

BEPICOLOMBO
An Interdisciplinary Mission to Mercury

SCIENCE MANAGEMENT PLAN
(Special emphasis on the Mercury Planetary Orbiter)

BepiColombo Mission Summary		
Scientific Objectives	<ul style="list-style-type: none"> • Origin and evolution of a planet close to the parent star • Mercury as a planet: form, interior, structure, geology, composition and craters • Mercury's vestigial atmosphere (exosphere): composition and dynamics • Mercury's magnetized envelope (magnetosphere): structure and dynamics • Origin of Mercury's magnetic field • Test of Einstein's theory of general relativity 	
Reference Payloads -	<ul style="list-style-type: none"> • Mercury Planetary Orbiter (MPO): cameras, spectrometers (IR, UV, X-ray, γ-ray, neutron), radiometer, laser altimeter, magnetometer, particle analyser, Ka-band transponder, accelerometer. • Mercury Magnetospheric Orbiter (MMO): magnetometer, ion spectrometer, electron energy analyser, cold and energetic plasma detectors, plasma wave analyser, and imager. 	
Transfer to Mercury	<ul style="list-style-type: none"> • MPO and MMO launched together on one Soyuz-Fregat 2-1B • Interplanetary cruise with Solar Electric Propulsion Module (SEPM) and gravity assists of the Moon, Venus and Mercury; SEPM jettisoned upon arrival at Mercury. • Mercury capture with Chemical Propulsion Module (CPM), jettisoned after insertion in polar orbit. 	
Spacecraft Module	MPO	MMO
Stabilisation	3-axis	15 rpm spin
Orientation	Nadir	Spin at 90° to Sun
TM band	X/Ka	X
Deployment	400 km x 1500 km	400 km x 12000 km
Operational lifetime	> 1 year	> 1 year
Data volume	1550 Gb/year	160 Gb/year
Equivalent average bit rate	50 kb/s	5 kb/s
Launch vehicle	Soyuz-Fregat 2-1B	
Launch date	mid-2012	
Cruise duration	3.9-4.2 years	
Ground TM station	Cebros (Spain), 35 m Antenna, 8 hours/day	Usuda (Japan) 64m Antenna 6-8 h/day
Programmatic	<ul style="list-style-type: none"> • ESA is responsible for MPO, SEPM, CPM, launch, transfer to Mercury, spacecraft deployment and MPO operations. • JAXA procures MMO and ensures its operation. • BepiColombo is the first ESA mission in close cooperation with Japan. 	

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1 SUMMARY AND SCOPE

BepiColombo is the planetary mission of the reconstructed Cosmic Vision Programme of the European Space Agency (ESA). The mission is devoted to the thorough exploration of Mercury and its environment with the aim to understand the process of planetary formation and evolution in the hottest part of the proto-planetary nebula as well as to understand similarities and differences between the magnetospheres of Mercury and Earth.

The mission will be carried out as a joint project between ESA and JAXA (Japanese Aerospace Exploration Agency)

The BepiColombo baseline mission consists of two spacecraft: the Mercury Planetary Orbiter (MPO) and the Mercury Magnetospheric Orbiter (MMO). The orbiters will be launched together on one Soyuz-Fregat 2-1B. ESA is responsible for MPO and the Japanese Aerospace Exploration Agency (JAXA) is responsible for the MMO. ESA will also provide the Solar Electric Propulsion Module (SEPM) and the Chemical Propulsion Module (CPM) for the transport of the two spacecraft to Mercury and the insertion into their dedicated orbits and subsequent MPO operations, as well as the launcher and the ground segment.

The Science Management Plan (SMP) deals with the scheme that will be implemented up to and including the post operational phase, to ensure the fulfilment of the scientific objectives of the BepiColombo mission and to optimise its scientific return, with special emphasis on payload procurement, science operation and data management.

The SMP first recapitulates the main aspects of the mission, including the planned participation of JAXA. The SMP then explains how the scientific community will be associated across the full mission to the exploration of the planet Mercury. There will be a separate payload selection procedure for the MPO and the MMO whereby the responsibility for the MPO lies with ESA and the MMO payload selection will be under the responsibility of JAXA.

The SMP deals, in particular, with the selection of the instruments, which will constitute the MPO scientific payload, and makes reference to a similar procedure, which will be applied for the selection of the MMO payload. The plan outlines the role of the BepiColombo 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 MPO investigators, as well as their interaction with the MMO science group.

The MMO SMP will be compatible with this document and will be issued separately.

2 MISSION OVERVIEW

2.1 Introduction

BepiColombo is an interdisciplinary mission to the planet Mercury. It has been defined as collaboration between ESA and JAXA. It consists of two orbiters, the Mercury Planetary Orbiter (MPO) and the Mercury Magnetospheric Orbiter (MMO), which are dedicated to the detailed study of the planet and its magnetosphere. Their orbits have therefore been optimized accordingly. The MPO is three-axis-stabilized and nadir pointing, whereas the MMO is a spinning spacecraft. The launch of the MPO/MMO complement is planned for 2012. Solar electric propulsion will be used for the journey to Mercury and chemical propulsion for the insertion of the spacecrafts into their dedicated orbits. The MMO will be provided by JAXA.

ESA will be responsible for the following tasks: 1) mission design, 2) spacecraft composite, the MPO procurement (without instrument front ends), 3) integration of the scientific payload into the MPO, 4) integration of the Japanese contributions into the composite, 5) system testing, 6) MPO mission operations, 7) MPO data acquisition and distribution to the PIs. The instruments of the MPO Reference Payload share common functions and resources. The Instrument Front Ends (IFE) will be provided by institutes through national funding.

JAXA will be responsible for the development of the MMO and part of its scientific payload. JAXA will also be responsible for the integration of the scientific payload into the MMO and for the compilation of the up and down link sequencing of the MMO.

2.2 Historical Background

In May 1993, a mission to Mercury was proposed to the European Space Agency in response to a “Call for Ideas”. The mission was selected as a cornerstone candidate in the Horizons 2000 scientific programme of the Agency in 1996. On 15 October 2000, ESA’s Science Programme Committee (SPC) approved BepiColombo (MPO, MMO, MSE) as ESA’s 5th Cornerstone mission with launch in 2009/2010. At that time, the mission scenario foresaw the MPO and MMO to be launched separately, on two Soyuz-Fregat, within the same launch window. It turned out that a third launch vehicle was required for the MSE. The severe reduction of the science budget after the Ministerial Conference in November 2001 caused the MSE to be dropped from the mission baseline.

Between 1 October 2002 and 30 June 2003 BepiColombo went through a reassessment process with the aim to maximise the scientific performance, through the optimisation of the payload complement, while attempting to reduce costs and programmatic risk. The preferred mission scenario that emerged from the reassessment was to launch the MPO and MMO together on a single launcher (Soyuz Fregat 2-1B with higher launch capability) in mid 2012, leaving the second launcher for the MSE. To achieve the above with adequate resource margins, the MPO payload resources, particularly mass, had to be significantly reduced while ensuring the mission scientific competitiveness is enhanced. This has been achieved by defining, from the analysis of the science objectives, the corresponding payload complement and resulting instrument requirements. An optimised reference payload suite was defined where instruments share common functions and resources, which led to an

enhanced science performance at significantly lower cost. The SSWG at its 112th meeting recognized that a traditional full AO process would not in these circumstances be possible and the Executive proposed a different approach to payload procurement. On 6 November 2003 the SPC approved the BepiColombo mission with the MPO/MMO complement as a part of the reconstructed Cosmic Vision Programme. The Payload Selection Procedure for the MPO payload as outlined in ESA/SPC 2003(41) was unanimously approved.

On the JAXA side, the Mercury Exploration Working Group (MEWG) was formed in June 1997 under the Steering Committee for Space Science (SCSS) in the former Institute of Space and Astronautical Science (ISAS) to investigate a mission to Mercury. The MEWG published the Japanese plan based on a spinning Mercury orbiter with chemical propulsion and multiple Venus and Mercury flybys. The possibility of collaboration with the ESA BepiColombo mission was discussed at the time of Inter-Agency Consultative Group (ICAG) in November 1999, and stated in a letter from the Director-General of ISAS to the Directorate of Science Programme of ESA, dated 31 July 2000. According to the approval of BepiColombo as the 5th Cornerstone of ESA, the MEWG was re-formed for the investigation of MMO for the BepiColombo mission. The International Mercury Exploration Mission in the framework of the BepiColombo programme was approved by the SCSS of ISAS in January 2002, followed by the formal approval by the Space Activities Commission in June 2003. It is noted that Japan Aerospace Exploration Agency (JAXA) was formed in October 2003 as merger of ISAS, National Space Development Agency (NASDA) and National Aerospace Institute (NAL).

2.3 Scientific Objectives

Mercury is an extreme of our planetary system. Since its formation, it has been subjected to the highest temperature and has experienced the largest diurnal temperature variation of any object in the Solar System. It is the closest planet to the Sun and has the highest uncompressed density of all planets. Solar tides have influenced its rotational state. Its surface has been altered during the initial cooling phase and its chemical composition may have been modified by bombardment in its early history. Mercury therefore plays an important role in constraining and testing dynamical and compositional theories of planetary system formation.

Only the American probe Mariner 10 has returned data from Mercury. The spacecraft made three flybys of Mercury in 1974-1975; it obtained images of somewhat less than half of the planet's surface and discovered its unexpected magnetic field that is, though weak, strong enough to stand off the solar wind and form the magnetosphere. Although these data have been fully exploited, a lot of gross features remain unexplained. Many conclusions are still speculative and have evoked a great number of new questions.

The BepiColombo Science Advisory Group outlined the general scientific objectives of the mission, in 2000. The main objectives can be summarised as follows:

- Exploration of Mercury's unknown hemisphere,
- Investigation on the geological evolution of the planet,
- Understanding the origin of Mercury's high density,
- Analysis of the planet's internal structure and search for the possible existence of a liquid outer core,

- Investigation on the origin of Mercury's magnetic field,
- Study of the planet magnetic field interaction with the solar wind,
- Characterisation of the composition of the planet's surface,
- Identification of the composition of the radar bright spots in the Polar Regions,
- Determination of the global surface temperature,
- Determination of the composition of Mercury's vestigial atmosphere (exosphere),
- Determination of the source/sink processes of the exosphere
- Determination of the exosphere and magnetosphere structures,
- Study of particle energisation mechanisms in Mercury's environment.
- Fundamental physics: verification of Einstein's theory of gravity

The complexity of these fundamental objectives hampers their straightforward translation into required payload, i.e. none can be achieved through measurements by any single instrument. Therefore, additional information was gathered to provide a concise quantification of the intended goals of the mission in terms of actual derived scientific quantities. These scientific quantities were consolidated in the Science Requirements Document (Sci-RD) that consists of three main chapters describing:

- Required investigations to reach the science objectives
- Resulting performance requirements of individual instruments
- Relevance of BepiColombo in the context of Mercury studies

As such the Sci-RD represents the reference document for the translation of the scientific requirements into instrument design and thus leads the contents of the Payload Study Document (PSD) that describes in detail the reference payload necessary to fulfil the science requirements.

Owing to its importance, the Sci-RD was therefore compiled from input from the science community, i.e. wider than just the members of the Science Advisory Group (SAG). Representatives of the various teams in the science community who indicated their interest in particular measurements through a Letter of Intent were brought together to collaborate rather than compete. Science Teams formed around the particular themes of MPO measurements, such as imaging, IR-spectroscopy/radiometry, laser altimetry, UV/x-ray/ γ -ray/neutron spectroscopy, radio science, magnetic field and particle measurements. Each of these Science Teams agreed on their objectives and resulting scientific requirements, which were documented in the Sci-RD. After a detailed review the Science Advisory Group approved the BepiColombo Sci-RD.

Similar activities, concerning the MMO payload, have been carried out by international science teams, consisting of Japanese and European scientists, in coordination with ISAS/JAXA. A document similar to the MPO payload PDD has been compiled for the MMO payload and will be made available similarly to the MPO PDD.

2.4 Mission Description

2.4.1 TRANSFER TO MERCURY AND TASK DISTRIBUTION

In the baseline scenario, MPO and MMO are launched together on a single Soyuz-Fregat 2-1B in mid 2012. The transfer to Mercury will be based on Solar Electric Propulsion with an approximate travel time of 4.2 years. Upon arrival the Solar Electric Propulsion Module (SEPM) will be jettisoned and the Chemical Propulsion Module will provide the required thrust for Mercury capture and orbit insertion.

ESA will be responsible, among other tasks, for (1) the cruise operations up to the delivery of the orbiters at their destinations and (2) the MPO operations and data acquisition. JAXA will be responsible for the MMO operation around Mercury.

2.4.2 MERCURY PLANETARY ORBITER (MPO)

The MPO is a three-axis-stabilized and nadir-pointing module with an operational lifetime of at least one Earth year. It has one axis aligned with the nadir direction for a continuous observation of the planet. Its low-eccentricity polar orbit (400 x 1500 km altitude) will provide excellent spatial resolution over the entire planet surface.

The reference payload was established from the analysis of the science objectives and the scientific measurements required to achieve these objectives. The scientific requirements outlined in the Sci-RD have been translated into the MPO reference payload as defined in the Payload Definition Document, PDD V4.0 (see also Table 1 of the Annex). The reference payload of the MPO does not consist of a number of self standing instruments each with their own supporting subsystems, but rather of the scientific sensors (instrument front ends, IFE's) which share common functions and resources for their back ends.

To ensure that the reference payload suite can satisfy those science requirements, which can be achieved without landing on the planet, an international Payload Review Committee (PRC) was asked to assess the Sci-RD and PDD and make recommendations for improvement if required. On the basis of their analysis and peer review the definitive reference payload of the MPO will be defined.

2.4.3 MERCURY MAGNETOSPHERIC ORBITER (MMO)

MMO is a spinning spacecraft to be placed in a 400 x 12000 km altitude polar orbit, with an operational lifetime of at least one Earth year.

MMO will accommodate instruments mostly dedicated to the study of fields, waves and particles in the environment of the planet. The MMO spacecraft is spin stabilised at 15 rpm, which facilitates the azimuth scan of the particle detectors and the deployment of wire electric antennas. The MMO spin axis will be nearly perpendicular to the equator. The orbit is polar and highly elliptic; its major axis lies in the equatorial plane to permit a global exploration of the magnetosphere up to a distance of nearly 6 planetary radii from the planet's centre.

The model payload of the MMO is given in Table 2 of the Annex.

2.5 Cooperation with Messenger

Messenger is a NASA Discovery Program mission to Mercury to be launched in May 2004. It will enter Mercury orbit in April 2009 and has a nominal lifetime of one Earth year.

Representatives of BepiColombo and members of the Messenger Team met on 10 September 1999. They recommended that ESA and NASA establish a framework within which regular meetings will occur to (1) maintain open communication for optimizing the implementation and scientific returns of both missions, and (2) identify areas of possible coordination.

The first such meeting shall be scheduled immediately after the launch of the Messenger.

3 PROGRAMME PARTICIPATION

3.1 Payload Consortium Confirmation Process

For the MPO payload ESA will issue a Request For Proposals (RFP) to the SPC Delegations and the Scientific Community. The RFP will be based on the definitive reference payload, established by the Payload Review Committee. The RFP will identify clearly those common elements expected to be provided by ESA for all instruments to and at the same time call for provision of the Instrument Front Ends (IFE's) from institutes and funding agencies willing to participate.

An IFE consists of as a minimum a sensor, associated optics, etc. and the front-end read-out electronics. The exact definition of the interface between the IFE and the spacecraft will be iterated and optimized during the evaluation process, including the common functions and resources which will be provided by the Agency or another instrument if required. In the response to the RFP, the potential PI has the flexibility to propose, with rationale, an interface which he/she believes should be the optimum.

The proposals for the MPO IFE's shall be compatible foremost with the scientific and operational objectives of the BepiColombo mission and also with its design and operational capabilities.

Each proposal for an IFE must identify a single Principal Investigator (PI) heading the instrument consortium and carrying final responsibility for all aspects of the provision of the IFE. It follows that the PI must be fully backed by the national funding agency of her/his country, henceforth called "Lead Nation" and "Lead Funding Agency" for the IFE. In some countries, resources may be provided by various organisations or institutions. In this case the "Lead Funding Agency" will be the organisation providing representation to the ESA Science Programme Committee. The Lead Nation is expected to provide the majority element of the funding for the respective IFE and have prime science and industrial responsibility through the PI and Instrument Manager. The Lead Funding Agency of the Lead Nation is expected to take full responsibility for the development and timely delivery of the IFE, by being signatory to a Formal Agreement.

It must be stressed that an IFE proposal will only be selected if accompanied by the formal financial commitment of the relevant national funding organisations representing all institutes participating in the IFE proposal. This must also include the clear agreement of the PI's funding agency to become the Lead Funding Agency, implying overall responsibility to deliver the IFE.

The RFP will be issued following the approval of the SMP by the ESA Science Programme Committee. The RFP will call for identification of Principal Investigators (PI's) and a Lead Funding Agency for each IFE. All responses should come through the Lead Funding Agency who represents the PI. 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 IFE consortium. It is envisaged that responses will not be prepared in isolation and ESA will work in support of the funding agencies and institutes in the definition of the consortia and the analysis of the technical and financial risks. The envisaged mechanism will be through a series of coordination meetings covering different technical, programmatic and financial areas. Only where clear competition between

consortia is evident in a given IFE domain will some level of ‘hands-off’ approach be instituted by the Executive for the sake of fairness.

For the MMO payload JAXA will issue a Request for Proposals separately. Both the ESA and JAXA RFP’s are open to European and Japanese scientists and to other scientific communities with which reciprocity or specific agreements exist. The issuances of the RFPs for MPO and MMO, and the selection processes may not be simultaneous due to the different schedules for the ESA and JAXA budgetary approvals. However, the two agencies will continuously exchange information and coordinate their actions.

Announcements of Opportunity (AOs) for participation as IDS will be issued after the payload selection is completed. AOs for Guest Investigators will be staged after launch.

3.2 Modes of Participation

The possible modes of participation to the BepiColombo programme are:

- (1) Principal Investigator (PI), heading an instrument consortium providing an instrument front end, IFE (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 front end, IFE (see section 3.2.3);
- (4) Interdisciplinary Scientist (IDS), an expert in specific science themes connected with Mercury (see sections 3.2.4);
- (5) Guest Investigator (GI), by participating in the data collection and analysis of one or more instruments (see sections 3.2.5).

3.2.1 PRINCIPAL INVESTIGATOR

The PI 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 IFE 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 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.) outlined in the Experiment Interface Document (EID).

(2) Science

- (i) Monitor the compliance of the IFE design to the scientific requirements outlined in the Sci-RD
- (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 all required calibration data to the ESA MPO SOC along with 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, and support the Science Operation Centre.
- (vi) Exploit the scientific results of the mission and assure their diffusion as widely as possible.
- (vii) Provide the scientific data (raw data, calibrated data, and higher level data), including relevant calibration products, to the BepiColombo ESA-JAXA archive in a format that will be agreed with the ESA SOC for application by the general science community.

(3) Hardware

- (i) Define the functional requirements of the IFE and auxiliary test equipment (e.g. MGSE, EGSE, CGSE, etc.)
- (ii) Ensure the development, construction, testing and delivery of the IFE. This shall be performed in accordance with the technical and programmatic requirements outlined in the RFP including its annexes such as the EID-A, and subsequently reflected in the PI response, EID-B.
- (iii) Ensure that the IFE 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 IFE 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 ruled by the EID-A, in accordance with technical programme needs.
- (v) Deliver an IFE Flight Model and Flight Spares in accordance with the technical requirements defined in the EID-A, together with the relevant Ground Support Equipment.
- (vi) Support the system level integration and test activities related to and involving the instrument

- (vii) The PI's shall provide the necessary equipment to process their data as agreed with ESA and specified in the EID-A.
- (viii) 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.
- (ix) Provide the overall documentation during the project, as defined in the EID-A.

(4) Software

- (i) Ensure the development, testing and documenting of all software necessary for the control, monitoring and testing of the IFE part of the instrument, in accordance with the rules and guidelines established in the EID-A.
- (ii) Specify and then support the development, testing and documenting of all software necessary for the testing, operation and data reduction/analysis of those parts of the instrument under ESA responsibility, in accordance with the rules and guidelines established in the EID-A.
- (iii) Ensure the delivery to ESA of any instrument specific software which is required for testing or operations and its documentation to ESA, or elsewhere, in accordance with approved ESA guidelines, procedures and schedules. This includes the provision of software required in the ESA SOC as agreed in the Science Operations Requirements Document.
- (iv) Maintain and update all PI provided instrument software and its documentation until the end of the mission.

(5) Product Assurance

Provide product assurance functions in compliance with EID-A requirements.

(6) Operations

Provide support for preparation and implementation of the mission and scienceoperation up to the end of the mission including delivery of a user manual and data base inputs in accordance to the EID-A requirements.

(7) Financial

The financial status of the European PI teams will have to be guaranteed by the Lead Funding Agency. The Lead Funding Agency will be considered responsible vis-à-vis ESA for all what concerns financial matters related to the selected investigations. Co-I teams are required via their national funding agencies to seek agreement with the Lead Funding Agency, which retains full responsibility for the IFE development and is the sole contact with ESA with respect to the LOC.

As for the Japanese contributions to the MPO and MMO payloads, JAXA (ISAS) must approve all financial engagements.

(8) Communications and Public Relations

Support ESA and JAXA science communications and public relations activities, and provide suitable information and data in a timely manner, as outlined in the Science Communication Plan (see section 6.5).

3.2.2 CO-PRINCIPAL INVESTIGATORS

In some exceptional circumstances and specifically with respect to JAXA, 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 and must be underwritten by formal interagency agreements with the Lead Funding Agency, representing the PI and which holds overall fiscal responsibility with respect to IFE development and delivery to ESA.

3.2.3 CO-INVESTIGATORS

Members of each PI-led IFE consortium may be proposed out 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 IFE consortium may review the status of its members regularly and implement changes if required. The Lead Funding Agency will however not change during the development of the IFE's.

Co-Is are responsible for their own funding which is guaranteed via their national funding agencies and must be underwritten by formal interagency agreements with the Lead Funding Agency, representing the PI and which holds overall fiscal responsibility with respect to IFE development and delivery to ESA.

3.2.4 INTERDISCIPLINARY SCIENTISTS

To ensure a solid top-level oversight of the mission science it is proposed that a number of interdisciplinary scientists (IDS) are selected through an open AO process. These IDS's should not reflect instrument specific domains but cover specific science themes such as for instance planetary surface morphology, mineralogy, exosphere, and interior structure. An IDS may also wish to undertake specific and time-limited tasks in areas such as modelling of the planet and its environment, mission and science operation planning, hazard assessment and similar activities that may be required during the course of the mission. The appointment of one or more IDS's may also be considered for the coordination of MPO-MMO science. Interdisciplinary Scientists (IDS's) will take part in the analysis of data from different instruments onboard one or more elements of the mission. They have the same data rights as the members of the PI-led instrument consortia.

The proposals submitted by IDS individuals must describe clearly their scientific case, the relevance of their contribution to the mission and the instrument data sets needed to carry out their research programme. Financial endorsement by the national funding agencies, should they require funds for their activity, is also required. The IDS's, like the PI's, are expected to provide adequate support to the communications activities of ESA.

The Agency may release additional AOs at a later stage for specific mission phases and interdisciplinary studies related to Mercury and other planets.

3.2.5 GUEST INVESTIGATORS

Guest Investigators (GI's) are individual scientists who wish to make use of the data collected by a single instrument. Their proposals shall be submitted to the PI's heading the instrument consortia with a copy to ESA. Their tasks shall be agreed with the PI's, with concurrence of the ESA Project Scientist.

Guest Investigators will be selected after launch.

4 SELECTION PROCESS

A new approach for the selection, funding and development of the MPO payload has been approved by the SPC. This approach (ESA/SPC(2003)41) aims at taking into account the limited funds available for the payload procurement, and the need to preserve an efficient procurement of a highly optimized 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. This requires that the payload must be solidly defined technically, fiscally and programmatically, in order to fit smoothly into the overall mission development schedule, with minimum risk to ESA and the member states 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 PRC shall, in the first instance, examine the scientific objectives and resulting scientific requirements of the mission, assess whether BepiColombo can achieve them with its reference payload and from that define the definitive reference payload.

After the international peer review by the PRC of the reference payload and updates based on its recommendations, ESA will issue of a Request for Proposal (RFP) based on the definitive reference payload established by the PRC. The RFP will identify those elements common for all instruments to be provided by ESA and at the same time call for the provision of the Instrument Front Ends (IFE's) from institutes and funding agencies willing to participate. Although the RFP will call for the identification of both a Principal Investigator (PI) and Lead Funding Agency for each IFE, RFP responses should come from the Lead Funding Agencies, rather than the PI's themselves and shall include a draft Letter of Commitment (LOC). The intention is that the response to the RFP will not only establish the technical character and level of the IFE but also the level of involvement together with the nature of the management structure and financial commitment. It is based on this draft LOC that the formal agreement with the Lead Funding Agency will be established. It is expected that the response to the RFP should not be prepared in isolation but rather ESA will work in support of the funding agencies and institutions in the definition of each IFE consortia as well as the definition of the technical and financial risks. The envisaged approach is through the development of a number of coordination meetings covering each IFE as specified in the definitive reference payload suite.

Once the individual IFE consortia are formed the PRC will be asked to review and confirm the scientific acceptability of each IFE proposal. The assessment of the PRC is particularly important in the cases where a proposal does not fully cover the scientific requirements or departs radically from the definitive reference payload. If competing IFE proposals are submitted by different PI-teams and Lead Funding Agencies the PRC will be asked to make a recommendation on which proposal should be selected. The deliberations of the PRC will be submitted to the ESA Advisory Structure.

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. In addition, agency staff will assist the PRC with respect to technical, programmatic and financial matters.

The technical requirements (including EID part A) will be available in February 2004, i.e. prior to the formal issue of the RFP, to ensure the timely specification of clear technical interfaces. It is essential that a solid cost and programmatic analysis can be completed between ESA, IFE Consortia and Funding Agencies in their response to the RFP, which will permit the Member States to focus on the provision of IFE's.

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 and structure of the IFE consortia coupled, via formal Letters Of Commitment (LOC), to the funding commitment by all parties involved. The timetable of events leading to this approval, is as follows:

- January 2004: Peer Review of the Reference Payload and specification of the Definitive Reference Payload.
- February 2004: Information note to the SPC of the initial results of the Payload Review with respect to the Science Requirements and the Definitive Reference Payload together with the approval of this Science Management Plan.
- February-May 2004: IFE instrument consortia formation through ESA organised IFE coordination meetings of all interested parties – science institutes and relevant funding agencies.
- Issue of the ESA RFP March 1st 2004.
- May 15th 2004: Receipt of PI-led proposals through the Lead Funding Agency in response to the RFP.
- June 2004: SPC Status Report on the RFP response and the status of the consortia formation and LOCs.
- July – September 2004: Peer Review of all IFE proposals.
- October 2004: Status Report on the BepiColombo payload to the ESA Science Advisory Structure.
- November 2004: Endorsement by SPC of IFE consortia and final approval for BepiColombo to enter the implementation phase.
- November 2004: Issue of an AO for BepiColombo interdisciplinary scientists.
- February 2005: Response to interdisciplinary scientists AO.
- April 2005: Peer Review of IDS AO response.
- May 2005: Confirmation of the IDS selection through the ESA science advisory structure.

4.1 Instrument Selection

4.1.1 PAYLOAD REVIEW COMMITTEE

To ensure that the scientific return of BepiColombo is of the highest quality, an independent international Payload Review Committee (PRC) shall assess the mission. The executive

shall appoint the Payload Review Committee members, after consultation with and agreement of the SSAC. The Payload Review shall, in the first instance, examine the scientific objectives and resulting scientific requirements of the mission and assess whether BepiColombo can achieve them with its reference payload. The Payload Review Committee will assess whether the MPO reference payload complement can fulfil the scientific objectives and make recommendations for improvement if required. This process will finally result in the specification of the Definitive Reference Payload against which the RFP for IFE's will be issued. After receipt of the responses to the RFP for IFE's the Payload Review Committee will perform the second part of its mandate; namely a full review of all RFP responses and the establishment of the final consolidated payload.

In the first step the Payload Review Committee shall review the scientific objectives of the BepiColombo mission to:

- Ensure their completeness
- Identify any need for further clarification or refinement

The Payload Review Committee shall review the Science Requirements Document with a view to:

- Ensuring its completeness and accuracy with regard to the scientific objectives
- Clarifying or refining requirements where necessary
- Identifying whether additions are necessary to ensure full compliance with the mission's scientific objectives.
- Determine those requirements that can only be satisfied through measurements performed on both, the MPO & MMO

The Payload Review Committee shall assess the MPO reference payload as defined in the Payload Definition Document with a view to:

- Determining whether the reference payload suite can satisfy the science requirements
- Identifying those science requirements which are not satisfied by elements of the reference payload
- Recommending improvements in the reference payload to achieve the scientific objectives as specified by the science requirements
- Determining additional payload elements (if necessary) which will, subject to resources and system studies, improve the overall scientific capability of the mission enabling it to fully satisfy all scientific objectives

The Payload Review Committee will consider the reference payload of the MMO payload with a view to:

- Establish the degree of overlap with the MPO with a view to ensuring an appropriate level of science redundancy
- Identify of those payload elements which are an essential complement to the MPO payload in order to achieve the scientific objectives

In a second step the Payload Review Committee shall perform, after receipt of all IFE proposals in response to the RFP, a review assisted by ESA technical, programmatic and financial analysis staff, supported by the potential prime contractors, in order to:

- Ensure that all science objectives are satisfied within the overall RFP response
- Ensure that each IFE proposal satisfies the science requirements in terms of sensitivity and performance, as specified in the SCI-RD, to achieve the specific science objectives
- Compatibility of each IFE against the peer reviewed definitive reference payload.

The Payload Review Committee is supported by technical review panels consisting of selected personnel of the Agency and its contractors as well as invited specialists. For each IFE in financial and programmatic areas ESA will consult extensively with funding agencies and provide the Payload Review Committee with input on the implementation feasibility and risk assessment.

The PRC will be supported by three JAXA representatives who will guarantee the appropriate flow of information and coherence between the ESA deliberation and the JAXA activities related to the MMO payload selection. The ESA MPO PRC as well as the ESA Advisory Structure will be kept informed about the MMO payload selection process.

The “No Conflict of Interest” rule will apply, i.e. no potential PI for any IFE can be a member of the PRC or involved in the selection procedure. Proposing IFE Co-I’s may be accepted as PRC members, if strictly necessary. They will have no voting right for their own investigation and other competing investigations.

4.1.2 EVALUATION CRITERIA AND SELECTION PRINCIPLES

The instrument IFE proposals will be evaluated by the PRC, individually, on the basis of the RFP with the following preliminary criteria:

- Relevance of the scientific objectives and their compatibility with the global 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 Sci-RD;
- Feasibility and heritage of the proposed technical solutions;
- Development status of the full instrument and IFE;
- Availability of relevant technologies forming part of the IFE and the need for the development of new technologies. The development status of such “new” technologies should also be evaluated based on the IFE-RFP response.
- Clear identification and justification of the proposed ESA hardware/software contribution to the full instrument.
- Compliance with the interfaces specified through the EID-A.
- IFE development plan including test and validation programme.
- Compatibility of the instrument IFE component with the Mercury environment, spacecraft resources and mission constraints;
- Operational complexity;
- Quality of data analysis plan;
- Management plan and its adequacy with the instrument IFE complexity; this specifically includes the complexity of the management interfaces within an IFE consortium.
- Continuity of human and institutional resources to ensure a timely execution of IFE instrument development, calibration and associated tasks, and to support post launch operation and data analysis. The man power funding profiles, at the science institute level within each consortium, backed by the appropriate funding agency and confirmed

through the Lead Funding Agency will be analysed through all mission phases including science exploitation and archive.

- Competence and experience of the team in all relevant areas (science, technology, software development and management);
- Credibility of costing; This will be performed by ESA staff experienced in instrument cost analysis acting in close cooperation with the relevant funding agencies and coordinated with the Lead Funding Agency through which the RFP IFE proposal was submitted.
- Compliance with ESA applicable management, engineering, reporting and product assurance requirements and standards;
- Possible financial impact of the proposed instrument IFE upon ESA;
- Commitment of all the national funding agencies to provide the correct level of support to member institutes within the consortium under the overall responsibility of the Lead Funding Agency which represents at a minimum the PI-institutes participation in the IFE consortium.
- Commitment of the PI's funding agency to become the Lead Funding Agency and agree to the LOC.

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

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

4.1.3 SELECTION PROCESS

The IFE proposal evaluation and selection for the MPO will be made in four steps:

- Scientific evaluation;
- Technical, managerial and financial evaluation;
- Payload/Spacecraft compatibility evaluation;
- Final recommendation.

(1) Scientific evaluation

The PRC will evaluate the merits of each IFE proposal from a scientific point of view. Specifically its validity with respect to the mission science objectives and its compliance with the science requirements will be assessed. Not only the scientific value, but also the complementary character of the scientific research, will be assessed. The predicted performance of the instruments and their capability to achieve the mission objectives will also be scrutinized. The feasibility of the instrument meeting its requirements within the resource and schedule constraints will also be assessed.

Candidate PI's with relevant Co-Is may be invited to clarification meetings, individually or collectively, to discuss critical issues and possible areas of overlap or complementarities.

(2) Technical, managerial and financial evaluation

The ESA BepiColombo Project Office supported by the Science Payloads and Advanced Concepts Office (SCI-A) will form a technical review team to evaluate all IFE proposals for their managerial and technical compliance with the mission requirements. The instrument concept, feasibility, management scheme and funding will be assessed. The ESA team will be complemented when required by additional ESA experts and external consultants.

In the frame of the selection process, potential IFE PI's, with the relevant Co-I's and technical support personnel may be invited to attend meetings at the European Space Research and Technology Centre (ESTEC) to clarify details on technical, managerial or financial issues.

(3) Payload/Spacecraft Compatibility Evaluation

Based on the technical and scientific assessments, the PRC will recommend the configuration of the IFE payload complement which would satisfy the mission science objectives and equates with the definitive reference payload. The two industrial teams involved in the BepiColombo definition will then study further the accommodation of this payload complement on the MPO. The goals of this exercise are:

- To analyse the detailed requirements of the selected IFE's to identify potential problem areas.
- To analyse the impact of the proposed IFE's on the spacecraft design and payload complement in order to keep the mission cost within the financial envelope, including that for national agency funding of the IFE's.

The PRC might recommend upgrading, descoping or merging of IFE proposals, during the whole selection process based on the science objectives, technical feasibility, programmatic and financial situation.

(4) Final Recommendation

The PRC will recommend a MPO payload complement matching as closely as possible the definitive reference payload. The recommendation will be subject to endorsement by the Solar System Working Group (SSWG) and Space Science Advisory Committee (SSAC), and finally submitted to the Space Programme Committee (SPC) for approval.

4.2 Selection of Interdisciplinary Scientists

Interdisciplinary Scientists will be selected through an open AO process (see 3.2.1). The proposals will be evaluated through an independent Peer Review. Each IDS will be selected on the basis of the scientific quality and value of the investigation proposed. The proposed research shall not require additional resources or any redesign of the definitive reference payload or IFE's. The selection will take place after the completion of the MPO and MMO payload confirmation procedure. The formal appointment will be made by SPC upon recommendation by SSWG and SSAC.

4.3 Selection of Guest Investigators

The selection criteria for Guest Investigators (GI's) will be established later, at the discretion of the instrument teams, in consultation with the SWT (see 3.2.5 and 5.2). The formal appointment will be made by SPC upon recommendation by SSWG and SSAC.

5 SCIENCE AND PROJECT MANAGEMENT

5.1 The Project Scientist

ESA nominates the BepiColombo Project Scientist (PS). The PS is located at ESTEC within the Planetary Missions Division within RSSD and is the Agency's interface with the Principal Investigators 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 BepiColombo Project Scientist will be responsible for all scientific issues within the Project. During the development phase, the PS will advise the ESA Project Manager (SCI-P) on technical matters affecting scientific performance and will be supported by the Science Payloads and Advanced Concepts Office (SCI-A) as required. 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 and Data System Division of ESA's Research and Scientific Support Department (RSSD) will provide support on science operations and archiving.

After the in-flight commissioning phase, the Mission Manager within RSSD takes over the responsibility for the mission throughout the exploitation phase. The Mission Manager will have overall responsibility for the delivery of the scientific output of the mission as approved within assigned constraints. The PS will continue his/her activity as the main interface with the scientific community and will coordinate the science operations with the Mission Operations Manager at ESOC. The PS will coordinate the creation of the scientific products, their archiving and distribution to the scientific community.

5.2 Science Working Team

The BepiColombo Science Working Team (SWT) will consist of all PI's/Co-PIs and IDS's. The BepiColombo Project Scientist will chair the SWT with the JAXA MMO Project Scientist as the Co-Chairperson.

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

In order to increase the working effectiveness, a Science Working Team sub-group (SWG) will be formed for each of the spacecraft elements. The MPO-SWG and MMO-SWG report to the SWT. The respective PS of ESA and JAXA will chair them.

An ESA MMO Science Coordinator will work within the ESA PS team and report to the PS. He/She will be the JAXA MMO Project Scientist representative in Europe. Similarly, a JAXA MPO Science Coordinator will be the ESA Project Scientist representative in Japan. The same individual may fulfil "Project Scientist" and "Science Coordinator" functions.

The SWT, MPO-SWG and MMO-SWG meetings may take place at different times and venues, in order to improve flexibility and minimize travel costs. The norm to be sought is that out of 3 SWT meetings, 2 will take place in Europe and 1 in Japan.

In order to account for the multidisciplinary aspects of this mission, the SWT may delegate tasks to scientific subgroups. These subgroups will focus on specific topics of research and on issues related to the spacecraft element they are associated with. One member of the SWT, preferably an IDS, will lead each scientific subgroup.

Participation of individual scientists to activities of several subgroups is possible and even recommended. The Project Scientist Team, through SWT scientific meetings, will insure the coordination between these subgroups.

5.3 The Project Office

ESA will establish a BepiColombo Project Office at ESTEC, headed by a Project Manager, which will fulfil 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 MPO Investigator teams, the Project Office will be responsible for:

- The procurement of MPO (including the payload) and the propulsion modules integrated into the spacecraft composites.
- Integration of the JAXA supplied MMO into the BepiColombo composite.
- The launch preparation and procurement.
- The commissioning of the composite system MPO+MMO+CPM+SEPM in the early phase of transfer to Mercury.

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

Correspondingly, JAXA will establish an MMO Project Team at ISAS, directed by a MMO Project Manager, which will fulfil its function until the completion of the MMO commissioning phases in orbit around Mercury. JAXA, via the MMO Project Manager and his Project Team, will have overall responsibility for the MMO.

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

Specifically this will include the overall responsibility for:

- Composite transfer via gravity assists to Mercury
- Insertion of the MPO & MMO into their respective Mercury orbits
- Checkout of the MPO in Mercury orbit.
- Coordination of all operations between MMO & MPO

- MPO Science operations
- Archiving of MPO and MMO data products.

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

5.4 Monitoring of Instrument Development

The ESA Project Office (SCI-P), in close coordination with the Project Scientist and supported by the Science Payload and Advanced Concepts office (SCI-A) will monitor the progress of the design, development and verification of all BepiColombo IFE's. The IFE instrument consortia will have to demonstrate to ESA, 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).

6 SCIENCE OPERATIONS AND DATA

6.1 BepiColombo Operations Concept

ESA will be responsible for the launch and operations/checkout of the composite spacecraft (MMO+MPO) into Mercury orbit. After separation of the spacecraft, ESA will retain responsibility for operations, including data acquisition, transmission and distribution for MPO, whilst JAXA will provide these services for MMO.

ESA will establish the BepiColombo Mission Operations Centre (MOC), located at the European Space Operations Centre (ESOC). ESA will also establish a Science Operation Centre (SOC). The SOC will be responsible for the science operations of MPO and coordinate its actions with the MMO science operations conducted by JAXA. After MMO separation from the stack controlled by the ESA MOC, it is the responsibility of the equivalent JAXA MOC to perform Mercury in-orbit commissioning and support the MMO science operations.

6.2 Mission Operations Centre

The BepiColombo Mission Operations Centre (MOC) will be responsible for the operation and control of the spacecraft composite during the transfer phase as well as MPO and MMO orbit insertion. The MMO will then be controlled and operated by JAXA after separation from the stack.

The BepiColombo 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 near real time, the Principal Investigators with raw data from their 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;
- Providing and monitoring the data lines within Europe and between the European and Japanese centres as mutually agreed;
- Performing anomaly (out of limit) checks on a set of payload parameters in near real time;
- Notifying payload anomalies to the SOC/PI's.

ESA and JAXA will establish a data link between the European and Japanese centres to support the mission and the scientific data distribution, as part of the programme implementation.

6.3 Science Operations Centre

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

Key science operations responsibilities and functions include:

- Optimisation of the science return from the BepiColombo 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, to be implemented by the Mission Operations Centre;
- Preparation of guidelines supported by the PI teams, to create the BepiColombo ESA-JAXA science data archive.

The specific responsibilities of the Science Operations Centre, in coordination with the JAXA MMO Office, are:

- Preparation of Mercury environmental models (atmosphere and surface), in collaboration with specialists from the science teams;
- 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;
- Support of instrument operations during the commissioning;
- 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;
- Coordination with the MMO science operations centre at JAXA;
- Harmonisation of the science operations plans of MPO and MMO;
- Analysis (with MPO team support) of critical science data required for science operations purposes related to spacecraft navigation and orbit insertion;
- Preparation with the MPO investigators of summaries of scientific results at regular intervals and for mission highlights;
- Preparation of guidelines for science data archiving and creation of the BepiColombo ESA-JAXA scientific data archive for MPO and MMO;
- Support to Public Relations activities;
- Ensure the Knowledge Management over the long mission duration;
- 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's are:

- 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 during payload commissioning and critical operations
- Support of the definition and implementation of the BepiColombo ESA-JAXA scientific data archive, as part of the pre-launch tasks;
- Provision of support required by the Science Operations Centre and other PI's 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, to the BepiColombo ESA-JAXA scientific archive, at the end of the proprietary period;
- 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.

A coherent science operations programme for all spacecraft shall be endorsed by the SWT and will be conducted by the Science Working Groups, under the overall responsibility of the BepiColombo Project Scientist. The MPO-SWG and MMO-SWG will be charged with the definition of dedicated campaigns of observations, in compliance with their respective resource allocations and overall constraints.

During critical phases of the mission (commissioning, planetary flybys, orbit insertion, special campaigns) the MPO investigator team and the SOC will be co-located with the MOC at ESOC. For routine operations (e.g. interplanetary cruise), the Investigators and the SOC will interface with the MOC from their home institutions.

The science operations will be defined by the BepiColombo 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 facilities like Internet, electronic communications, video conferencing etc. In order to fulfil from the start their assignments for science operations, the PI's will require adequate support from their funding agencies, at the same time as resources for IFE development.

6.4 Data Rights

BepiColombo data will be made available in compliance with the established ESA rules concerning information and data rights and release policy. The MMO data sets will similarly be made available in compliance with decisions made by the MMO Science Working Group. Reduction of science data is under the responsibility of PI teams. Exclusive data rights reside with the PI team for a maximum of 6 months from receipt of the original science telemetry and auxiliary orbit, attitude and spacecraft status information. After this time, data will be made available by PI's to the scientific community at large through the ESA-JAXA science

data archive. The exclusive data rights will only commence once the instrument in-orbit commissioning has been completed.

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

The PI teams will provide records of processed data with all relevant information on calibration and instrument properties to the ESA-JAXA science data archive. The data format for the two spacecraft shall be compatible with those defined for the ESA-JAXA science data archive. The ESA-JAXA science data archive will be the repository of all mission products (MPO and MMO). ESA and JAXA will collaborate in ensuring a mission system view is achieved for data products from the BepiColombo mission. The ESA-JAXA science data archive, which will be compatible with the Planetary Data System (PDS), will be based on and part of the Planetary Science Archive (PSA) developed for Smart-1, Mars Express and Rosetta.

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 JAXA will be made.

The PI IFE teams will provide ESA with processed and useable data for Science Communication purposes as soon as possible after their receipt. The PI teams will also engage in supporting a Science Communication Plan that will be prepared by ESA in due time.

6.5 Communication and Public Outreach

6.5.1 PUBLIC OUTREACH

The BepiColombo 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 MPO/MMO Investigator must provide material and information for Public Relations to ESA and JAXA.

For the MPO ESA is the overall responsible for planning and coordinating with national agencies such an activity around the mission, while JAXA will have similar responsibilities for the MMO.

During the development phase of the mission, ESA and JAXA will set up web pages on the BepiColombo 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.

All communication plans concerning the mission will be generated and implemented when appropriate under the responsibility of the ESA Science Programme Communication Service, in coordination with JAXA. This Service will work in full coordination with the scientific individuals responsible for the mission (Project Manager, Project Scientist, Principal Investigators, etc.).

The active cooperation of all scientists involved in the BepiColombo mission in providing relevant information and results is expected for the success of the related communication activities.

ESA and JAXA will coordinate their Public Outreach activities.

6.5.2 SCIENCE COMMUNICATION

ESA will have the overall responsibilities for planning and carrying out science communication on BepiColombo. JAXA will retain responsibility for the MMO. A general outline of these activities will be provided under the form of a Communication Plan. This plan must be formally agreed - and adhered to - by the PI's.

The Project Scientist will initiate and publish project related progress reports and scientific results. Articles suitable for 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.

ESA and JAXA will inform each other about their science communication.

ACRONYMS

AO	Announcement of Opportunity
Co-I	Co-Investigator
Co-PI	Co-Principal Investigator
CGSE	Calibration Ground Support Equipment
D/SCI	Director of the Scientific Programme
EGSE	Electrical Ground Support Equipment
EID	Experiment Interface Document
EID-A	EID-Part A
EID-B	EID-Part B
EM	Engineering Model
ESA	European Space Agency
ESTEC	European Space Research and Technology Centre
FM	Flight Model
FOP	Flight Operations Plan
GI	Guest Investigator
GSE	Ground Support Equipment
IFE	Instrument Front End
IDS	Inter-Disciplinary Scientist
JAXA	Japanese Aerospace Exploration Agency
LOC	Letter Of Commitment by Lead Funding Agency
MGSE	Mechanical Ground Support Equipment
MIP	Mission Implementation Plan
MIRD	Mission Implementation Requirements Plan
MMO	Mercury Magnetospheric Orbiter
MMO-SWG	MMO-Science Working Group
MPO	Mercury Planetary Orbiter
MPO-SWG	MPO-Science Working Group
PI	Principal Investigator
P/L	Payload
PSD	Payload Study Document
PRC	Payload Review Committee
RSSD	Research and Scientific Support Department of ESA
S/C	Spacecraft
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
SSWG	Solar System Working Group
SWG	Science Working Group
SWT	Science Working Team
WWW	World Wide Web
3-D	3-Dimension

ANNEX

Table 1: BepiColombo MPO Reference payload

High Resolution Colour Camera
 Stereo Camera
 Limb Pointing Camera
 Visible-Near-IR Mapping Spectrometer
 Thermal IR Spectrometer/Radiometer
 Laser Altimeter
 Ultraviolet Spectrometer
 X-Ray Spectrometer
 Solar X-Ray Monitor
 Gamma-Ray-Neutron Spectrometer
 Radio Science Experiment Accelerometer
 Magnetometer
 Neutral Particle Analyser
 Miniature Plasma Analyser
 Planetary Ion Camera

Table 2: BepiColombo MMO Reference payload

Electron Spectrum Analyser (ESA) [x2]	Low energy electrons
Mass Spectrum Analyser (ASA)	Low energy ions (in magnetosphere)
Solar Wind Analyser (SWA)	Low energy ions (in solar wind)
High Energy Particle (HEP)	High energy electrons and ions
Energetic Neutral Atoms (ENA)	Energetic neutral atoms (imaging)
Magnetic Field Sensor (MGF) [x2]	DC magnetic field
Plasma Wave Instrument (PWI)	DC electric field, Plasma waves, radio waves
Mercury Dust Monitor (MDM)	Dust
Mercury Imaging Camera (MIC-A)	Na and K Atmosphere
Mercury Imaging Camera (MIC-S)	Surface imaging