Rosetta Lander

Cometary Lander of the Rosetta-Mission

Project Plan

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ROSETTA Lander Project Plan

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1. Scope of the Project Plan

This project plan summarises the scientific objectives and technical boundary conditions, which are the basis for the Rosetta Lander Project (section 2). Technical details on the Lander design are not included here. For these design details reference is made to the Rosetta Lander System Specification (RO-LAN-SP-3101) and the sub-system specifications. The interface between the Rosetta Lander and the Rosetta System is defined in the Lander Interface Document LID-B (RO-EST-RS-3020/LID B).

The project plan includes the project management scheme (section 3) and the Lander integration and test plan (section 4) and its operations concept (section 5). The sharing of work within the Rosetta Lander consortium is defined by the work break down structure (section 6) and work package description sheets (compiled in Annex 1). The project schedule including a critical path analysis is given (section 7).

Each partner of the Rosetta Lander Project may attach the cost and funding plan of its contribution as Annex 2 to this project plan.

2. Project Overview and Scientific Objectives

Comets are among the most interesting bodies in our solar system. They are believed to have preserved material from the early stages of formation of the planetary system. For this reason ESA is developing one of its Cornerstone Missions, named "Rosetta", to visit a comet and perform scientific investigations intended to contribute significantly to our knowledge of the evolution of the solar system. Rosetta will be launched in January 2003 to rendezvous with comet P/Wirtanen in the year 2012 at a distance of about 3.25 AU. Orbiting the comet along its approach to the sun will allow observations from close vicinity with a wide range of remote sensing instruments.

Rosetta will carry a Lander, named **Rosetta Lander**, designed to separate from the orbiter and land on the surface of the comet. The Lander science instruments are designed to make in situ observations of cometary material and the local environment, such enhancing considerably the scientific potential of the Rosetta mission. The Rosetta Lander will be contributed, in a form similar to the provision of scientific instruments, within the project „Rosetta Lander“ described in this project plan.

The Rosetta Lander consortium has been formed from European scientific institutes and funding agencies consisting of:

- Deutsches Zentrum für Luft- und Raumfahrt (DLR), Köln, Braunschweig,
- Max-Planck-Institut für Aeronomie - Abteilung Rosenbauer, Lindau - (abbreviated MPAe throughout the document for simplification reasons)
- Max-Planck-Institut für Extraterrestrische Physik (MPE), Garching,
- The former Deutsche Agentur für Raumfahrtangelegenheiten (DARA), now DLR Bonn,
- Centre National d’Etudes Spatiales (CNES), Paris, Toulouse,
- Agenzia Spatiale Italiana (ASI), Roma, Matera,
- KFKI Research Institute for Particle and Nuclear Physics, Budapest,
- Budapesti Muszaki Egyetem (BME)
- Institut d’Astrophysique Spatiale (IAS), Orsay,
- PPARC/BNSC, London,
- Irish Space Technology Institute (STIL), Maynooth,
- Finnish Meteorological Institute (FMI), Helsinki,
- Rutherford Appleton Laboratory (RAL), Chilton,
- Institut für Weltraumforschung (IWF), Graz,

The members of this consortium will commit resources from their own institution, supported by national space agencies as applicable. Each member will contribute to the common goal as described in the present project plan on the basis of "best effort" in fulfilling the agreed obligations, which are minuted in the Rosetta Lander Steering Committee. The project is managed by a Project Management Team with a Project Manager (DLR) and two Co-Project Managers (CNES, ASI), with two Lead Scientists (MPAe, IAS) interfacing to the scientific side. A Steering Committee has been constituted that serves as a supervisory body and as a means to resolve potential conflicts between the partners.

The Rosetta Lander project is challenging:

- scientific:

  a close approach to pristine material of our solar system, with the potential to obtain key scientific knowledge relating to the early stages of formation of the planetary system and its evolution;

- technical:

  landing and operating a scientific payload in an unknown and hostile environment, with the specific problems of a long passive transport phase, an unknown physical surface structure, extreme temperatures during cometary days and nights and low energy input;

- managerial:

  the international project based on contributions from research institutions and space agencies requires level of coordination; extremely long time periods inherent in the mission require novel approaches to project management and have to ensure continuity of scientific and technical expertise;

- financial:

  while a low cost philosophy is accepted throughout the project, this will not be achieved by compromising on technical standards. In contrast, an attempt is made to combine a low cost approach with an ambitious advanced technical concept by accepting a calculated risk for subsystems not endangering the overall mission goals, and including into the technical development scientific research institutes and small industrial companies.

The Rosetta Lander will carry a scientific payload of 10 instruments overviewed in table 1.1.

Experiment	*Principal Investigator*
Chemistry	
APX - Spectrometer	R. Rieder MPC - Mainz
COSAC	H. Rosenbauer MPAe - Lindau
MODULUS	C. Pillinger Open University, UK
Chemistry / Imaging System	
ÇIVA	J.P. Bibring, IAS
ROLIS	S. Mottola, DLR
Physical Properties	
MUPUS	T. Spohn Universität Münster
SESAME = CASSE - DIM - PP	D. Möhlmann (**CASSE**) DLR Köln; H. Laakso (**PP**) FMI; I. Apathy (**DIM**) KFKI
ROMAP = ROMA - SPM	H.-U. Auster (**ROMA**) MPE, Berlin; I. Apathy (**SPM**) KFKI Budapest
CONSERT	W. Kofman Centre d'Etude des Phénomènes Alétoires et Géophysiques
Sampling and Drilling System	
SD2	A. Ercoli Finzi Politechnico - Milano

Table 1.1: Rosetta Lander scientific instruments

Our present knowledge on comets is very limited. The closest optical investigation was achieved in the Giotto fly-by mission to comet P/Halley in 1986 at a distance of about 1700 km. Detailed information on parameters, such as shape, size, rotation axis, or surface properties of the Rosetta target comet will only be known once the Orbiter has arrived. Therefore the design of the Rosetta Lander is based on a high degree of flexibility and robustness, which allows to adapt crucial parameters to observed values upon arrival of the Orbiter and to ensure a safe landing on the comet without relying on assumptions concerning surface properties.

The primary goal of the Rosetta Lander is to transport its payload to the surface of the comet nucleus and operate it in the local hostile environment. In order to achieve the above defined objectives within the uncertainties prevailing, the Rosetta Lander is designed to meet a set of goals which include:

- an operational lifetime long compared to the comet's rotation period, covering part of the orbital period,

  this is achieved by using solar power, primary and rechargeable batteries and a suitable thermal design;

- operational flexibility in order to adapt the spacecraft system and its instruments to an environment and to operational situations unpredictable at time of launch,

  this is achieved by both, onboard autonomy, and interactively commanding experiments from ground, using the orbiter as a relay station of a two-way radio link;

- a landing scenario which can be adapted to a range of physical and surface properties of the comet unknown at the time of launch,

  this is achieved by an eject mechanism with adjustable Δv and on board (cold gas) propulsion;

- experiment support with respect to positioning of experiment sensors and to reaction forces for sampling or drilling,

  this is achieved by a rotable landing gear and an active anchoring system.

The Rosetta Lander system is aiming for a total mass of 85 kg. The Lander shape is shown in figure 1.1. It will land on legs which will keep it off ground by about 0.25 m. The structure will be based on high strength carbon fiber composite elements in a form that ensures flexibility for experiment accommodation.

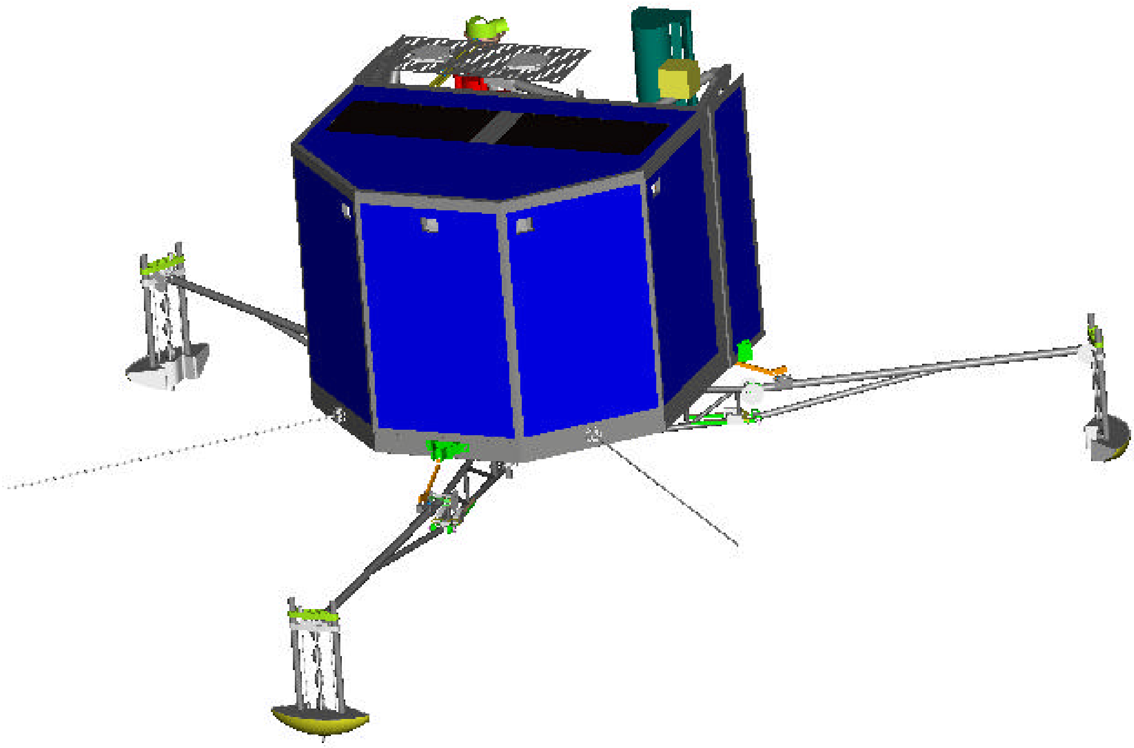

Figure 1.1: Rosetta Lander geometry

Power will be provided by a solar generator covering nearly all of the top lid and the side wall area. At 3 AU, this generator will produce an untreated electric power of about 11 W when sunlit. A primary battery will secure a first sequence of science operations. In addition a rechargeable battery of about 70 Wh energy will cover peak power requirements during the long duration mission phase and enable (reduced) operations during cometary nights.

The thermal concept is based on high-performance multilayer superinsulation (MLI) and the collection of solar energy.

The Rosetta Lander Command and Data Management Subsystem (CDMS) serves as the central intelligent interface for the two-way data transmission between the Rosetta Lander receiver-transmitter and all subsystems and instruments. It controls the subsystems on the basis of special software and telecommands and also realises the Rosetta Lander housekeeping system. It offers storage capacity for the instruments and is redundant. The command and data link will operate in S-band.

To initiate the landing sequence a push off mechanism with an eject V adjustable prior to separation from the orbiter will be applied. An active descent system, based on cold gas propulsion in a vertical direction will be used during descend and landing. The landing gear will absorb the impact energy and provide a rotation capability. An anchoring system will fix the Rosetta Lander to the comet's surface in order to accept reaction forces arising from instruments such as the mechanical drill.

A predetermined investigation strategy will be pursued in a first measurement sequence of 5 days, updated in regular intervals by a ground operations team. In the long duration mission phase measurements of up to several months will be performed sequentially for most of the instruments with a few exceptions as required for scientific reasons.

3. Project Management

3.1. Functional Organigramme

The functional organigramme of the Rosetta Lander Project is shown in figure 3.1.

The Rosetta Lander project is a cooperative effort of research institutes and space agencies (listed in section 2) with the goal to design, manufacture, test, validate, and operate the Rosetta Lander in order to provide the opportunity for scientific investigations on a cometary nucleus.

The institutes providing contributions to the Rosetta Lander system and space agencies providing financial support are represented in the Steering committee. Day-to-day project management is performed by the Rosetta Lander Project Office under the responsibility of the Project Manager. The Project Manager is supported by two Co-Project Managers. The Project Manager and the Co-Project Managers are responsible for coordination of the complete Project. Each Co-Project Manager is responsible for the contribution of the Work Packages of his respective country.

The scientific coordination of the Rosetta Lander is performed by two Lead Scientists acting sequentially as spokesperson.

The Project Advisor directly supports the Project Manager in all technical, financial and administrative matter.

The lander platform engineering and the payload management/engineering, are under the responsibility of the System Engineer.

The Product Assurance Engineer the lander AIV Manager, the Data-I/F manager, the mission analysis/navigation and the operations and ground segment management report directly to the Project Manager.

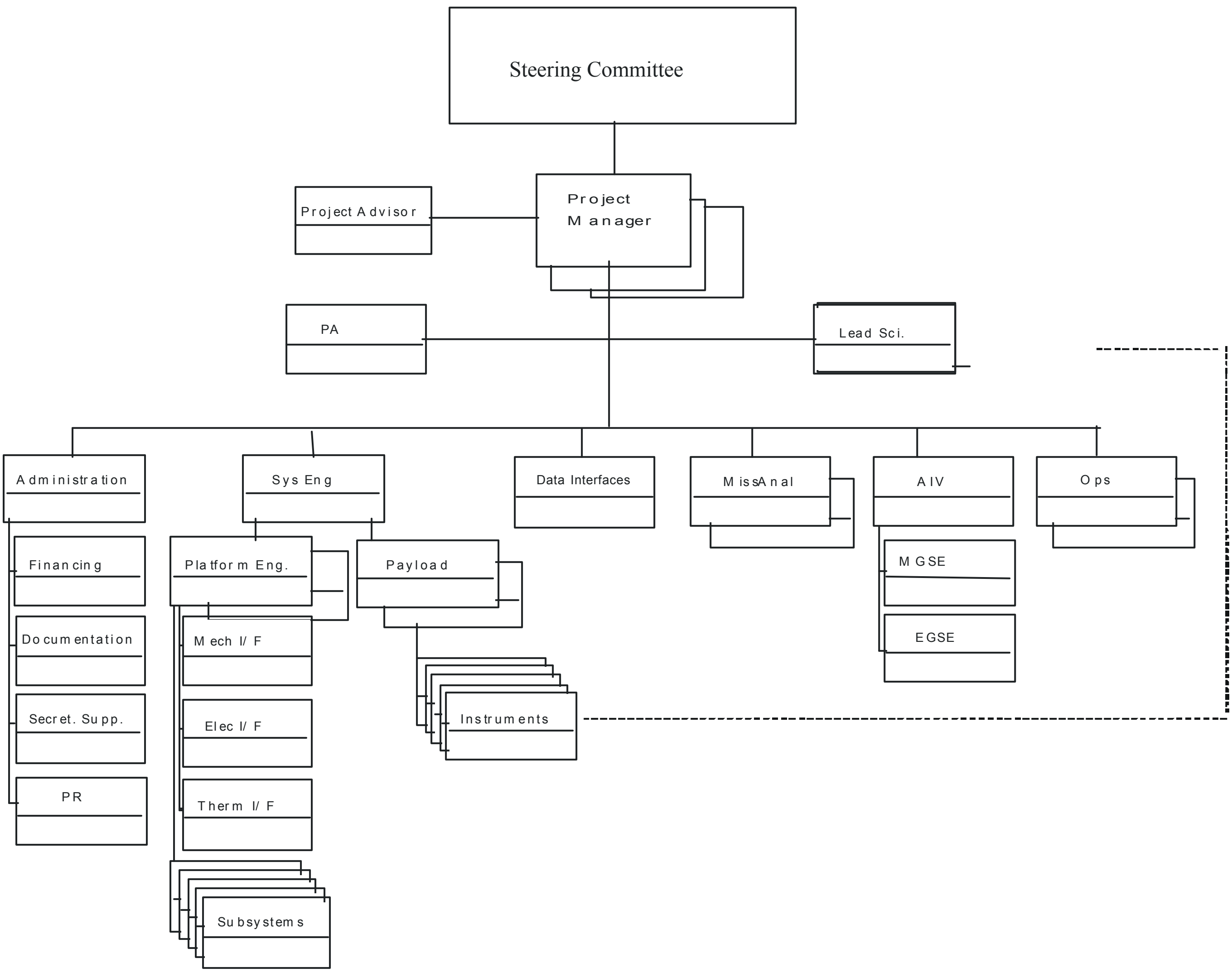

Figure 3.1: Rosetta Lander Project Organisation

It is important to note that the cooperation of the institutes of the Rosetta Lander consortium is based on a best effort agreement with no exchange of funds between the partner institutions.

The Rosetta Lander instruments will be provided by Instrument Teams, headed by PIs. The PIs will be responsible for technical realisation of their instruments interfacing to the Rosetta Lander as defined in the respective REID-A and REID-B documents within the schedule given in section 4. The PIs will be responsible for the funding of their contributions. They will form the Science Team, which is chaired by the Lead Scientists.

3.2. Key Personnel

The following key personnel has been identified:

Project Manager:	Dr. Stephan Ulamec
Deputy Project Manager:	Prof. Denis Moura
Deputy Project Manager:	Dr. Raffaele Mugnuolo
Lead Scientist:	Dr. Helmut Rosenbauer
Lead Scientist:	Prof. Dr. Jean-Pierre Bibring
Project Advisor/System Engineer:	Hans-Jürgen Schuran
Product Assurance Engineer:	Dr. Johannes Boßler
Payload Manager	Dr. Jens Biele / M. Cau*
Payload Engineer:	Peter Hemmerich
Platform Engineer:	Hans-Peter Schmidt / M. Cau*
Data I/F Manager:	Tobias Trautmann
Mission Analysis Coordinator:	Felix-Xavier Chaffaut /Dr. Martin Hilchenbach
AIV-Manager	Dr. Gerhard Gritner
Operations Manager	Pascale Rangeard / T. Trautmann
Administration:	Ursula Jacobs

* responsible for French contributions

Principle Investigators (PIs) of Rosetta Lander instruments:

Dr. Hans-Ulrich Auster, Prof. Dr. Jean Pierre Bibring, Dr. Wlodek Kofman, Prof. Dr. Diedrich Möhlmann, Dr. Stefano Mottola, Prof. Dr. Colin T. Pillinger, Dr. Rudolf Rieder, Dr. Helmut Rosenbauer, Prof. Dr. Tilman Spohn, Dr. H. Laakso, I. Apathy

3.3. Formal Communication, Reporting, Reviews

Formal communication addressee between the Rosetta Project and the Rosetta Lander Project will be the Project Manager.

The interface between the Rosetta Project Scientist and the Rosetta Lander science team will be the Lead Scientists. The spokesmanship of the two Lead Scientists will change on an annual basis. Helmut Rosenbauer is the 1999 spokesman.

Within the Rosetta Lander team, reporting is covered by monthly progress reports, which will be made available to ESA and the funding agencies. On the other hand, ESA will provide upon request the Rosetta progress reports. Lander instrument PIs will provide bi-monthly progress reports.

The ESA review cycle consists of Experiment Conceptual Design Review (ECDR), Experiment Integration Design Review (EIDR), Experiment Flight Readiness Design Review (EFDR) and Experiment Flight Operations Design Review (EFOR).

For helping the preparation of the ESA reviews as well following their development, the lander experiments will have their own reviews, organized by the lander system team.

3.4. Project Funding

The project is funded by resources of the cooperating institutes (on the principle: no exchange of funds) and by financial support of the space agencies DLR, CNES, ASI and PPARC.

The Rosetta Lander PIs will secure the funding of the instrument development.

A detailed cost and funding plan for the German contribution to the Rosetta Lander Project is contained in Annex 2 of this Rosetta Lander Project plan.

3.5. Project Control

The Rosetta Lander Project Manager establishes a Configuration Management System which will be affected throughout the design, construction, integration, test and mission operations of the Lander. The objectives are to:

- establish requirements, design, and construction baselines,
- ensure that all changes to these baselines are coordinated and evaluated prior to incorporation,
- maintain a library of the actual configuration of all hardware, software and documentation including changes that have been incorporated.

The detailed configuration management implementation will be defined in the configuration management plan.

The Rosetta Lander configuration management comprises the following techniques:

- configuration item identification,
- approval procedure,
- configuration accounting (Rosetta Lander library),
- change processing,
- implementation verification.

Figure 3.5.1. shows the organisation of the above tasks. A brief task description is given in the following.

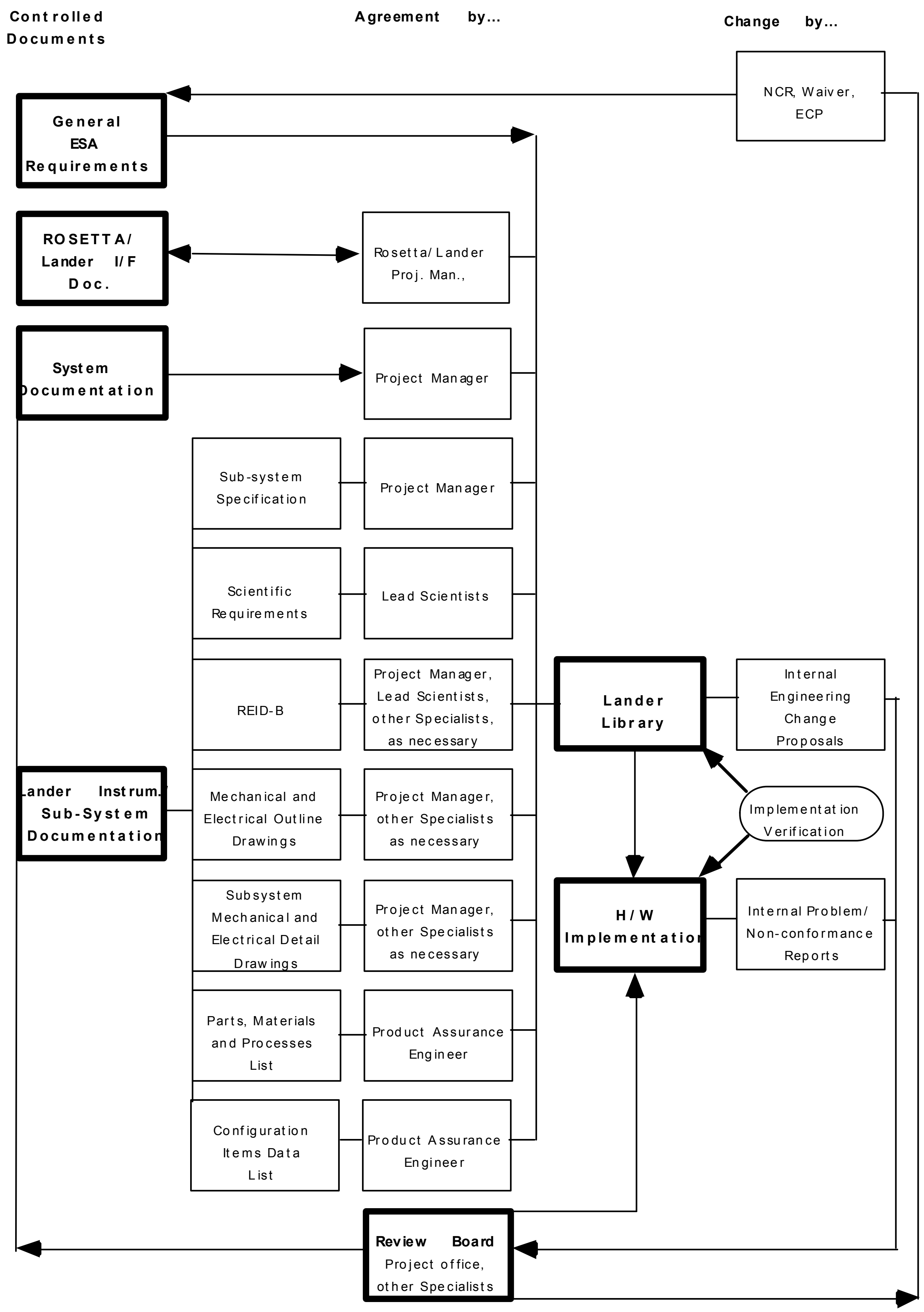

Figure 3.5.1 Configuration Control Task Flow

As the starting point of configuration management, the configuration items are defined. The main configuration item categories will be:

- documents,
- hardware items,
- software items.

Configuration controlled documents will be reviewed by the Project Manager and the Co-Project Managers, the Lead Scientists, the System Engineer and dedicated specialists. The review and approval process may be facilitated by the formation of working groups. They will provide a means for information exchange and to keep the Project Manager informed about the system development.

After approval, documents will become part of the library which shall provide the information focal point for all participating organisations. The library will consist of all approved documents in physical and electronic (e.g. FTP, HTTP..) form and of lists reflecting the change history. The Rosetta Lander system and all interfacing subsystems are designed according to the documents in the library. Changes will become effective only after approval by all partners concerned.

Changes from the configuration established at the review points will be controlled through formal evaluation of the proposed change by the Project Manager, system and subsystem responsibles, product assurance and any interfacing agencies affected by the change.

Any manufactured item for the Rosetta Lander will be verified for conformity to design configuration before and after delivery and before acceptance for integration and test. The design information is continuously updated. Non-conformance reports shall be issued and submitted to ESA for approval for all Rosetta interface relevant discrepancies between the agreed manufacturing baseline and the actual hardware. The Rosetta Lander product assurance will provide a verification together with a procedure resolving discrepancies. During assembly and test a final verification program is carried out to validate the baseline documentation and to ensure that all changes have been incorporated.

3.6. Rosetta Lander Product Assurance

The Rosetta Lander product assurance program covers the following disciplines:

1. reliability assurance,
2. quality assurance,
3. safety assurance,
4. software quality assurance,
5. parts, materials and processes application
6. cleanliness
7. configuration control.

The Lander PA program shall ensure that no failures within the Lander can propagate into the Orbiter system, that the maximum Lander mission success probability is achieved and that no safety risk is created at any phase of the Lander operations. The PA program has started already in the development phase and shall be effective in all following project phases until delivery of the flight model to the Orbiter integration site. During the following check-out and integration on Orbiter level, the overall PA responsibility is transferred to the Rosetta system integrator. However, the Rosetta PA team shall be assisted in the fulfillment of their tasks.

The Product Assurance Plan is contained in the Rosetta Lander Interface Document LID-B (Volume 3). It describes the product assurance (PA) tasks, organization and responsibilities for the Lander and includes the implementation of:

- generic ESA (PSS resp. ECSS) requirements,
- specific Orbiter requirements as outlined in the EID-A/LID-A and

- Lander peculiar PA requirements.

4. Rosetta Lander Assembly, Integration and Test

4.1. Rosetta Lander Model Philosophy

It is planned to deliver a Structure/Thermal Qualification Model (STM), an Electrical/EMC Qualification Model (EQM) and a Flight Model (FM) to ESA. Delivery dates are given in section 7 (Project Schedules). Flight spares will be available on component level. A ground reference model (GRM) is foreseen for ground reference purposes.

For qualification purposes, two Rosetta Lander models will be built.

The Structural/Thermal Model (STM) haws been built for development/qualification testing consisting of a flight type basic structure equipped with all mechanisms (advanced development models). The subsystems and scientific instruments are at least simulated by mechanically and thermally representative mass dummies (dimensions, CoG, mounting, heaters).

The STM has been used to achieve the mechanical and thermal qualification of the Lander. The thermal qualification will mainly address solar simulation and thermal balance tests. Especially, the predictions of the thermal analysis were verified.

After completion of the tests on Rosetta Lander level, the STM is made available to the Rosetta Project for mechanical and thermal qualification as a part of the Rosetta system as a whole.

The Electrical/EMC Model (EQM) will be used for harness and connector layout develop-ment, verification of electrical functions, electrical interface testing, s/w verification and EMC tests. The EQM will be integrated from a flight standard basic structure and development models of the subsystems and scientific instruments. For the EMC tests, the subsystems and scientific instruments, power and data harnesses need to be flight identical with respect to their electrical properties. The EQM will be provided to ESA for Rosetta interface/compatibility and overall EMC tests.

The Flight Model will be manufactured, and then will undergo a series of functional, interface and acceptance level environmental tests.

The ESA required subsystem spares together with the basic structure from the electrical model and the scientific instrument development models (flight spares if applicable) will be integrated into the Ground Reference Model, GRM. All flight spares will be tested to the same levels as the FM. The FM/spare tests will be performed for single non-integrated instruments or subsystems with test levels which have been derived from the tests of the flight hardware integrated into the Rosetta spacecraft. The GRM is intended for use in case of anomaly investigations during Rosetta integration, pre-launch operations and during the mission and as source for unit or even Lander system exchange in case of problems during Rosetta higher integration level activities.

For the Mechanical Support and Separation System (MSS) and the Electrical Support System (ESS) structure/thermal models, electrical/EMC models, flight and flight spare models analogous to the ones described for the Lander will be provided to ESA. Delivery dates are given in section 7 (Project Schedule).

4.2 Test Requirements

A sequence of tests will be performed to verify the specified Lander performance under all conceivable mission conditions. They are an integral part of the overall assembly and integration flow. In general, they will be performed at the earliest possible stage, in order to avoid redesign which would be more difficult or even impossible on higher integration levels. The test strategy, as described in the Rosetta Lander Test Specification (RO-LAN-TS-3301)will be followed. The two main test categories are:

- functional tests and
- environmental tests.

Special effort will be taken for functional tests of the MSS and descent system. The interface to the Rosetta Orbiter will be verified by I/F tests. Considerations will be given to the need for simulations (dynamic, cometary, etc.) for system and subsystems. Functional tests will be performed at various development and integration stages. Reduced functional tests will be part also of environmental tests. Environmental tests shall cover the complete load spectrum to which the spacecraft will be exposed to. The tests will not only prove the immunity of the spacecraft against external conditions, but also that the spacecraft will not have any negative effects to the launcher and other Rosetta equipment.

These environmental mission conditions are covered by the following tests:

- mechanical tests: resonance survey, shock, linear acceleration, sinus and random vibrations,
- EMC: radiated and conducted emissions and susceptibility,
- thermal vacuum tests: solar simulation/thermal balance,
- outgassing tests, to be performed on component level; bake-out of system constituents like harness or MLI will be considered,
- acoustic noise tests.

As far as possible, also the long time mission duration implications will be considered. Environmental tests will be performed both with:

- qualification level and
- acceptance level.

Tests at qualification level will be restricted to dedicated models in order not to limit the life expectancy of the flight spacecraft. In general, the qualification tests will be performed with the completely integrated Lander. Tests will be supplemented or substituted by analytical methods where tests are either technically not feasible or not cost effective.

Test procedures for qualification and acceptance tests will be submitted to ESA for approval. As a rule, qualification and acceptance tests will establish Mandatory Inspection Points (MIP).

The verification program for the Rosetta Lander is defined in the Verification Program Plan (VPP, RO-LAN-PL-3301)), which provides a systematic and concise overview about the Lander specification items and their verification. The VPP lists in tabular form each physical or technical parameter.

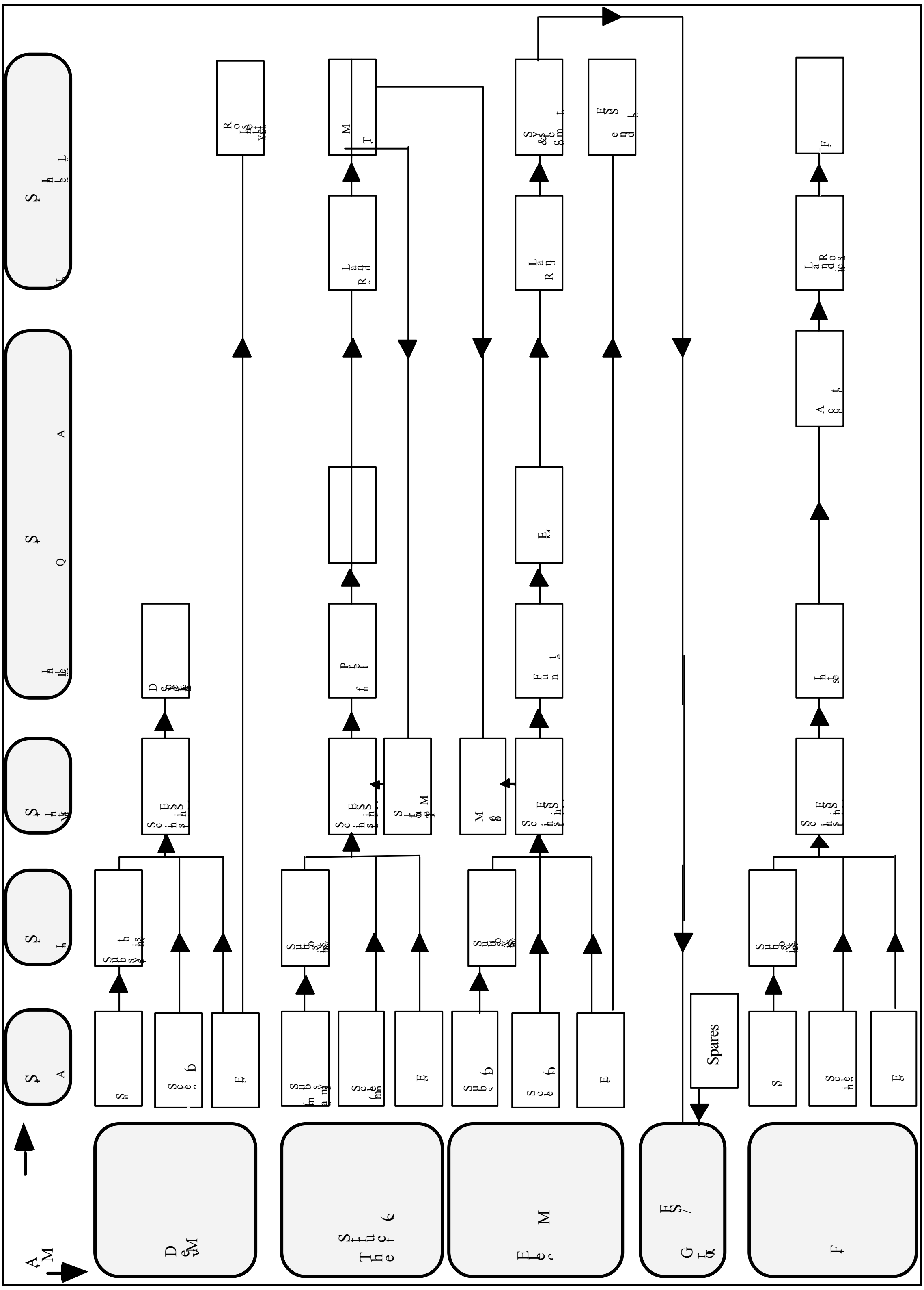

Figure 4.1: Lander AIV flow

Figure 4.1 provides an overview of the Lander AIV flow.

Safety requirements and their implementation into Lander will be documented in a dedicated safety data package (SDP).

For each listed requirement a method will be specified which provides the adequate evidence that the requirement has been successfully implemented. Verification methods shall be:

- test (functional, environmental etc.),
- inspection (incoming inspection, materials inspection),
- review of documentation or drawings (Review of Design),
- analytical assessment,

or a combination of the above. The VPP specifies the verification level on which the verification shall take place. Verifications may be performed on development or breadboard level, qualification model level or flight model level (acceptance tests).

The successful completion of a verification item will be documented in the verification program plan. The completely filled out verification program plan becomes the verification control document. Open verification activities which need to be transferred to the next higher integration level will be listed in the list of open items which is part of the acceptance data package.

4.3 Lander Test Matrix

The Lander tests will be carried out according to the following test matrix. The matrixlist the types of tests but do not reflect the sequence of tests. The detailed test sequences and their relation to analytical verifications will be specified in the test plan.

Test matrix 4.3.1 shows planned tests with the fully integrated lander (SSP) and tests with the lander integrated in the orbiter (SSP-S/C).

The following verification methods shall be used:

A = Analysis
I = Inspection
R = Review of design
S = Similarity
Sim = Simulation
T = Test
Q: tests at qualification level
A : tests at acceptance level

The completely integrated lander is called **SSP** and the lander attached to the Rosetta spacecraft is identified as **SSP-S/C**.

Test-Description	**STM**		**EQM**		**FM**		**FS**	
	SSP	SSP-S/C	SSP	SSP-S/C	SSP	SSP-S/C	SSP	SSP-S/C
Mech. Interface		R, T_Q		R, T_Q		T_A		I
Mass Property	T_Q		T_Q		T_A		I	
Electr. Perform.			T_Q	T_Q	T_A	T_A	T_A	T_A
Functional Test	T_Q *		T_Q *	T_Q *	T_A	T_A	T_A	T_A
Separation Test		A,Sim, T_Q		T_Q				
Telecom. Link				T_Q		T_A		T_A
Strength Load	A, T_Q	A, T_Q			T_A		T_A	
Shock	T_Q	T_Q			T_A		T_A	
Sine Vibration	A, T_Q	A, T_Q			T_A		T_A	
Low Level Sine	A, T_Q	A, T_Q			T_A		T_A	
Random Vibration	T_Q	T_Q			T_A		T_A	
Acoustic noise		T_Q				T_A		
Outgasing	on component level only							
Thermal ballance	A, T_Q							
Thermal vacuum	T_Q	T_Q	T_A	T_A	T_A		T_A	
Grounding/Bond.	R, T_Q	R, T_Q	R, T_Q	R, T_Q	R, T_A	R, T_A	R,T_A	
EMC cond.interf.			T_Q	T_Q	T_A	T_A	T_A	
EMC rad. interf.			T_Q	T_Q	T_A	T_A	T_A	
DC magnetic			T_Q	T_Q	T_A	T_A	T_A	
Purging rate			T_Q	T_Q	T_A	T_A	T_A	

* = only as far as testable on system level

Table 4.3.1 Lander test matrix (TBC) Functional tests include separation tests. Low level sinus tests will be performed as part of the series of mechanical tests.

5. Rosetta Lander Operations concept

5.1 General ground segment overview

Mission Operations of the Rosetta Lander are more complex than for a typical instrument, incorporating elements of both an instrument and a spacecraft. For this reason, the Project is planning to perform operations from a Rosetta Lander Ground Segment (RLGS) linked by reliable telecommunications to the Rosetta Project facilities (RMOC and RSOC in Darmstadt). During critical phases (delivery and 5 day relay phase) a Rosetta Lander authority and some experts will be located at RSOC.

The RLGS will conduct all Rosetta Lander operations: post-launch, cruise, near-comet, delivery and on-comet. It will provide PIs with scientific data received from Rosetta Lander.

The CNES/DLR facilities dedicated to Rosetta Lander mission and data analysis operations are known as the Rosetta Lander Ground Segment (RLGS). They are operated by the Rosetta Lander Operation Teams, and led by the Rosetta Lander Project Office which includes ground segment and operations management. All tele-command and telemetry packets will be routed between the RLGS and the lander through the RMOC/RSOC and the Orbiter. The figure 5.1-1 depicts the End-To-End information System.

The operational scientific requirements on the Rosetta Lander Operation Teams will be issued by Rosetta Lander Co-lead Scientists, which will coordinate all the PI's requirements and submit an updated science plan. The RLGS will assess it from the operations point of view.

At the RLGS, the Operation Teams will perform telemetry processing, payload and lander monitoring, some scientific Level 0 processing, quick-look processing, lander and instrument analysis and prediction, Rosetta Lander operation elaboration, navigation, telecommand processing, and data archiving and dissemination.

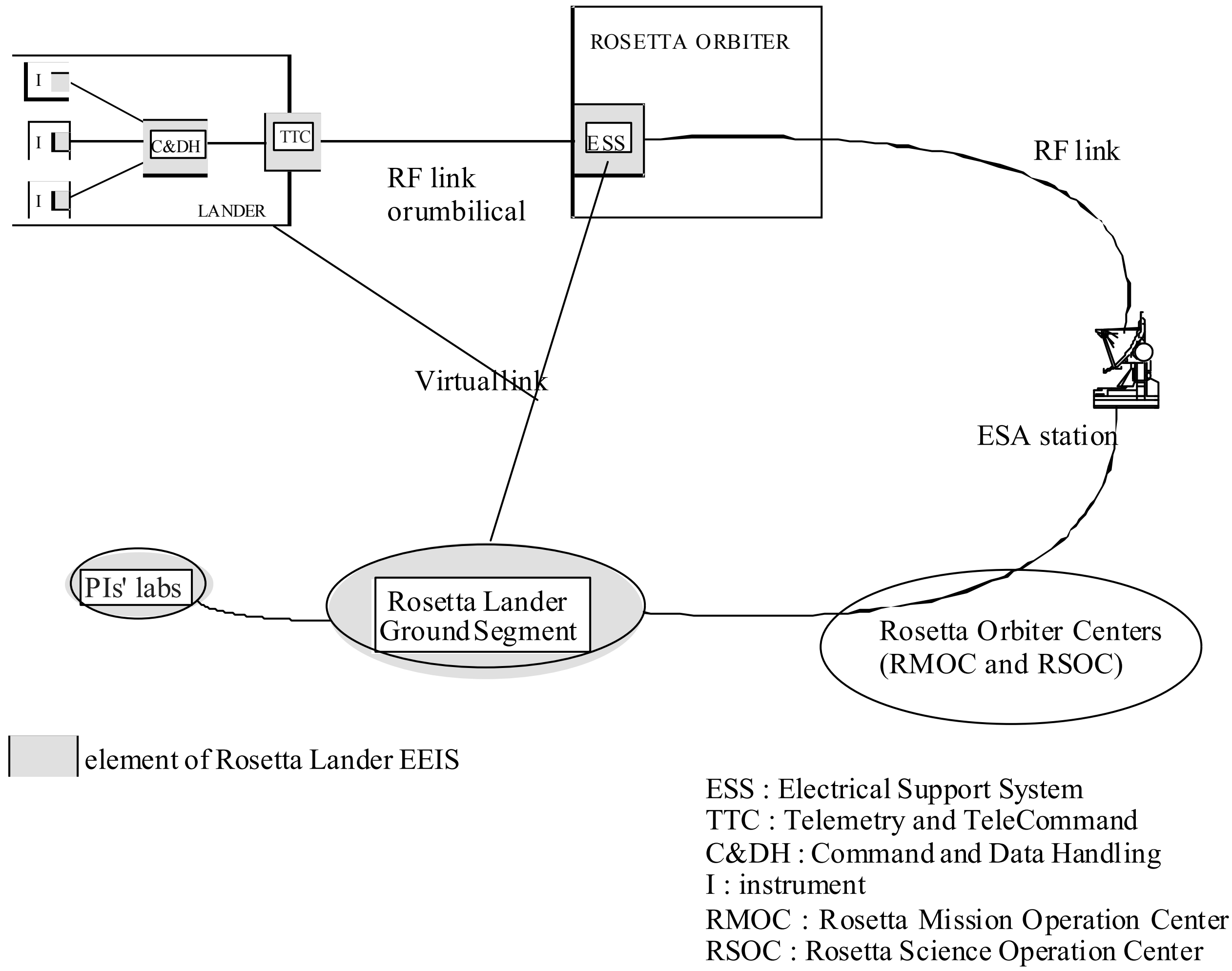

Figure 5.1-1 End-to-End Information System Components

Rosetta Mission phases and operations

The mission phases and operations are shown in the schedule 5.2-1.

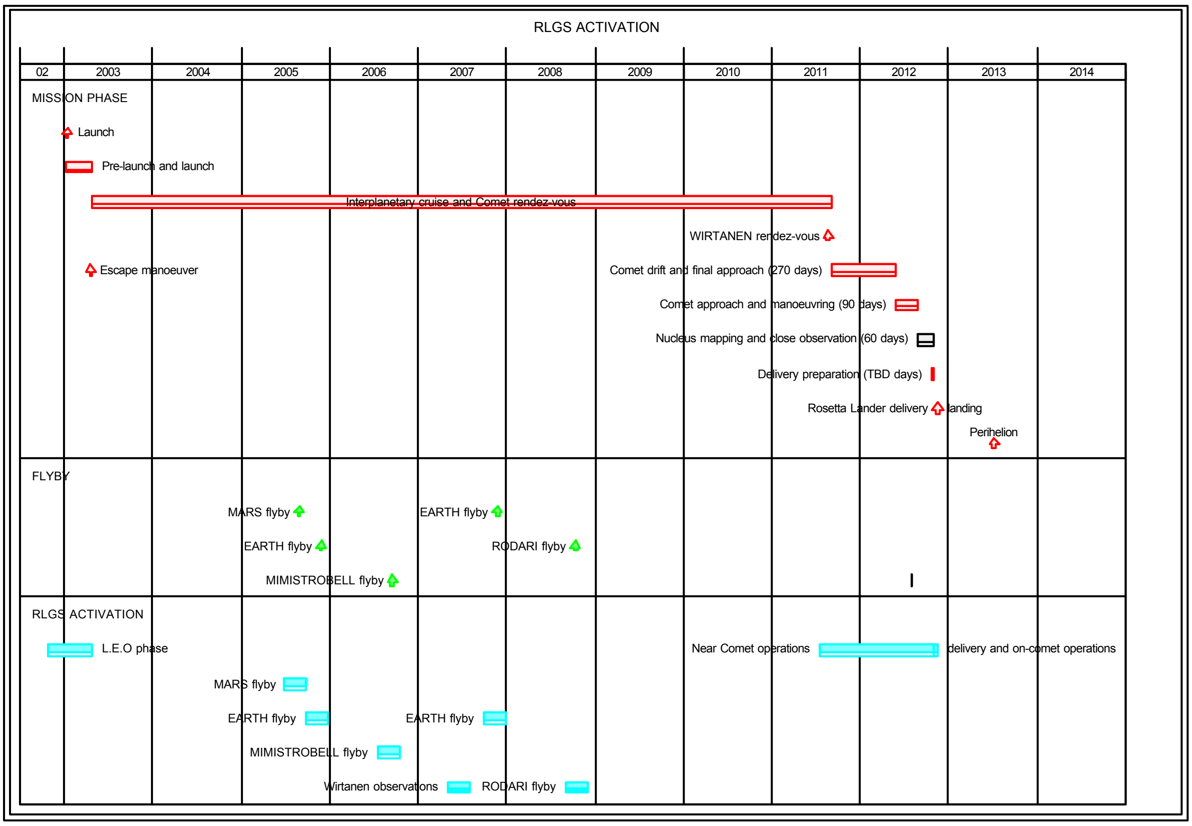

Figure 5.2-1 Rosetta Lander mission phases and operations

The RLGS is activated at each opportunity during the cruise phase (during the Rosetta Orbiter activated phases) to perform mainly experiments and plat-form check-outs.
The overall Rosetta Lander mission will be managed under CNES and DLR responsibilities.

Preliminary ground segment architecture

The preliminary architecture of the Rosetta Lander ground segment has been defined taking into account the preliminary requirements, the constraints (including the sharing between CNES and DLR).

The chosen architecture is shown in Figure 5.3-1 below; all mission operations dedicated to the Rosetta Lander lander are managed, coordinated, and for the most part, performed from the RLGS which includes two main centers :

- a Lander Control Center (LCC), in DLR/MUSC Cologne,

- a Science Operations and Navigation Center (SONC), in CNES Toulouse.

They are operated by two teams, led by the Ground Segment and Operations Manager within the Rosetta Lander Project office.

The LCC is in charge of

- monitoring and controlling the lander platform in order to be sure to support the scientific operations,
- integrating the scientific operation plan in a lander command set to be sent, after validation, to the lander via the ESA centers,
- archiving and disseminating to the PIs all the Rosetta Lander scientific telemetry and auxiliary data necessary.
- participation in the final validation of the ROSETTA Lander operation plan with SONC and implementing the Lander operations plan with respect to RMOC/RSOC
- specific support to german PI's

The SONC is in charge of :

- monitoring scientific experiments, generation and validation of the scientific operation plan to be sent, participation of the ROSETTA Lander operation plan with LCCsending to the LCC the scientific
  operations plan, after validation,
- performing all the navigation studies necessary to define separation/descent/landing strategies,
- archiving and disseminating to the PIs all Rosetta Lander scientific telemetry and auxiliary data necessary.
- specific support to french PI's

These both centers are operated by two teams, led by the Ground Segment and Operations Manager within the Rosetta Lander Project office. During any Lander operation the LCC is the responsible center for the technical health of the Lander. The SONC will lead the scientific operation planning during pre-delivery and 5 day relay phase, while the LCC will lead the scientific operation planning during the cruise and extended mission phases.

In addition to these both centers, facilities will be supplied by the Rosetta Lander Project to enable the Rosetta Lander authority and some experts, while stationed at the RSOC during critical periods of the mission, to strategically orient and follow the RLGS operations thanks to communications and discussion with the operation teams. Other facilities may also be installed at PIs'laboratories.

The RLGS will guarantee the keeping of the mission/scientific/engineering expertise and knowledge throughout the long cruise phase.

Finally, as an option, it is planned to evaluate the cost, feasibility and interest to duplicate parts of the two centers.

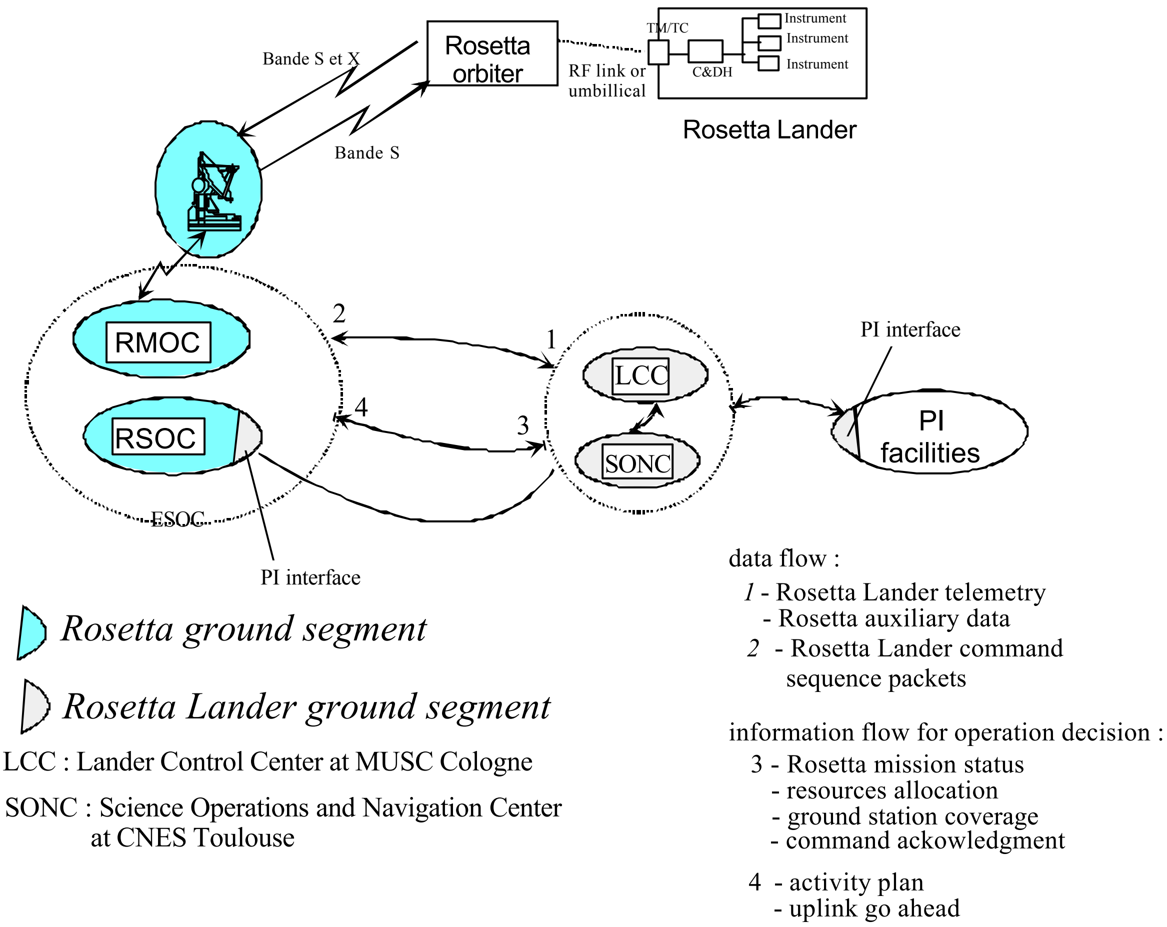

Figure 5.3-1 Preliminary RLGS Architecture.

Development and operation philosophy

Not all the functions are necessary for the different mission phases. For example, the navigation function will be operational only during near-comet operation phase. The development philosophy adopted for the Rosetta Lander ground segment is to have several ground segment updates, or new development if needed, according to the mission phase functional requirements.

– It is planned, for the moment, to have the following ground segment versions :

– for flight AIT: includes part of telemetry and telecommand functions necessary for AIT,

– for launch and commissioning: includes telemetry, telecommand processing and preliminary navigation tools,

– for flybys and Wirtanen earth observation : the previous ones plus updates of the mission navigation,

– for near comet operations: the previous ones plus operational navigation tools, scientific operation tools, quicklook function, specific data archiving and dissemination system.

6. Work Breakdown Structure

The institutes contributing to the Rosetta Lander project are compiled in table 6.1 with full institute's name and short name as used in the work breakdown structure (WBS). The responsibility of these institutions on work package level is given in the WBS shown in figure 6.2.a to 6.2.c. For some work packages two or more institutes are collaborating. In this case, the institute named first is responsible for the respective work package.

Institutes providing Rosetta Lander system contributions	**short name in WBS**
Deutsche Forschungsanstalt für Luft- und Raumfahrt, Köln, Braunschweig	DLR
Max-Planck-Institute für Aeronomie, Lindau	MPAe
Max-Planck-Institute für Extraterrestrische Physik, Garching	MPE
Centre National d'Etudes Spatiales, Paris,Toulouse	CNES
Agenzia Spatiale Italiana, Roma, Matera	ASI
KFKI Research Institute for Particle and Nuclear Physics, Budapest	KFKI
Budapesti Muszaki Egyetem (Technical University Budapest)	BME
Institut d'Astrophysique Spatiale, Orsay	IAS
Irish Space Technology Institute	STIL
Finnish Metereological Institute, Helsinki	FMI
Rutherford Appleton Laboratory, Chilton	RAL
Institut für Weltraumforschung, Graz	IWF
Institutes providing Rosetta Lander Instruments	**short name in WBS**
Max-Planck-Institute für Chemie, Mainz	MPC
Max-Planck-Institute für Aeronomie, Lindau	MPAe
Institut d'Astrophysique Spatiale, Orsay	IAS
Open University, Milton Keynes	OU
Deutsche Forschungsanstalt für Luft- und Raumfahrt, Köln, Berlin	DLR
KFKI Research Institute for Particle and Nuclear Physics, Budapest	KFKI-A
Universität Münster	Uni. Münster
Polytechnico Milano	PolyMilano*
Max-Planck-Institute für Extraterrestrische Physik, Berlin	MPE
Centre d'Etude des Phenomenes, Aleatoires et Geophysiques, St. Martin d'Heres/Service d'Aeronomie du CNES, Verrieres-le-Buisson	CEPHAG/SA

Table 6.1 Institutions cooperating in the Rosetta Lander Project
* SD2, (PI from Polytechnico Milano) is mentioned as ASI-contribution in the WBS

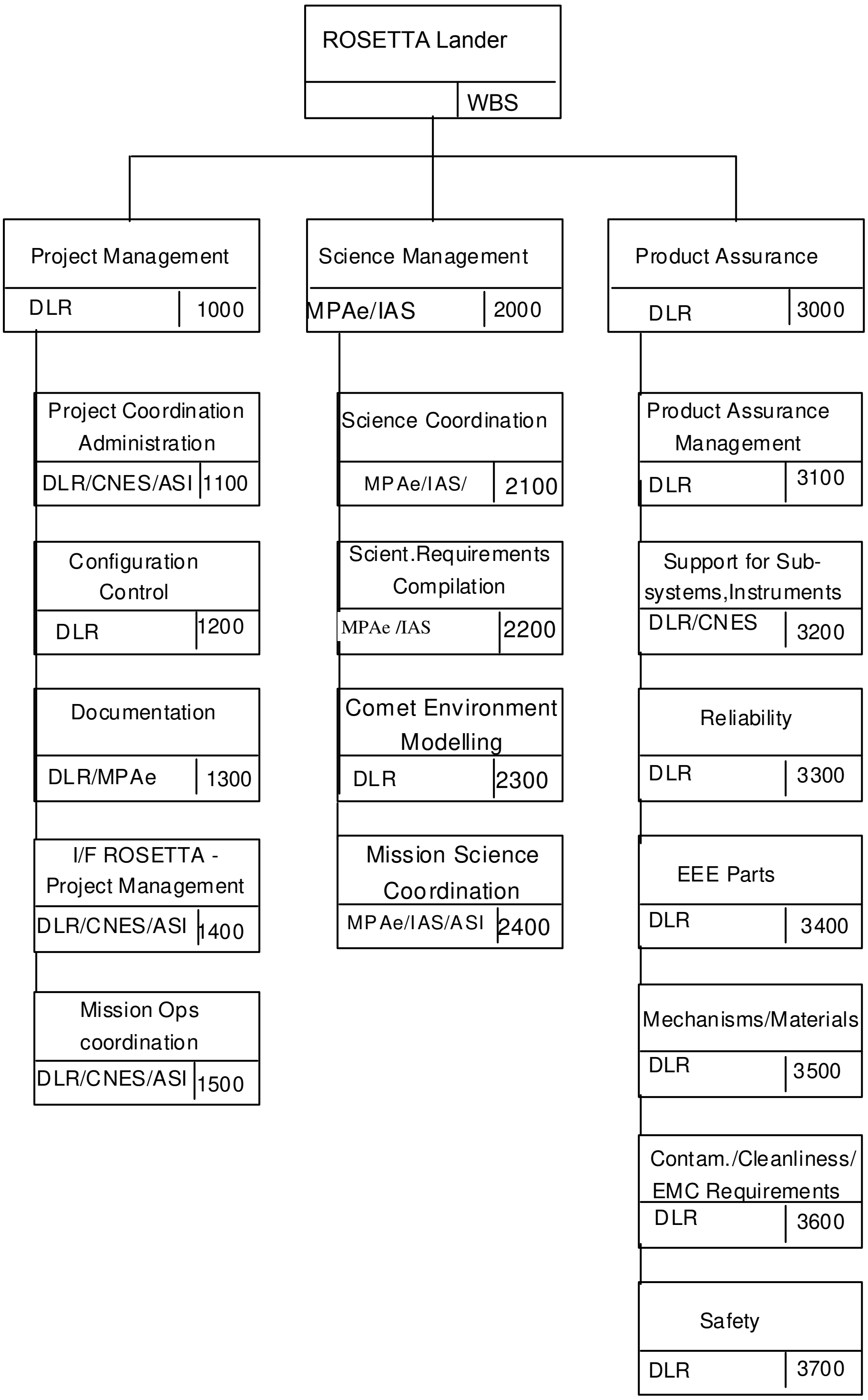

Figure 6.2.a Rosetta Lander Work Breakdown Structure (part 1)

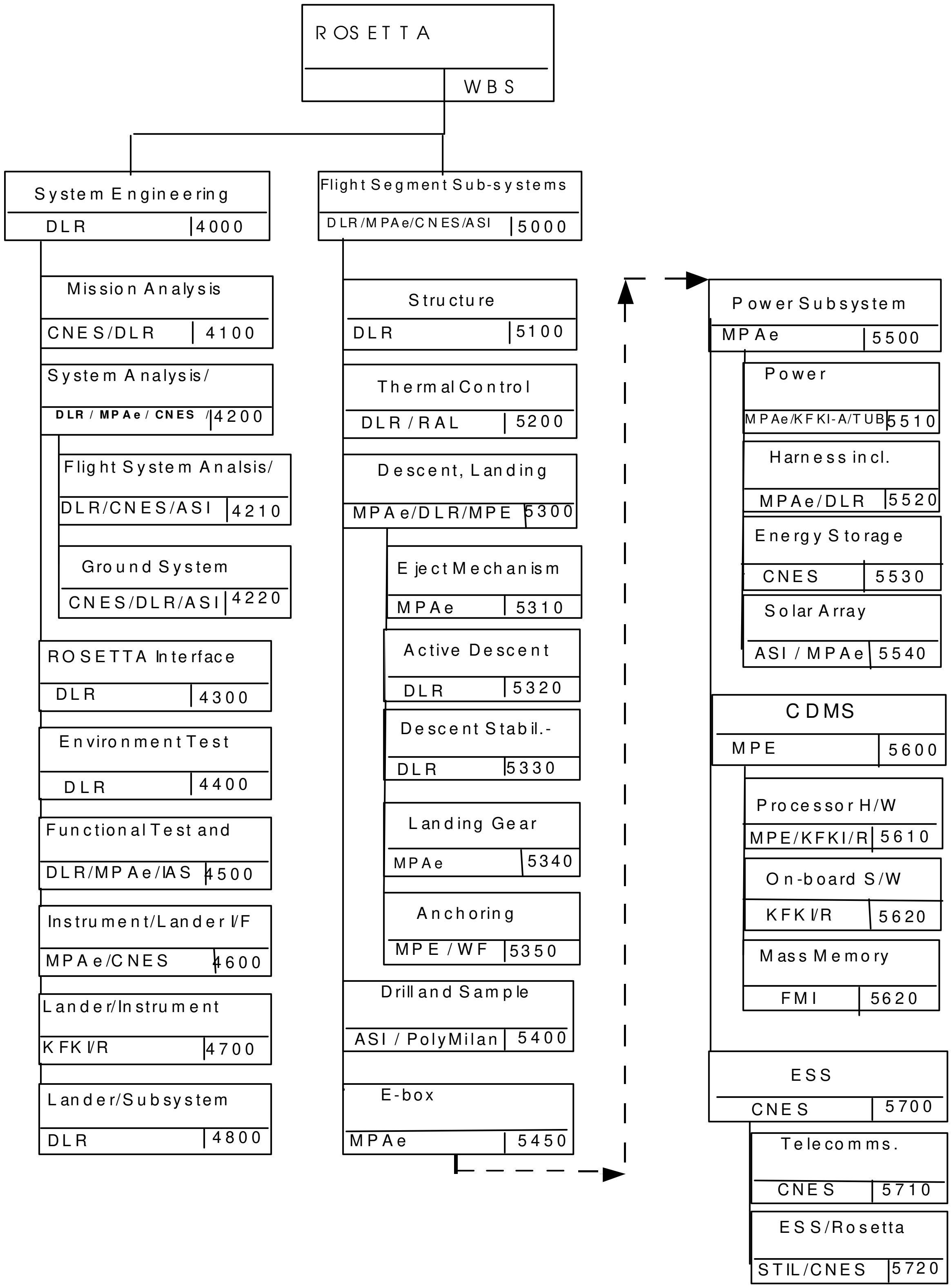

Figure 6.2.b Rosetta Lander Work Breakdown Structure (part 2)

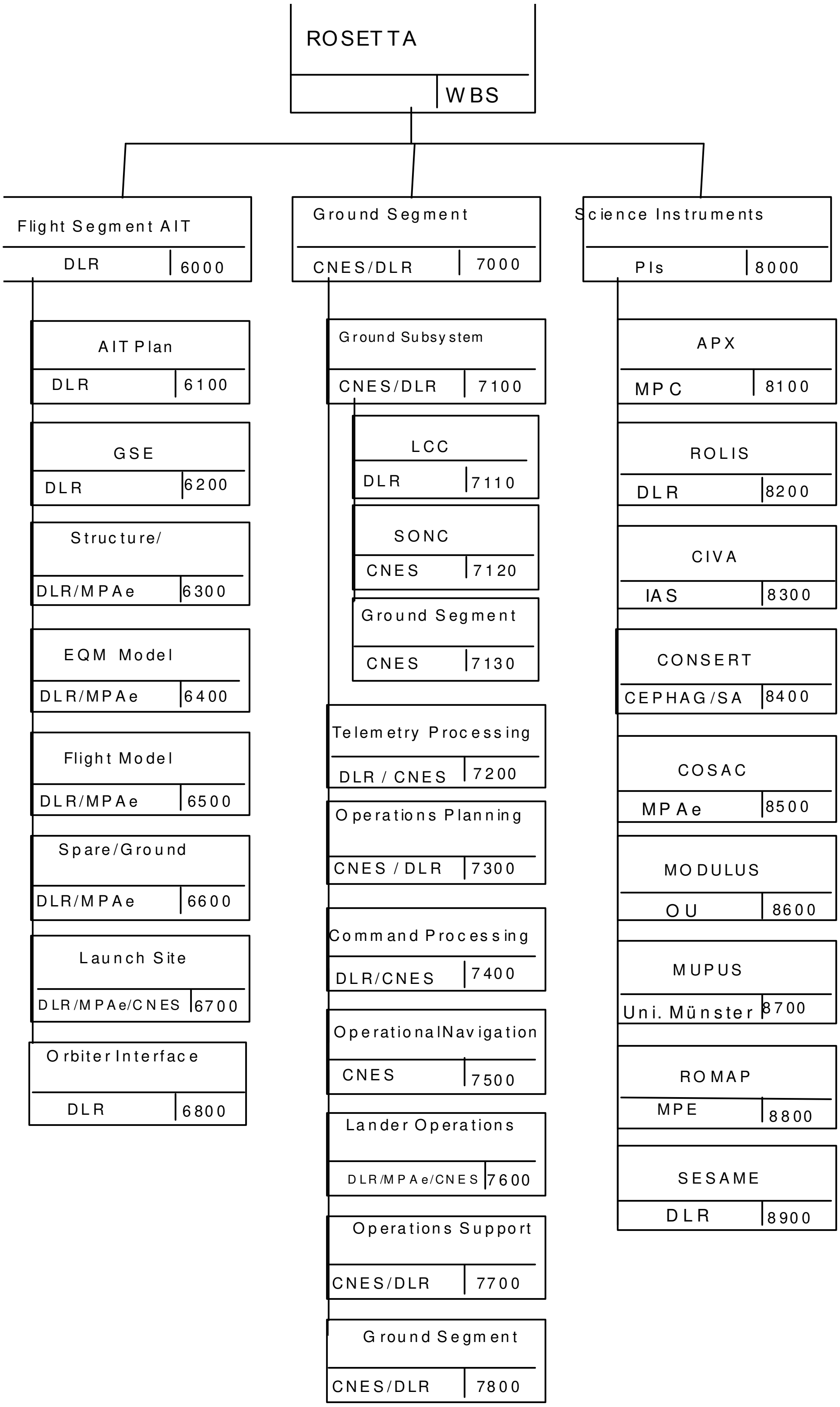

Figure 6.2.c Rosetta Lander Work Breakdown Structure (part 3)

Descriptions for work packages on the level X100 and XX10 are given in Annex 1.

7. Project Schedules

Schedule

The schedules for the major milestones and activities of the ROSETTA Lander is given in Figure 7.1. The milestones reflect the ROSETTA Project requirements for the delivery of the different Lander models as outlined in the ROSETTA Interface Document Part A - DRAFT 2 (RO-EST-RS-3002/EID A) chapter 7.4 .

A detailed model design, manufacturing, integration and test and verification schedule is contained in the Rosetta Lander master schedule (RL-PL-DLR-97001). The Project Management will update the master schedule according to the project evolution. Necessary changes or updates will be guided by the model delivery milestones as given, respecting the sensitivity of the overall ROSETTA project to late delivery due to the fixed launch date. A ROSETTA Lander Critical Path Analysis is also contained in the Rosetta master schedule and will be updated as a living document and project management tool until Launch.

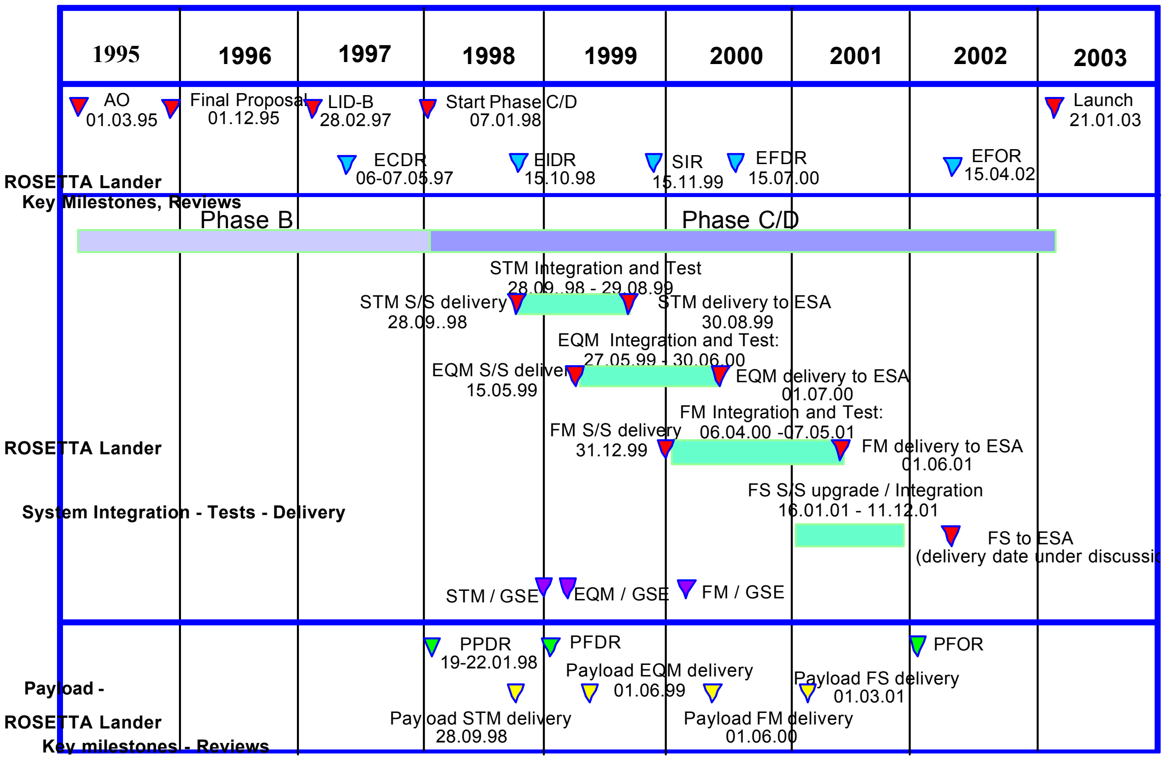

Figure 7.1 ROSETTA Lander Schedule of major milestones and activities

Rosetta Lander

Cometary Lander of the Rosetta-Mission

Preliminary Project Plan

01/16/01

Annex 1: Workpackage Descriptions

Prepared by: **<u>ROSETTA Lander Project Office</u>**

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Dave Hall - BNSC
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S. McKenna-Lawlor - STIL
Werner Klinkmann - DLR-Bonn

....
Karoly Szegö - KFKI
Chairman of Steering Committee

Annex 1: Workpackage Descriptions

Rosetta Lander

Cometary Lander of the Rosetta-Mission

Preliminary Project Plan

01/16/01

Annex 2: Cost and Funding Plan

Authorised by :

....	....
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....	....
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A2.1 Cost Estimation and Funding Concept

The Rosetta Lander will be built by an international cooperative team without exchange of funds between the involved institutes. This cost and funding plan covers the German costs for developing, building and operating the Rosetta Lander system. Costs to launch as well as costs to completion have been covered.

The cost figures for the workpackages have been updated after phase B with respect to the Preliminary Project Plan from July 1997. . By summing up the costs for the work packages assigned to an institute the total Rosetta Lander Project cost figures for the individual institutes have been generated.

In the funding plan, both the financial support from DLR and from the instutes' resources has been specified. Funding, originally planned to come from the German Space Agency DARA will be covered by BEO/Sockel ressources.

The Project plan does not include any project reserve.

The Rosetta Lander subsystems provided by institutions outside Germany are contributions in kind, funded by the international partners.

A2.2 Cost Breakdown

The cost figures for the Rosetta Lander work packages are compiled in the tables A2.2-2 and A2.2-WP1100 to A2.2-WP7600.

Personnel costs are based on 1997 cost figures. For DLR personnel the annual cost figures for categories within the participating institutes are given in table A2-1 below.

	Category 1 (Scientific Personnel) in TDM/PY	**Category 2** (Engineering staff) in TDM/PY	**Category 3** (Secretaries) in TDM/PY	**Category 4** (Workshop Personnel) in TDM/PY
WB-RS	*207*	*172*	*114*	*144*
HA-QS	*201*	*167*	*111*	*136*
WB-SM	*188*	*157*	*104*	*128*

Table A2-1: Categories of annual personnel costs within the participating DLR institutes

For the involved Max Planck institutes average annual personnel costs of around 90 to 110 TDM have been used, depending on personell category. All personnel costs are escalated by 1,5 % per year.

Investments as specified are required for the participating institutes, costs for consumables are required for materials, communication costs, travel etc.. Costs for industry contracts are allocated to the institutes taking the responsibility for the respective workpackages needing industrial contributions.

Summary table A2.2-3 gives a cost overview on X000 workpackage level, table A2.2-2 contains summary cost figures for the participating institutes.

A2.3 Funding Plan

Tables A2.3-1 to A2.3-5 indicate the funding concept for the Rosetta Lander contributions of the participating individual German institutes.

Figures concerning funding of the international partners by their respective agencies are not subject of this funding plan and thus not included in the tables.

Tables A2.3-6 to A2.3-8 show a summarizing funding charts for instute's contributions, DARA contributions and total German contributions to the Rosetta Lander project.

Table A2.3-1: Funding DLR WB-RS

Table A2.3-2: Funding DLR WB-SM

Table A2.3-3: Funding MPAe

Table A2.3-4: Funding MPE

Table A2.3-5: Funding DLR WT-QS

Table A2.3-6: Funding summary (institute's contributions)

Table A2.3-7: Funding summary (DARA/BEO/Sockel contributions)

Table A2.3-8: Funding summary (total funding)

Rosetta Lander

Cometary Lander of the Rosetta-Mission

Preliminary Project Plan

14.04.1997

Annex 3: List of Acronyms and Glossary

List of Acronyms and Glossary

AIV:	Assembly, Integration and Verification
Ariane 5:	ESA launch vehicle
ASA:	Austrian Space Agency
ASI:	Agenzia Spaziale Italiana
AU:	Astronomical Unit ($150*10^6$ km)
BME	Budapesti Muszaki Egyetem
CDMS:	Command and Data Management System
CDR:	Critical Design Review
CEPHAG/SA:	Centre d'Etude des Phenomenes, Aleatoires et Geophysiques d'Heres/Service d'Aeronomie du CNES
CESR:	Centre d'Etude Spatiale des Rayonnements
CNES:	Centre Nationale d´Études Spatiales (French Space Agency)
DARA:	Deutsche Agentur für Raumfahrtangelegenheiten (German Space Agency)
DLR:	Deutsche Forschungsanstalt für Luft- und Raumfahrt e.V.
DLR WB-RS:	DLR Institute of Space Simulation
DLR WB-SM:	DLR Institute for Structural Mechanics
EGSE:	Electrical Ground Support Equipment
EID:	Experiment Interface Document
EMC:	Electromagnetic Compatibility
ESA:	European Space Agency
ESOC:	European Space Operations Centre
FAR:	Flight Acceptance Review
FM:	Flight Model
FMI:	Finnish Meteorological Institute
FTP:	File Transfer Protocol
Giotto:	ESA Fly-By mission to Halley's Comet (1985/86)
GSE:	Ground Support Equipment
IAS	Institute d'Astrophysique Spatiale
ICD:	Interface Control Document
IWF:	Institut für Weltraumforschung, Graz
KFKI:	Hungarian Institutes: Research Institute for Atomic Energy (KFKI-AEKI) and Research Institute for Particle and Nuclear Physics (KFKI-RMKI)
KFKI-A:	Research Institute for Atomic Energy
KFKI-R:	Research Institute for Particle and Nuclear Physics
LCC:	Lander Control Center (DLR-MUSC)
LID:	Lander Interface Document
MGSE:	Mechanical Ground Support Equipment
MPAe:	Max Planck Institute for Aeronomy
MPE:	Max Planck Institute for Extraterrestrial Physics
MPG:	Max Planck Gesellschaft
MUSC:	Microgravity User Support Centre
OU:	Open University

PDR:	Preliminary Design Review
PFM:	Proto Flight Model
PI:	Principal Investigator
QA:	Quality Assurance
QM:	Qualification Model
RAL:	Rutherford Appleton Laboratory
RMOC	Rosetta Mission Operations Center
Rosetta Lander:	European Lander for Rosetta mission
Rosetta:	ESA comet rendezvous mission
RSOC:	Rosetta Science Operations Centre
S/C:	Spacecraft
SDR:	System Design Review
SONC:	Science Operations and Navigation Center (CNES-Toulouse)
SRD:	Scientific Requirements Document
SSP:	Surface Science Package (lander for Rosetta mission)
STIL:	Irish Space Technology Institute
STM:	Structural/Thermal Model
SWG:	Rosetta Lander Science Working Group
VEGA:	Soviet Fly-By mission to Halley's Comet (1984-86)
VPP:	Verification Program Plan