.31	14				500000	51
APPR	Far approach trajectory	FAT	3765	18-Jun-14	34	3.86	2.92	22	Comet acquisition point (CAP) reached	comet images (size, shape, rotation), identification of landmarks		100000	46
	Close approach trajectory	CAT	3799	22-Jul-14	17	3.68	2.70	22	Approach transition point (ATP) reached	estimate spin (2°), rotation (0.1%), gravity, landmarks		2000	0
	Transition to global mapping	TGM	3816	8-Aug-14	15	3.59	2.71	22	Orbit insertion point (OIP) reached	estimate spin (0.2°), rotation (0.01%), gravity (0.6%), inertia tensor (10%), landmarks (3 m)		80	10-170
	Global mapping phase	GMP	3831	23-Aug-14	35	3.50	2.78	22	Global mapping insertion point (GMIP) reached	Mapping (MAP), estimate gravity (0.3%)	Duration of this phase will be driven by the comet mapping requirements	40	10-170
	Close observation phase	COP	3866	27-Sep-14	22	3.29	3.06	22		Close encounter (CLOSE), estimate gravity (0.15%), inertia tensor (5%), landmarks (2 m)	Duration of this phase will be driven by the comet mapping requirements, start of full science at 3.25 AU	4-40	50-130
	Lander delivery and relay	SSP	3888	19-Okt-14	27	3.15	3.24	14			Phase starts 22 days before SSP delivery, ends 5 days after, SSP delivery at 3.0 AU on 10-Nov-14	5-35	10-180
ESCO	Comet activity: low activity	LOW	3915	15-Nov-14		2.97	3.41	14	Start of low activity	Initial science (INSCI)			
	Comet activity: moderate increase	MINC							Start of moderate activity increase	nominal science, timesharing			
	Comet activity: sharp increase	SINC							Start of sharp activity increase	nominal science, timesharing			
	Comet activity: high activity	HIGH							Start of high activity	nominal science, timesharing			
	Near perihelion	PERI				1.24	1.77	22		nominal science, timesharing	Perihelion on 12-Aug-15		
	Extended mission	EXT	4326	31-Dec-15		2.0		22		nominal science, timesharing			

Note 1: APPR = Approach phase

Note 2: ESCO = Escort phase

Note 3: "Cometary phase" is colloquial usage and means APPR + ESCO

Note 4: At least one asteroid fly-by will be scheduled. AST (Asteroid phase) = ASTA (Asteroid approach phase) + ASTP (Asteroid post fly-by phase)

Note 5: If Rosetta is launched later in the window, another DSM in Nov-04 adds to or replaces the DSM in May-04.

Note 6: Science downlink rate is lower than total downlink rate due to s/c housekeeping, tracking and manoeurves. Downlink is only possible during passes, i.e. not 24h per day.

11. Appendix B - Currently defined mission scenarios

11.1 Introduction

In the following, the currently defined mission scenarios are listed. The section "Priority experiments" states the names of the experiment(s) that most likely will be the main data producers in the corresponding scenario. This does *not* imply that only these experiments will be switched on. This will be mainly driven by the available power and data transmitting capabilities. It *does* imply that these instruments will be given priority when it comes to checking for conflicts. If there are several experiments with priority, each of these might have single priority within part of a scenario.

11.2 Interference (INTERFER)

11.2.1 Mission phase

Commissioning.

11.2.2 Science goal

To check for interferences among the experiments and between the experiments and the spacecraft.

11.2.3 Trajectory

Normal cruise trajectory, no requirements.

11.2.4 Priority experiments

n/a

11.2.5 Description

This scenario will be performed after all experiments are commissioned. The aim is to analyse the interferences among the individual experiments and between the experiments and the spacecraft sub-systems.

In the first part all experiments will switch to an emissive mode for 30 min. Then all experiments will switch to a susceptible mode, where they also stay for 30 min. This is followed by operations in which each of the experiments will switch to an emissive mode, while the others stay in a susceptible mode. Specific operations requiring exact timing will be included in the timeline. In the second part specific tests will be performed, which result from the data from the first part.

11.3 Pointing (POINT)

11.3.1 Mission phase

Commissioning.

11.3.2 Science goal

To point the s/c to stars and star fields and calibrate the individual experiments and their alignment with respect to each other and the Rosetta coordinate system.

11.3.3 Trajectory

Normal cruise trajectory, no requirements.

11.3.4 Priority experiments

Remote sensing experiments.

11.3.5 Description

This scenario will be performed during the commissioning phase. The s/c will slew to different stars and star fields and all remote sensing experiments will image the stars, preferably at the same time. This allows the experimenter teams to calibrate their individual experiments (*i.e.* spectral response, *etc.*) and it allows the cross-calibration of the experiments.

11.4 Close encounter (CLOSE)

11.4.1 Mission phase

(a) Close observation phase.
(b) Escort phase.

11.4.2 Science goal

(a) High-resolution mapping of a potential landing side for the lander.
(b) High-resolution mapping of an active area to determine the change in morphology on a cm-scale.

11.4.3 Trajectory

Elliptical arc with pericentre over the site of interest at good illumination conditions, typical distance 1-3 cometary radii.

11.4.4 Priority experiments

(a) OSIRIS.
(b) ALICE, MIRO, OSIRIS, VIRTIS (remote sensing experiments).

11.4.5 Description

tbd

11.5 Mapping scenario (MAP)

11.5.1 Mission phase

Global mapping phase, escort phase.

11.5.2 Science goal

To map the nucleus surface with the remote imaging experiments, with medium resolution.

11.5.3 Trajectory

Typically 10-25 nucleus radii distance, such that most time is spent over the illuminated side. The ground track of the orbit shall cover at least 80 % of the total surface. Most likely, more than one complete revolution around the comet is necessary.

11.5.4 Priority experiments

ALICE, MIRO, OSIRIS, VIRTIS (remote sensing experiments).

11.5.5 Description

tbd

11.6 Gas/dust jet sampling (JET)

11.6.1 Mission phase

Escort phase.

11.6.2 Science goal

To sample gas and dust particles in a cometary jet.

11.6.3 Trajectory

Such that it intersects the gas/dust jet. Distance to the comet is *tbd*.

11.6.4 Priority experiments

COSIMA, GIADA, MIDAS, ROSINA.

11.6.5 Description

tbd

11.7 Coma mosaic (COMA)

11.7.1 Mission phase

Escort phase.

11.7.2 Science goal

To sample the coma in different viewing directions.

11.7.3 Trajectory

No special requirements *(tbc).*

11.7.4 Priority experiments

VIRTIS.

11.7.5 Description

see EID-B of VIRTIS.

11.8 Tail excursion (TAIL)

11.8.1 Mission phase

End of escort phase / extended mission.

11.8.2 Main science goal

Observe the plasma properties of the cometary tail, in a large distance from the comet.

11.8.3 Trajectory

Elliptical arc going to a large distance (in the order of 100000 km) away from the comet. Oriented such that the apocentre is located in the cometary tail. Note that the typical time for such an orbit can be in the order of months.

11.8.4 Priority experiments

RPC

11.8.5 Description

Tbd - NOTE: This scenario will only be performed if time permits.

12. Appendix C - Abbreviations

AD	Applicable Document
AIV	Assembly, Integration and Verification
ALICE	Rosetta experiment: UV spectrometer
APPR	Mission phase: Approach
AST	Mission phase: Asteroid fly-by
ASTA	Mission phase: Asteroid approach
ASTP	Mission phase: Asteroid post fly-by
ATP	Approach transition point
CAM	Rosetta Navigation Camera
CAP	Comet acquisition point
CAT	Mission phase: Close approach trajectory
CDMS	Command and Data Management System
TB	Test Bed
C-G	Churyumov-Gerasimenko
CLOSE	Mission scenario: Close encounter
CNES	French Space Agency
COMA	Mission scenario: Coma mosaic
CONF	Conflict File
CONSERT	Rosetta experiment: Comet Nucleus Sounding Experiment by Radiowave Transmission
COP	Mission phase: Close observation phase
COSIMA	Rosetta experiment: Cometary Secondary Ion Mass Analyzer
CR	Mission phase: Cruise
CRID	Command Request Interface Document
CSU	Command Sequence Update (passed via file type CS_P to the RSOC)
CVP	Mission phase: Commissioning and verification
D/TOS	Directorate of Technology and Operations Support of ESA
DAVIS	Name of a tool that is the basis of TC/TM management at LCC
DCR	Document Change Request
DDID	Data Delivery Interface Document
DDS	Data Distribution System
DLR	German Space Agency
DSM	Deep Space Manoeuvre (also used as mission phase)
DSS	Dornier Satellite Systems (now Astrium)
DVP	Data Volume Profile
EAR	Mission phase: Earth swing-by
ECSS	European Cooperation of Space Standardization
EDF	Experiment Description File
EGSE	Electrical Ground Support Equipment
EID	Experiment Interface Document
EMM	Modelling and Simulation Section of TOS
EOP	Experiment Operations Plan of the Lander
EPS	Experiment Planning System
ESA	European Space Agency
ESCO	Mission phase: Escort
ESOC	European Space Operations Centre
ESTEC	European Space and Technology Centre
EVF	Event File
EXT	Mission phase: Extended mission

FAT	Mission phase: Far approach trajectory
FCP	Flight Control Procedure
FCT	Flight Control Team
FDT	Flight Dynamics Team
FOP	Flight Operations Plan
GIADA	Rosetta experiment: Grain Impact Analyzer and Dust Accumulator
GMP	Global mapping insertion point
GMP	Mission phase: Global mapping phase
GRM	Ground Reference Model
GSSTP	Ground Segment System Test Plan
HIGH	Mission phase: Comet activity: high activity
ICA	Ion Composition Analyzer (part of RPC)
ICD	Interface Control Document
IES	Ion Electron Sensor (part of RPC)
INERT	Pointing mode: Inertially fixed pointing
INSCI	Mission scenario: Initial science
INSLW	Pointing mode: Slewing between two inertial positions
INTERFER	Mission scenario: Interference
ITL	Input Timeline
JET	Mission scenario: Gas/dust jet sampling
LAP	Langmuir Probe (part of RPC)
LCC	Lander Control Centre at DLR
LEOP	Mission phase: Launch and early operations
LID	Lander Interface Document
LIMB	Pointing mode: Limb tracking
LIMBOF	Pointing mode: Limb tracking with offset
LOP	Lander Operations Plan
LOR	Lander Operational Request
LOW	Mission phase: Comet activity: low activity
MAG	Fluxgate Magnetometer (part of RPC)
MAP	Mission scenario: Mapping
MARS	Mission phase: Mars swing-by
MEX	Mars Express
MIDAS	Rosetta experiment: Micro-Imaging Dust Analysis System
MINC	Mission phase: Comet activity: moderate increase
MIP	Mutual Impedance Probe (part of RPC)
MIP	Mission Implementation Plan
MIRO	Rosetta experiment: Microwave Instrument for the Rosetta Orbiter
MOIS	Mission Operations Information System
MOST	Lander EPS
MPAE	Max-Planck-Institut für Aeronomie
MSP	Master Science Plan
MTL	Mission Timeline
MTPM	Medium-Term Planning Meeting
MUSC	Microgravity User Support Center at DLR
NADIR	Pointing mode: Nadir pointing
NADOF	Pointing mode: Nadir pointing with offset
NASA	National Aeronautics and Space Administration
NAVCAM	Navigation camera
NCD	Mission phase: Near comet drift
NNO	New Norcia ground station
OBCP	On-Board Control Procedure
OIOR	Orbiter Instrument Operational Request
OIP	Orbit insertion point
ORF	Operational Request File
ORFA	ORF Acknowledger
OSIRIS	Rosetta experiment: Science camera

PDS	Planetary Data System
PERI	Mission phase: Near perihelion
PI	Principal Investigator
PISA	PI Support Area
p/l	Payload
POINT	Mission scenario: Pointing
POR	Payload Operational Request
PP	Power Profile
PTB	Payload Test Bed
PTR	Pointing Request
RAI	Reference Attitude Information
RD	Reference Document
RDVM	Rendezvous manoeuvre
RGS	Rosetta Ground Segment
RMIB	Rosetta Mission Implementation Base
RMOC	Rosetta Mission Control Centre
ROSINA	Rosetta experiment: Rosetta Orbiter Spectrometer for Ion and Neutral Analysis
RPC	Rosetta experiment: Rosetta Plasma Consortium
RSDB	Rosetta System Data Base
RSOC	Rosetta Science Operations Centre
RSSD	Research and Scientific Support Department of ESA
RV	Mission phase: Rendezvous
s/c	Spacecraft
s/s	Subsystem
SAP	Science Activity Plan
SIM	Simulator
SINC	Mission phase: Comet activity: sharp increase
SOIA	Science Operations Implementation Agreement
SONC	Science Operations and Navigation Centre for the Lander at CNES
SOP	Subsystem Operations Plan of the Lander
SOT	Science Operations Team
SOWG	Science Operations Working Group
SPL	Scenario Parameter Lists
SSP	Surface Science Package (also referred to as "Lander" or "Rosetta Lander")
SSP	Mission phase: Lander delivery and relay
START	Start of mission
STPM	Short-Term Planning Meeting
SVT	System Validation Tests
SWT	Science Working Team
TAIL	Mission scenario: Tail excursion
TC	Telecommand
TGM	Mission phase: Transition to global mapping
TM	Telemetry
TRACK	Pointing mode: Tracking a landmark on the comet surface
TRCOM	Pointing mode: Tracking a feature in the cometary coma
TVR	TC verification request
UDP	User Defined Procedure
UM	User Manual
UoM	University of Maryland
VIRTIS	Rosetta experiment: Infrared spectrometer