# PROBA 3

# SCIENCE MANAGEMENT PLAN

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date of issue/*date d'édition* 24 June 2009

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| PROBA 3<br>Mission Summary | | |
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| **Mission Objectives** | **Demonstration** | Develop and demonstrate in-orbit techniques and technologies for satellite formation flying for model user missions |
| | **Scientific** | Observations of the solar corona using a giant coronagraph of 150 meters length to characterise dynamic processes in the inner corona |
| **Payload** | **Demonstration** | FDIR, management and GNC software, relative navigation sensors (metrology) in RF and optical domain, Formation Flying (FF) propulsion, FF manoeuvres and precision FF |
| | **Scientific** | solar coronagraph, mass: 35kg, power: 35W, telemetry: 8 Gb/day. |
| **Mission Profile** | | Orbit: HEO, 800 x 72,000 km, 24 h period, inclination 50°, Argument of Perigee 180°<br>Lifetime: 2 years |
| **Spacecraft** | | Two spacecraft: Coronagraph and Occulter<br>Stack of 600 kg |
| **Orientation** | | Sun-pointing |
| **TM band** | | S |
| **Data volume** | | 8 Gbit/day |
| **Launch vehicle** | | Launch on PSLV (industrial proposal) |
| **Launch date** | | Fall 2013 |
| **Nominal Mission duration** | | 2 yr |
| **Ground TM station** | | Redu (ESA) + ESTRACK ground station |
| **Programmatic** | | Funded by General Studies Technology Programme |

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# 1 SUMMARY AND SCOPE

PROBA 3 is a mission to demonstrate new technologies from the ESA Directorate of Technical and Quality Management at ESTEC. It is the 3rd mission of the PROBA (Project for Onboard Autonomy) line.

PROBA 3 is an experimental mission devoted to the in-orbit demonstration of formation flying techniques and technologies. The high level objectives of the PROBA 3 project are:
• The development to technology readiness level (TRL) 9, in-orbit demonstration, of the formation flying techniques and associated technologies,
• The development and validation of the engineering approach, ground verification tools and facilities required by formation flying.
• The observation of the Sun corona as part of the demonstration of formation flying

The mission will be implemented with a set of 2 small spacecraft. One spacecraft will carry the main optical bench and associated detectors, electronics, etc., while the second spacecraft will carry the occulter. The two spacecraft will be launched by the Polar Satellite Launch Vehicle (Indian Space Research Organization; India). The launch date is Fall 2013.

The PROBA 3 Science Management Plan (SMP) describes the implementation of those aspects of the project, up to and including the post operational phase, that are required to ensure the fulfillment of the mission's scientific objectives, and to optimize its scientific return, with special emphasis on payload procurement, science operations and data management.

The SMP first summarizes the main aspects of the mission, followed by a description of how the scientific community will be associated with the mission, focusing in particular on the selection of the instruments that will constitute the PROBA 3 scientific payload. The plan outlines the role of the science advisory structure, and the ESA science management tasks from instrument selection to data distribution and archiving. The SMP also addresses the duties and rights of the PROBA 3 investigators, as well as their interaction with the PROBA 3 Science Working Team.

# 2 MISSION OVERVIEW

## *2.1 Introduction*

Formation Flying has been identified as a key operational technique to enable future high performance missions with relatively small, affordable satellites. It implies new technologies and techniques, multiple interactions between space and ground segment and between the participating spacecraft. It cannot be simulated on ground with the appropriate level of fidelity. In orbit demonstration is the natural final step of developing technologies and techniques as well as validating design and development tools and verification facilities to the appropriate level.

Mission requirements for PROBA 3 are to demonstrate technologies and techniques required by future Formation Flying missions (scientific, earth observation …) capitalising on the on going technology developments. This has to be performed with a set of 2 small satellites flying on an elliptical orbit. The mission is also designed to fly a coronagraph instrument benefiting from and demonstrating the Formation Flying performances.

The PROBA 3 mission was proposed to IPC in 2005 (ESA/IPC(2005)76 rev. 1). Two parallel industrial Phase A studies were initiated under GSP in 2006 together with technology developments as part of GSTP (ESA/IPC(2006)76 and add.), followed by a bridging phase. This last phase was inserted in the project phases to allow the Prime and the industrial consortium planned for the implementation phase to take over and consolidate the results from phase A. The GSTP-4 Specific Area Work Plan and Procurement Plan for PROBA 3 has been approved by Industrial Policy Committee (IPC) (ESA/IPC(2008)76).

## *2.2 Mission Objectives*

PROBA 3 is an experimental mission devoted to the in-orbit demonstration of new techniques and technology, namely formation flying.

The objectives of the PROBA 3 project are:

• The development to technology readiness level (TRL) 9, in-orbit demonstration, of the formation flying techniques and associated technologies, this in turn implies

• The development and validation of the ground verification tools and facilities

• The implementation of a guest mission devoted to the observation of the sun-corona as part of the demonstration of Formation Flying (FF).

Requirements have been established in a Mission Requirements Document and a System Requirements Document.

The mission requirements are of two types:

• Requirements related to the demonstration of the FF technique and the associated technology. These were established by D/TEC based on future missions needs and reviewed in the frame of the IA of the IPREV and the TEB process, mainly by D/SRE.

• Requirements related to the mission's scientific objective to observe the solar corona.

## *2.3 Scientific Objectives*

Although solar physics missions have probed the corona in several temperatures and heights, the region within 3 solar radii where the solar wind and Coronal Mass Ejections (CME) are born remains extremely difficult to observe with sufficient spatial resolution and sensitivity to understand these phenomena. Progress on this front requires eclipse-like conditions for long periods of time and these are precisely offered by the PROBA-3 coronagraph. This mission is focused on the following objectives that can be addressed by answering a set of science questions.

- Understanding the physical processes that govern the solar corona by answering:

  - What is the fine scale nature of the solar corona?
  - What processes contribute to the heating of the corona and what is the role of waves?
  - How and where does the solar wind originate?
  - What processes contribute to the acceleration of the slow and fast solar winds?

- Understanding the physical processes that lead to coronal mass ejections (CMEs) and space weather by answering:

- What is the nature of the structures that form the CME?
- What is the connection between CMEs and dynamic processes on the solar surface?
- How do CMEs erupt and accelerate in the low corona?
- Where and how can a CME drive a shock in the low corona?

## *2.4 Mission Description*

The baseline mission is planned to start in fall 2013 with the PSLV launch. After an early orbit phase, the two spacecraft will be put into a highly eccentric orbit of 800 x 72000 km with a 50 deg. inclination and 180 deg. of argument of perigee. The inclination was chosen in an attempt to reduce the total dose of radiation experienced by the spacecraft and therefore offer more attractive operating environments and reducing the shielding mass required by sensitive components. The orbital period will be 24 h. The commissioning phase will last 3 months. After that time the science operations will start during 12 h/orbit (TBC) around apogee.

## *2.5 Payload Consortium Confirmation Process*

ESA will issue an Announcement of Opportunity (AO) to the Scientific Community for the PROBA 3 coronagraph that will be based on the reference payload (PRDD). The AO will call for provision of the coronagraph from individual scientists or science consortia willing to participate.

The proposals for the instrument shall be compatible with the scientific and technical objectives of the PROBA 3 mission and with its design and operational capabilities as defined in the Mission Requirement Document (MRD). Each proposal for the instrument must identify a single Principal Investigator (PI) heading the instrument consortium and carrying final responsibility for all aspects of the provision of the instrument. It follows that the PI must be fully backed by the national funding agency of her/his country. In some countries, various organisations or institutions may provide resources.

It must be stressed that an instrument proposal submitted by a PI will only be selected if accompanied by a Letter Of Endorsements (LOE) providing for financial support for the Definition Phase, accompanied by a time-line showing milestones leading to full commitment, from the relevant national funding agency, representing all institutes participating in the proposal. Responses will clearly need to spell out the character and level of participation together with the nature of the management structure and financial commitments within each instrument consortium.

The ESA AO is open to the Members States of ESA and to other scientific communities with which reciprocity or specific agreements exist.

It is anticipated that an Announcement of Opportunity for participation of a number of Guest Investigators will be issued after launch.

## *2.6 Modes of Participation*

The possible modes of participation to the PROBA 3 programme are:

(1) Principal Investigator (PI), heading an instrument consortium providing an instrument (see section 3.2.1);

(2) Co-Principal Investigator (Co-PI) may be appointed if a major development is carried out in a country/institution different from the one of the PI; A Co-PI will have similar rights as a PI, but the PI will remain the formal interface to the Project Office (see section 3.2.2);

(3) Co-Investigator (Co-I), a member of an instrument consortium providing an instrument (see section 3.2.3);

(4) Guest Investigator (GI), by participating in the data collection and analysis of one or more instruments (see sections 3.2.4).

### 2.6.1 Principal Investigator

The PI, in coordination with the Funding Agency will have the following responsibilities:

*(1) Management*

(i) Establish an efficient and effective managerial scheme, which will be used for all aspects and through all phases of her/his instrument programme.
(ii) Organise the efforts, assign tasks and guide other members of the instrument consortium.
(iii) Ensure that plans are established, implemented and analysed such that the status reporting complies with the requirements of the ESA Project Office.
(iv) Provide the sole formal managerial and technical interface of the instrument to the industrial prime via the ESA Project Office.
(v) Support ESA management requirements (e.g. investigation progress reviews, programme reviews, change procedures, product assurance, etc.).
(vi) Where applicable, be responsible for ensuring compliance with all International Traffic in Arms Regulations (ITAR) regulations in a timely manner. Surveillance requirements arising from ITAR regulations shall be reported to ESA and any costs associated with such requirements shall be borne by the PI.

*(2) Science*

(i) Monitor the compliance of the instrument design to the mission requirements outlined in the System Requirement Document (SRD).
(ii) Attend meetings of the Science Working Team and Groups, as appropriate; report on instrument development, and take a full and active part in their work.
(iii) Provide the formal scientific interface of the instrument consortium with the ESA Project Office.
(iv) Ensure adequate calibration of all parts of the instrument, both on the ground and in space. This includes the provision of a full instrument technical and science user manual for use by the general science user community.
(v) Participate in the definition of the science operations and data handling.
(vi) Define the Science Operation Centre (where applicable in coordination with the ESA Liaison Scientist(s)).
(vii) Exploit the scientific results of the mission and assure their diffusion as widely as possible.
(viii) Provide the scientific data (raw data, calibrated data, and higher level data), including relevant calibration software and/or products, to the PROBA 3 archive (in a format that will be agreed with ESA for application by the general science community) upon delivery to, and verification by, the PI team.

*(3) Hardware*

(i) Define the functional requirements of the instrument and auxiliary test equipment (e.g. MGSE, EGSE, CGSE, etc.)
(ii) Ensure the development, construction, testing and delivery of the instrument. This shall be performed in accordance with the technical and programmatic requirements outlined in the AO including its annexes such as the SRD, and subsequently reflected in the PI response interface document
(iii) Ensure that the instrument is to a standard that is appropriate to the objectives and lifetime of the mission, and to the environmental and interface constraints under which it must operate.

(iv) Deliver adequate verification models (EQM's, STM's, etc.) of the instrument to the prime contractor, as required to verify system interfaces. The envelope of this delivery is in accordance with technical programme needs. The model philosophy will be refined with the instrument provider in view of the criticality of the developments and interfaces. The baseline is however to have one PFM of the full instrument, electrical models to be available/delivered at an early stage to validate all interfaces (electrical, command and control), mechanical model to be available/delivered at an early stage for structural and mechanical accommodation compatibility verification. In addition, thermal and mechanical mathematical models will be required.

(v) Ensure the design, development, deployment and validation of the Science Operations Centre in compliance with the overall ground segment architecture and interfaces

(vi) Participate to the test preparation and prepare the SOC for end to end testing activities involving the instrument

(vii) Deliver a Flight Model in accordance with the technical requirements defined in the PRDD, together with the relevant Ground Support Equipment.

(viii) Support the system level integration and test activities related to and involving the instrument.

(ix) The PI shall provide the necessary equipment to process their data as agreed with ESA.

(x) Ensure that all procured hardware is compliant with ESA requirements, through participation in technical working groups and control (e.g. cleanliness) boards, as requested, and that the hardware allows system level performance compatibility to be maintained.

(xi) Provide the overall documentation during the project.

*(3) Software*

(i) Ensure the development, testing and documenting of all software necessary for the control, monitoring and testing of the instrument.

(ii) Specify and then support the development, testing and documenting of all software necessary for the testing, operation and data reduction/analysis of any parts of the instrument provided under ESA responsibility.

(iii) Ensure the delivery to ESA of any instrument-specific software that is required for testing or operations and its documentation to ESA, or elsewhere, in accordance with approved ESA guidelines, procedures and schedules.

(iv) Maintain and update all PI provided instrument software and its documentation until the end of the mission.

*(4) Product Assurance*

Provide product assurance functions in accordance with PROBA 3 Product Assurance Requirements P3-EST-RS-1005 Issue 1 Rev 1.

*(5) Operations*

Provide support for preparation and implementation of the mission and science operation up to the end of the mission including delivery of a user manual and data base inputs.

*(6) Financial*

The proposing PI will select the Funding Agency for the instrument that will take the financing responsibility. The PI is expected to take full responsibility for the development and timely delivery of the instrument and its associated SOC. All proposals in response to this AO shall therefore be submitted by a PI, with full transparency to the corresponding Funding Agency, and shall include a Letter of Endorsement (LOE) from this agency.

National funding agencies representing other members in an instrument consortium (e.g. Co-PIs or Co-Is, see definition in 1.4) shall guarantee the funding of the respective Co-PI/Co-I contribution. LOE from these funding agencies shall be submitted to ESA.

*(7) Communications and Public Relations*

Support science communications and public relations activities of ESA (and where applicable, the funding agency), and provide suitable information and data in a timely manner, as outlined in the Science Communication Plan (see section 5.5.2).

### 2.6.2 Co-Principal Investigators

Although not a preferred arrangement, in some exceptional circumstances, a Co-PI may be appointed. The single point interface to the Project Office will remain the PI.

Co-PIs are responsible for their own funding which is guaranteed via their national funding agencies. A Letter of Endorsement (LOE) from this agency must be provided with the proposal.

### 2.6.3 Co-Investigators

Members of each PI-led consortium may be proposed as Co-Investigators. Each Co-I should have a well-defined role either with regard to hardware/software delivery or with regard to scientific support of the investigations within the instrument consortium. The PI-led consortium may review the status of its members regularly and implement changes if required.

Co-Is are responsible for their own funding which is guaranteed via their national funding agencies. A Letter of Endorsement (LOE) from this agency must be provided with the proposal.

### 2.6.4 Guest Investigators

Guest Investigators (GIs) are individual scientists who wish to make use of the data collected by one or more instruments. Their proposals shall be submitted to ESA. Their tasks shall be agreed with the PI, with concurrence of ESA.

Guest Investigators will be selected after launch and will be expected to participate in the activities of the Science Working Team, including science communications.

# 3 SELECTION PROCESS

The approach to be adopted for the selection, funding and development of the PROBA 3 payload aims at taking into account the limited funds available for the payload procurement, and the need to preserve an efficient procurement of a highly optimised payload to ensure maximised science return from the mission with minimum resources. It is also essential that the payload will not eventually drive the cost at completion of the mission that is currently based on the reference payload (Table 1, Annex). This requires that the payload must be solidly defined technically, financially and programmatically, in order to fit smoothly into the overall mission development schedule, and strictly within the available spacecraft resources, with minimum risk to ESA and the various instrument funding agencies.

Through the iteration of the arrangements for the payload procurement, there clearly needs to be a guardian of the payload's scientific capability. A Payload Review Committee (PRC) of independent experts will perform this essential role. The terms of reference of the PRC are defined in section 3.1.1.

ESA will issue an AO calling for the provision of the instrument from institutes and funding agencies willing to participate. This AO will call for the identification of both a Principal Investigator (PI), Vo-Is and funding Agencies. AO responses should come from the PI himself and shall include a Letter Of Endorsement (LOE) from their funding agency as well as LOE from the funding agency of their CoIs as referred to in section 2.6. The intention is that the response to the AO will not only establish the technical character and design maturity of the instrument, but also the level of involvement, together with the nature of the management structure and financial commitment.

The PRC will be asked to review and confirm the scientific acceptability of the instrument proposal. The assessment of the PRC is particularly important in the cases where a proposal does not fully cover the scientific requirements or departs significantly from the reference payload. If competing instrument proposals are submitted by different PI-teams and funding agencies, the PRC will be asked to make a recommendation on which proposal should be selected. In parallel with the work of the PRC, ESA shall undertake an internal technical, financial and management review of each proposal to establish the overall proposal integrity. The deliberations of both the PRC and ESA internal review will be submitted to the ESA Advisory Structure (SSEWG, SSAC and SPC) for approval.

The aim of the Payload Review Process is to provide all parties with a minimum risk strategy, while safeguarding the scientific integrity and oversight of the mission within an agreed mission envelope. ESA will prepare all data packages with the documentation relevant for the PRC.

The technical requirements (including SRD) will be available together with the formal issue of the AO, to ensure the timely specification of clear technical interfaces. It is essential that a solid cost and programmatic analysis can be completed between ESA, instrument consortia and funding agencies in their response to the AO, which will permit in a timely manner the relevant parties to focus on the provision of instruments.

The involvement of the funding agencies themselves in the consortia organisation and definition of the undertakings is mandatory and should lead to an in-depth analysis of the managerial and financial arrangements as well as risk aspects before submission to ESA. It should be understood that ESA will not propose to commence the implementation phase without the agreement by the SPC of the character, structure and funding commitment of the instrument consortia. The timetable of events leading to this approval is envisaged as follows:

- June 2009: Issue of the ESA AO.
- August 2009: Receipt of PI-led proposals with funding agencies Letters Of Endorsement in response to the AO.

- October-November 2009: Selection of instrument consortia.

## *3.1 Instrument Selection*

### 3.1.1 Payload Review Committee

To ensure that the scientific return of PROBA 3 is of the highest quality, an independent international Payload Review Committee (PRC) shall assess the mission in close cooperation with internal ESA technical, financial and management teams. The Executive shall appoint the Payload Review Committee members, after consultation with and agreement of the SSEWG and SSAC.

The terms of reference of the Payload Review Committee are as follows:

The PRC shall perform, after receipt of all instrument proposals in response to the AO, a review in close cooperation with ESA technical, programmatic and financial analysis teams, supported by the potential prime contractors, in order to:

- Ensure that all science objectives are satisfied within the overall AO response.
- Ensure that each instrument proposal satisfies the science requirements in terms of sensitivity and performance, as specified in the relevant documents, to achieve the specific science objectives.
- Ensure compatibility of each instrument against the optimised reference payload.
- Identify clear alternatives in case of too high a development risk and/or incompatibility with available spacecraft resources or interfaces.

The Payload Review Committee will work in close collaboration with internal ESA review teams consisting of selected personnel of the Agency and its contractors as well as invited specialists. For the instrument proposal, in financial and programmatic areas, ESA will consult extensively with funding agencies and provide, via the appropriate internal review team, the Payload Review Committee with input on the implementation feasibility and risk assessment.

The "No Conflict of Interest" rule will apply, i.e. no potential PI for the instrument can be a member of the PRC, nor be involved in the selection procedure. Proposing Co-Is may be accepted as PRC members, if strictly necessary. They will have no voting right for their own investigation and other competing investigations.

### 3.1.2 Evaluation Criteria and Selection Principles

The individual instrument proposals will be evaluated by the PRC (in close collaboration with internal ESA technical, managerial and financial review teams) on the basis of the AO and using the following preliminary criteria:

♦ Relevance of the scientific objectives and their compatibility with the technological objectives of the whole mission;
♦ Adequacy of the measurements to fulfil the stated objectives and capability of the instrument to perform the required measurements as indicated in the SRD and PDD
♦ Feasibility and heritage of the proposed technical solutions;
♦ Development status of the instrument;
♦ Availability of relevant technologies and the need for the development of new technologies. The development status of such "new" technologies should also be evaluated based on the AO response. All ITAR-related approval aspects shall be clearly identified and included in the planning.
♦ Compliance with the characteristics specified through the SRD and PDD.
♦ Availability of an instrument development plan including test and validation programme.

♦ Compatibility of the instrument with the mission environment, spacecraft resources, accommodation and mission constraints;
♦ Operational complexity;
♦ Quality of data analysis plan;
♦ Management plan and its adequacy with the instrument complexity; this specifically includes the complexity of the management interfaces within a consortium.
♦ Continuity of human and institutional resources to ensure a timely execution of instrument development, calibration and associated tasks, and to support post launch operation and data analysis. The manpower funding profiles, at the science institute level within each consortium, backed by the appropriate funding agency, should be analysed for all mission phases including science exploitation and archive.
♦ Competence and experience of the team in all relevant areas (science, technology, software development, management and outreach/science communications);
♦ Credibility of costing; This will be performed by ESA staff experienced in instrument cost analysis acting in close cooperation with the relevant funding agencies.
♦ Compliance with ESA applicable management, engineering, reporting and product assurance requirements and standards;
♦ Possible financial impact of the proposed instrument upon ESA;
♦ Commitment of all the national funding agencies to provide the correct level of support to member institutes within the consortium .

The composition of the overall payload carried by PROBA 3 will take into account the following criteria:

- Evaluation of individual instrument proposals (see above);
- Potential scientific achievement within the global mission objective;
- Compatibility with the reference payload.
- Compatibility with system resources, mission and programme constraints, and financial envelope imposed by national agencies.

The PRC in close cooperation with the ESA review teams will recommend a PROBA 3 coronograph which must fulfil the science requirements for the mission and be fully compatible with the allocated spacecraft resources. The recommendation will be subject to endorsement by the Solar System Exploration Working Group (SSEWG) and Space Science Advisory Committee (SSAC), and finally submitted to the Science Programme Committee (SPC) for approval.

## *3.2 Selection of Guest Investigators*

The selection criteria for Guest Investigators (GIs) will be established later, at the discretion of the instrument teams, in consultation with the SWT (see 2.7.4 and 4.2). The formal appointment will be made by SPC upon recommendation by SSEWG and SSAC.

# 4 SCIENCE AND ESA PROJECT MANAGEMENT

## *4.1 The Project Scientist*

ESA nominates the PROBA 3 Project Scientist (PS). The PS is located at ESTEC within ESA's Research and Scientific Support Department (SRE-SM) and is the Agency's interface with the Principal Investigator for scientific matters. The PS will chair the Science Working Team (SWT) and coordinate its activities.

During all phases of the mission, i.e. implementation phase until the end of the exploitation phase, the PROBA 3 Project Scientist will be responsible for all scientific issues within the Project. During the development phase, the PS will advise the ESA Project Manager on technical matters affecting scientific performance. The PS will monitor the state of implementation and readiness of the instrument operations and data processing infrastructure. A small team will support the PS in the above-mentioned tasks. The Science Operations Department and Science Operations Development Division located at ESAC (SRE-O) will provide support on science operations and archiving.
The PS will coordinate the creation of the scientific products, their archiving and distribution to the scientific community.

## *4.2 Science Working Team*

The executive membership of the PROBA 3 Science Working Team will consist of the Principal Investigator and the Project Scientist. Co-Investigators, Guest Investigators, and other interested scientists will be invited to participate in SWT meetings. The PROBA 3 Project Scientist will chair the SWT.

The SWT will monitor and advise ESA on all aspects of the PROBA 3 mission that will affect its scientific performance. It will assist the PS in maximizing the overall scientific return of the mission within the established boundary conditions. It will act as a focus for the interests of the scientific community in PROBA 3.

## *4.3 The Project Office*

ESA will establish a PROBA 3 Project Office at ESTEC, headed by a Project Manager, which will fulfill its function until the completion of the spacecraft initial commissioning phases. ESA, via the Project Manager and later by the Mission Manager, will retain overall responsibility for the mission through all phases.

The Project Office will be responsible for the mission design and implementation.

Within the executive mandate of the project and with regards to the PROBA 3 Investigator teams, the Project Office will be responsible for:

- The procurement of PROBA 3 (including the payload)
- The launch preparation and procurement.
- The commissioning of the system in the early transfer phase.

The ESA Project Manager will periodically call Project Reviews, which will include all aspects of the mission including the development status of the PROBA 3. In particular the PROBA 3 Team will have to show compliance with schedule, resources, interfaces, safety and any other relevant aspect of the PROBA 3 implementation.

Following completion of the in-flight commissioning, the Mission Manager will assume responsibility for management of the PROBA 3 project: organisation and overall management of teams and staff assigned to the PROBA 3 project, of the science operations team and the mission operations teams.

Specifically this will include the overall responsibility for:

- Insertion of the PROBA 3 into its initial science orbit
- Science operations
- Archiving of PROBA 3 data products.

The Mission Manager will be supported by the PROBA 3 Project with respect to spacecraft system engineering issues.

### *4.4 Monitoring of Instrument Development*

The ESA Project Office will monitor the progress of the design, development and verification of the PROBA 3 coronagraph. The instrument consortia will have to demonstrate to ESA (and where applicable, the funding agency), in regular reports and during formal reviews, compliance with the scientific mission goals, the spacecraft system constraints, the spacecraft interfaces and the programme schedule as defined in the mutually agreed Experiment Interface Document (EID).

# 5 SCIENCE OPERATIONS AND DATA

## *5.1 PROBA 3 Operations Concept*

ESA will be responsible for the launch and operations/checkout of the spacecraft.

ESA will establish the PROBA 3 Mission Operations Centre (MOC).

## *5.2 Mission Operations Centre*

The PROBA 3 Mission Operations Centre (MOC) will be responsible for the operation and control of the spacecraft.

The PROBA 3 Project Office will define, in agreement with the MOC, the requirements and responsibilities for mission operations, on the basis of a Mission Implementation Requirement Document (MIRD) and a Mission Implementation Plan (MIP).

The MOC will, in particular, be responsible for the following tasks, relevant to science operations:

- Overall mission planning
- Supplying, in a timely manner, the Principal Investigator with raw data from her/his instrument, and spacecraft housekeeping and auxiliary data in an agreed format;
- Providing the SOC with a subset of payload data and spacecraft housekeeping and auxiliary data in an agreed format;
- Performing anomaly (out of limit) checks on a set of payload parameters;
- Notifying payload anomalies to the SOC/PI.

## *5.3 Science Operations Centre*

Science operations will be conducted in close coordination between ESA and the PI teams.

Key science operations responsibilities and functions include:

- Optimisation of the science return from the PROBA 3 mission by defining and implementing an efficient and cost-effective science ground system and operational scheme for all mission phases;
- Preparation of the long-term and short-term payload operations plan based on input from the SWT chaired by the PS, to be implemented by the Mission Operations Centre;
- Preparation of guidelines supported by the PI teams, to create the PROBA 3 science data archive.

The specific responsibilities of the Science Operations Centre are:

- Definition and implementation of efficient and cost-effective science operations planning, data handling and archiving concepts;
- Act as the sole interface seen from the MOC perspective on any matter related to routine instrument operations and mission planning;

- Provision of Liaison Scientists where applicable;
- Support of instrument operations during commissioning, nominal and extended mission phases ;
- Coordination of the science planning;
- Coordination of science-related inputs and updates for the Flight Operations Plan (FOP);
- Consolidation of the instrument operation timelines before their submission to the MOC;

- Analysis of critical science data required for science operations purposes related to spacecraft navigation and orbit insertion;
- Preparation with the PROBA 3 investigators of summaries of scientific results at regular intervals and for mission highlights;
- Preparation of guidelines for science data archiving and creation of the PROBA 3 scientific data archive;
- Support to Public Relations activities;
- Provide software support to the PI teams for payload operations;
- Support the MOC in the preparation of the payload operations before the end of the commissioning phase;
- Follow up the development of the experiments and participate in tests;
- Archiving of non-scientific data needed for instrument calibration, e.g. from check-outs during cruise phase;
- Distribute pre-processed instrument data and supporting information

The specific responsibilities of the PI are:

- Implementation and delivery of the SOC
- Support the definition of the science operations;
- Provision of inputs for the definition and implementation of the science operations planning, and data handling and archiving concepts;
- Support the preparation of the instrument operation timelines;
- Provide expert support at the MOC and/or SOC during payload commissioning and critical operations
- Support of the definition and implementation of the PROBA 3 scientific data archive, as part of the pre-launch tasks;
- Provision of support required by the Science Operations Centre for science planning purposes, as mutually agreed within the SWT;
- Monitoring and optimisation of instrument performance;
- Deliver raw, calibrated, and high level data, including relevant calibration products and/or software, to the PROBA 3 scientific archive (see also 5.4);
- Provision to ESA with unlimited access to all processed and analysed data for public relation purposes;
- Provision of summaries of the main scientific results at regular intervals.

The science operations will be defined by the PROBA 3 Project Scientist and the SWT. This process will include the production of a Science Implementation Requirements Document (SIRD) and Science Implementation Plan (SIP).

The SOC will be implemented in a cost-effective manner making use of electronic communications and its functionality may be augmented by national data centres that act as local sites and, where appropriate, provide specialised data processing and other user services. In order to fulfil their responsibilities with respect to science operations during all phases of the mission (both pre- and post-launch), the PI and CoIs will require adequate support from their funding agencies. Such support must be clearly specified in the response to the AO and agreed by all funding agencies.

## *5.4 Data Rights*

PROBA 3 data will be made available according to the following procedure. Reduction of science data is under the responsibility of PI teams. Following in-orbit commissioning, the PI teams retain exclusive data rights for the purpose of calibration and verification for a period of 3 months (TBC) after the receipt of the original science telemetry and auxiliary orbit, attitude and spacecraft status information. Upon delivery of data to ESA it will be made available to the scientific community at large through the ESA science data archive. It must be stressed that PI and CoI teams must clearly indicate in their proposal the level of resources allocated to the task of ensuring science data enters the

ESA science archive in a timely manner. These resources must be agreed by the funding agencies involved.

The PI teams will also be required to share data with the GIs so as to enhance the scientific return from the mission, in accordance with procedures to be agreed and formalised within the SWT.

The PI team will provide records of processed data with all relevant information on calibration and instrument properties to the ESA science data archive. The format for the spacecraft data shall be compatible with those defined for the ESA science data archive. The ESA science data archive will be the repository of all mission products. The ESA science data archive will be compatible with NASA's National Space Science Data Center.

Scientific results from the missions will be published, in a timely manner, in appropriate scientific and technical journals. Proper acknowledgement of the services supplied by ESA (and where applicable, the funding agency) will be made.

The PI teams will provide ESA (and where applicable, the funding agency) with processed and useable data for Science Communication purposes as soon as possible after their receipt.

## *5.5 Communication and Public Outreach*

### 5.5.1 Public Outreach

The PROBA 3 mission is expected to attract much public interest. Hence, the mission will be given proper importance and exposure within the framework of the communication activities of the Science Programme. Each PROBA 3 Investigator must provide material and information for Public Relations to ESA (and where applicable, to the funding agencies).

During the development phase of the mission, ESA will set up web pages on the PROBA 3 mission as an information tool for the general public and the media. With the progress of the mission the web pages will be enriched with more material and features related to the mission.

The active cooperation of all scientists involved in the PROBA 3 mission in providing relevant information and results to ESA (and where applicable, to the funding agencies) is expected for the success of the related communication activities.

### 5.5.2 Science Communication

The PROBA 3 Mission will be included in the overall ESA Communications Plan and a detailed PROBA 3 Communication Plan will be drafted in due time with inputs from the Project Scientist.

The Project Scientist will initiate and publish project related progress reports and reviews of scientific results from the mission. Scientific articles suitable for public release will be provided by the members of the SWT, upon their own initiative or upon request from the Project Scientist, at any time during the development, operational and post-operational phases of the mission.

# ACRONYMS

| | |
|---|---|
| AO | Announcement of Opportunity |
| Co-I | Co-Investigator |
| Co-PI | Co-Principal Investigator |
| CGSE | Calibration Ground Support Equipment |
| CME | Coronal Mass Ejection |
| COR | Coronagraph |
| D/SRE | Director of the Scientific and Robotic Exploration Programme |
| EGSE | Electrical Ground Support Equipment |
| EID | Experiment Interface Document |
| EM | Engineering Model |
| EQM | Electrical Qualification Model |
| ESAC | European Space Astronomy Centre |
| ESA | European Space Agency |
| ESTEC | European Space Research and Technology Centre |
| ESTRACK | ESA Tracking Network |
| FF | Formation Flying |
| FM | Flight Model |
| FOP | Flight Operations Plan |
| GI | Guest Investigator |
| GSE | Ground Support Equipment |
| GSTP | General Support Technology Programme |
| IPC | Industrial Policy Committee |
| ITAR | International Traffic in Arms Regulations |
| LOE | Letter Of Endorsement by Funding Agencies |
| MGSE | Mechanical Ground Support Equipment |
| MIP | Mission Implementation Plan |
| MIRD | Mission Implementation Requirements Plan |
| MRD | Mission Requirement Document |
| PI | Principal Investigator |
| P/L | Payload |
| PRDD | Payload Requirement and Definition Document |
| PROBA | Project for Onboard Autonomy |
| PRC | Payload Review Committee |
| PS | Project Scientist |
| PSLV | Polar Space Launch Vehicle |
| RSSD | Research and Scientific Support Department of ESA |
| S/C | Spacecraft |
| SRD | System Requirements Document |
| SIP | Science Implementation Plan |
| SIRD | Science Implementation Requirements Document |
| SMP | Science Management Plan |
| SOC | Science Operation Centre |
| SPC | Science Programme Committee |
| SSAC | Space Science Advisory Committee |
| SSEWG | Solar System Exploration Working Group |
| STM | Structural/Thermal Test Model |
| SWT | Science Working Team |
| WWW | World Wide Web |