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EUROPEAN SPACE AGENCY

SCIENCE PROGRAMME COMMITTEE

National Activities parallel to Cosmic Vision Studies

Summary

This note describes the general approach that is proposed by the Executive on the national activities for the Cosmic Vision studies, from mission assessment to mission adoption.

Required decision

The SPC is invited to take note and comment on the proposed approach for the national activities parallel to Cosmic Vision Studies.

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1. Introduction

This paper describes the general approach that is proposed by the Executive on the preparatory studies related to the implementation of the Cosmic Vision plan and the parallel national activities.

The general approach is directly inspired by the Science Programme Review Team (SPRT) report (ESA/C(2007)13, January 2007) and from the SPC response to this report (ESA/C(2007)19, position paper approved at SPC meeting of 22-23 February 2007). Emphasis is given here on payload study activities before mission adoption. The SPC/SPRT recommendations on payload developments, as approved by SPC, can be summarized as follows:

i) The traditional baseline of delivery of instruments to ESA by the Member States is maintained,
ii) Critical payload technology developments must be brought forward in time, for enabling a clear assessment of the technology readiness at the time of mission implementation decision,
iii) Phase A/B1 study level of the payload must be reached before the payload and the mission are finally adopted by the SPC. The phase B1 study would also allow assessing the payload suppliers and their ability to deliver prior to the mission implementation (phases B2/C/D)

The rationale presented in this note is the logical development of these recommendations. The document is divided in three sections:

Section 2 defines three payload categories depending on the procurement scheme. Although the mission assessment studies are just starting, a classification of the science missions is provided in this section, based on the Cosmic Vision mission proposals, with a preliminary identification of the instruments procured through Member State.

Section 3 details the general approach on payload activities during the Assessment and the Definition Phases.

Section 4 focuses on the activities during the Assessment Phase and addresses related organization aspects.

2. Payload Categories

An *instrument* is defined as the ensemble of elements intended for measuring a physical quantity by relying on some physical process. This definition is commonly used in instrumentation industry not limited to space activities. The instrument hardware starts from the input signal collection up to the digital output production representing the signal amplitude. Therefore, an instrument generally includes a signal collector (e.g. optics, coil etc), related mechanical and thermal hardware, detection and electronics assembly, and specific data handling electronics if any.

A *science instrument* is an instrument mounted on the spacecraft and dedicated to some science measurement defined by the mission science case.
A space science mission *Payload* is the assembly of science instruments mounted on the spacecraft.

The science payloads can be grouped in three categories depending on the payload procurement scheme:

Category A:
The payload is entirely under ESA responsibility and project funding (GAIA-type case) The case is characteristic of some Astrophysics missions and generally (but not necessarily) occurs when the two following conditions are met: 1) The payload consists of a large major instrument strongly inter-related with the spacecraft development, and 2) The payload technology is well mastered by space industry and can be efficiently developed within ESA geo-return rules and constraints,

Category B:
The payload is constituted of a number of instruments that are provided by science institutes through National Agencies funding. This case is typical of planetary missions such as Mars Express, Bepi-Colombo or Solar Orbiter,

Category C:
The payload is partly under ESA responsibility and budget (e.g. the telescope, a cryostat), with some parts of the payload – for example a cryogenic instrument, a focal plane assembly or a mechanism device – being proposed to be manufactured by science institutes using National Agency funding. This case is typical of most astrophysics observatory missions, such as XMM or Herschel. Often, the payload part that is built by institutes requires specific skills and sharp technologies that are used in a few institutes only.

Table 1 provides the corresponding categories for the selected CV mission studies with a preliminary indication of the Member State provision, as deduced from the mission proposals. Two missions, namely Plato and the Dark Energy mission, are single instrument missions that could logically fall in category A. They have been proposed in category C and will be treated as such, but will also be treated in the industrial studies as belonging to category A for the sake of efficiency. As explained below, the Instrument Teams who proposed to be in charge of elements of the payload will be encouraged to perform parallel studies of those elements, under National Agencies funding. A comprehensive flow of information will be ensured between these teams and the industrial study teams through ESA, the formal interface for the payload teams being the study scientist. This approach will preserve the possibility for the Instrument Teams to contribute to the Definition and Implementation Phases.

Mission	Payload category	Member state provision
Marco-Polo	B	Instrument suite
Cross-scale	B	Instrument suite
Laplace/Tandem	B	Instrument suite
Plato	C	Focal planes, and potentially the whole instruments.
Dark Energy mission	C	Focal planes (IR and VIS).
SPICA	C	Telescope provided by ESA. ESI cryo instrument provided by science institutes under ESA management.
XEUS	C	Optics under ESA responsibility, cryogenic elements TBD, focal plane instruments provided by institutes

Table 1: Payload cases, as resulting from the science proposals. Category A = ESA payload; Category B = Payload provided by institutes; Category C = Payload is shared between ESA and institutes.

3. General approach for payload activities before mission adoption

The preparation of mission adoption, which includes approval of payload and mission CaC, is conditioned on a successful outcome of the assessment and definition study phases. The study progress of a science instrument must be properly phased with that of the overall spacecraft, regardless which entity is funding the instrumentation activities. A number of consequences can be drawn from the SPC/SPRT recommendations and have been grouped in five major points.

3.1 Instrument Phase B1 study (corresponding to the spacecraft Definition Phase)

Before entering the spacecraft Implementation Phase of the mission (phases B2/C/D), the instrument definition must have reached phase B1 level, like the rest of the spacecraft, therefore including the detailed design of the instrument, a consolidated development plan (schedule and cost) and a consolidated definition of the instrument interfaces with the rest of the spacecraft.

The instrument phase B1 is assumed to be financed by the Member States. In accordance with the SPC response to the SPRT report, the instrument phase B1 has to be achieved with a good visibility to ESA, in particular implying the involvement of ESA experts in the instrument reviews at national level. Later on, in the Implementation Phase, ESA will closely monitor the instrument development and a Steering Committee with the appropriate composition will be in place issuing early warnings and discussing solutions in case of problems.

3.2 Instrument AO and team building

The instrument phase B1 (typically twelve months) will take place in parallel with the spacecraft Definition Phase, which lasts typically 18 months. Therefore, the instrument team building and its funding scheme must be defined at the beginning of the Definition Phase the latest, for having the instrument team operational at an early stage of this phase, typically within 3-4 months following the Definition Phase kick-off. This implies that the selection

process (AO, tender evaluation and selection) should be completed within 3-4 months following the Definition Phase kick-off.

3.3 Instrument activities during the Assessment Phase

In order to fulfil the schedule presented above, the Instrument phase A activities must logically be conducted by dedicated Instrument Teams funded by the Member States in parallel with the spacecraft industrial Assessment Phase.

In practice, each Cosmic Vision mission study will be conducted by an ESA team, including a Study Scientist, a Study Manager and a Payload Study Manager. The study scientist chairs the Study Science Team and is in charge for all science aspects for the mission. The study manager is the technical manager and is responsible of the study implementation and for mission programmatic evaluation. The payload study manager reports to the study manager and is in charge of coordinating all payload aspects, both technical and programmatic, for the study needs. Therefore, the study scientist and the payload study manager are privileged interfaces to the Instrument Teams.

Each Cosmic Vision study includes an internal ESA assessment, followed by two parallel and independent industrial studies over one year. It is assumed that the Instrument Teams will be in place at the beginning of the industrial studies and will work in phase with the industrial teams. At the end of the industrial and instrument team studies, two different mission concepts can potentially be produced. The synthesis of the studies will be made by the ESA team, with the support of the Study Science Team, leading to an Assessment Study Report where the science objectives, mission baseline, spacecraft and instrumentation characteristics will be presented including the programmatic aspects. The Assessment Study Report will be public and will constitute the common new starting point for the Mission Definition Phase studies for all parties. At this stage, the spacecraft and instrumentation should be sufficiently well defined for enabling a clear identification of the instruments (or instrument parts) that would be provided by Member States.

The payload procurement scheme will then effectively materialise at the beginning of the Definition Phase with the science instrumentation AO which will require Letters of Endorsement (LOEs) from the national agencies. The LOEs will constitute a preliminary agreement between ESA and the funding agencies, ensuring the instrument phase B1 funding. The contractual agreement for the instrument development (phases B2/C/D) will be formalized through the Multi-Lateral Agreements (MLAs) between all participating agencies at completion of the Definition Phase, when the mission is adopted.

The construction of Instrument Teams and their timely involvement in the Assessment Phase is essential for the implementation of the SPC/SPRT recommendations, and calls for practical organisation details that are addressed in section 4.

3.4 Instrument technology developments (L missions)

Critical basic technology developments of the science instruments must be completed before entering the Definition Phase. In the context of the Cosmic Vision studies, this is essentially applicable to L missions, since M missions are supposed to rely on demonstrated

technologies. As a general rule, Technology Readiness Level (TRL) 5 is requested at the start of the Definition Phase and TRL 5-6 at the start of the Implementation Phase.

It is assumed that the Member States will take in charge the technology developments of the instruments they are expecting to provide, while ESA will take in charge all technology developments related to the rest of the spacecraft. Therefore, for the sake of efficiency, it is important that the scope of the science institute activities is properly defined and agreed when building the mission technology development plan. For the case of elements that cannot be firmly placed under ESA or Member States direct responsibility, the approach is to coordinate the technology developments between the national agencies and ESA for both avoiding duplication of effort and enabling decisions on missing technology developments.

The June 2008 SPC workshop will initiate and implement as far as possible this coordination of technology developments between ESA and the National Agencies, on a time-scale of 3-4 years. It will be updated on a regular basis or when necessary.

3.5 Instrument pre-developments during the Definition Phase (L & M missions)

According to the general Cosmic Vision Plan, a science mission will be adopted only at the end of the Definition Phase. The competition between the missions will be an essential element in the overall process and will be maintained during both the Assessment and Definition Phases.

Therefore, as a general principle, prior to mission adoption, the investment on instruments to be supported by the Member States shall be sufficient for enabling the Implementation Phase. This includes the engineering work (phases A and B1) and the necessary technology developments that have been mentioned above for reaching TRL 5. But this may also include necessary hardware pre-developments during the Definition Phase, although the mission is not yet adopted at this stage.

A pre-development is defined as a hardware development that would not be mandatory before the Implementation Phase from the strict TRL standpoint (TRL $\geq$ 5) but that is mandatory for securing the overall spacecraft schedule. A typical example is the development of science instrument detectors: It is generally mandatory for schedule risk management to develop fully representative prototypes before entering the Implementation Phase, even if the detector relies on existing tool-kit technologies.

The need for pre-developments and the level of investment cannot be a priori defined and must be evaluated on a case by case basis through the development schedule risk analysis and clearly identified at the end of the Assessment Phase.

It is worth noting that the above approach is equally valid at spacecraft level: ESA investments will be reduced to the strict needs prior to the Implementation Phase, and spacecraft pre-developments will be conducted by ESA whenever dictated by the schedule risk and constraints, even if the mission is not yet confirmed.

4. Payload activities during the Assessment Phase

This section addresses the practical organisation scheme for the Payload activities that are expected to be conducted during the Assessment Phase. We consider here, for convenience, the case of a science instrument that would potentially be provided by Member States during the Implementation Phase, but the discussion equally applies to any instrument part, for example a focal plane assembly, a cryo-mechanism or some payload electronics.

Several questions are addressed here below:

- **In which cases is the instrument study requested during the Assessment Phase?**

  The study is requested for all new instruments and is expected to be of phase A level. Recurring instruments do not require a study. However, the studies for upgrade of existing instruments should be limited to new or modified areas.

  In the last two cases, the instrument provider will produce at least the available Interface Control Document for the purpose of the system studies, and will give sufficient visibility to the ESA study team for enabling an independent assessment of the instrument development risks and verification of the technology readiness level.

- **How to handle the instrument studies while preserving competition for the spacecraft and for the instrument at a later stage?**

  It is anticipated that in many cases, it will be necessary for confidentiality reasons, to monitor the information flow between the various Instrument Teams, between the Instrument Teams and the Science Team in case of conflict of interest, and between the Instrument Teams and the two industrial teams.

  Therefore, the instrument study teams will interface with the industrial system study teams through ESA. More precisely, the formal interface will be the ESA study scientist.

  Regarding the instrument competition, there is no objection on ESA side for having two or more Instrument Teams working on the same object during the Assessment Phase, potentially with different instrument designs. The ESA study team will have to monitor the instrument interfaces that would be produced by the various teams and to inject relevant inputs in the industrial system studies. As mentioned in section 3.3, a synthesis work is required anyhow at spacecraft level at the end of the two parallel industrial studies, and will be made by ESA with the support of the study science team. This synthesis will include instrumentation aspects whenever necessary.

  The instrumentation requirements and technical interfaces will be made visible to all parties. They are initiated by the study science team at the beginning of the Assessment Phase and expressed in the Payload Definition Document (PDD). The PDD is an input document to both industrial and Instrument Teams and will be coordinated and maintained by the ESA payload study manager during the Assessment Phase.

During the studies, the instrument science requirements will be monitored by the study science team, under the responsibility of the study scientist. An appropriate reporting to the study science team will be made by the study scientist on the instrumentation study progress.

The instrument technical design will be followed by the ESA payload study manager with the support of ESA experts through dedicated technical meetings to be held at ESTEC. It is anticipated that Member States who are funding the instrument studies will participate to these meetings, enabling a continuous and efficient interaction between ESA and Member States representatives during the Assessment Phase and a smooth transition to the Definition Phase.

- **What is the scope of activities to be handled by the science Instrument Teams?**

  The instruments or instrument parts to be considered are already defined in the Cosmic Vision science proposals and are briefly recalled in the Table 1 above. They will be confirmed as potential items that could be provided by Member States subject to the following conditions:

  i) The instrument must be confirmed by the Study Science Team at the beginning of the Assessment Phase, and reflected in the Payload Definition Document,
  ii) The item to be provided must have clear and viable technical interfaces,
  iii) Availability of a "Declaration of Interest" for the instrument by a team of institutes, appropriately supported by national agencies.

  A very important point should be clarified at this stage, in particular regarding M missions: An instrument or more generally any object can be proposed to be built by some instrument team through a national funding scheme. This object can be studied by this team during the Assessment Phase, but this does not necessary imply that the object will be developed by this team in the Implementation Phase. As mentioned above (see 3.2 and 3.3), the final procurement scheme for the science instruments will be consolidated only after technical conclusions of the Assessment Phase and will materialise at the beginning of the Definition Phase, through a competitive Announcement of Opportunities and LOEs with the national agencies.

  Conversely, if an instrument is seriously intended to be provided by a consortium of science institutes, it is mandatory to have an instrument Phase A study team in place during the Assessment Phase. Otherwise, the instrument team will hardly be in a position of making a phase B1 proposal at the beginning of the Definition Phase as planned.

- **What is the practical procedure and the foreseen schedule for having the Instrument Teams in place, with appropriate funding from the Member States Agencies?**

  Each Cosmic Vision mission study will proceed through the following four steps:

  - Step 1: Definition of science requirements and first issue of the Payload Definition Document,
  - Step 2: Internal ESA assessment and industrial ITTs,

- Step 3: Parallel industrial studies
- Step 4: Synthesis and Assessment Study Report for the mission down-selection.

The building of the Instrument Teams should take place in step 2 (typical duration about 4 months).

The instrument studies should be conducted during step 3 (typically one year), in phase with the industrial studies.

The proposed practical procedure is the following:

i) At the end of step 1, ESA will issue a Call for "Declaration of Interest" towards the European instrumentation community, with copy to the Member States.
ii) Within three months, the Instrument Teams will produce the Declaration of Interest, which shall include key information on the instrument study: team organisation and heritage, work description, study logic and expected funding scheme. The Instrument Teams will send a copy of their Declaration of Interest to the relevant Member States.
iii) ESA will close the loop with the concerned Member States, who will be invited to confirm their support. Meeting plan and study details would then be consolidated and agreed.

The above procedure will be applied for each Cosmic Vision study. M and L missions will be addressed separately, since the two classes of missions do not have the same schedule and are not treated in the same manner for what regards technology developments (see paragraph 3.4). ESA is currently doing its best for minimizing the schedule dispersion between the M mission studies, to within 3 months.

- **What is the follow-up process for the Member States Agencies**?

The Member States follow-up will be provided in particular through the technical progress meetings involving the instrument study team, ESA experts and Member States representatives. This mechanism will be maintained during the Definition Phase, and the follow-up team constituted by ESA and Member States representatives will pre-figure the Steering Committee that will be put in place during the Implementation Phase.

5. Conclusion

The SPC is invited to take note and comment on the overall approach developed in sections 3 and 4. The approach should be implemented in the coming months, since the first industrial assessment studies are planned to start by June 2008.