PLATO
PLAnetary Transits and Oscillations of stars
Science Management Plan

October 26, 2020

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1 INTRODUCTION

The *PLAnetary Transits and Oscillations of stars* mission (PLATO) is the M3 mission in ESA's Cosmic Vision 2015-2025 Programme. PLATO aims at finding and studying a large number of extrasolar planetary systems, with emphasis on the properties of terrestrial planets in the habitable zone around solar-like stars. PLATO aims also at investigating seismic activity in stars, enabling the precise characterisation of the planet's host star, including its age.

The Science Management Plan (SMP) describes the approach that will be implemented to ensure the fulfilment of the scientific objectives of the PLATO mission and to optimise its scientific return, with special emphasis on payload procurement, science operations and data generation and management.

The SMP includes a summary of the main features of the mission (Section 2), followed by a description of the mission operations, the ground-based observation strategies and the data generation approach and data rights (Sections 3 and 4). Then the SMP describes how the scientific community can participate in the mission (Section 5). The plan outlines the tasks and responsibilities of PLATO mission stakeholders up to the data distribution and archiving (Sections 6 and 7) and the principles for the publication policy (Section 8). Finally, it describes the key aspects for the implementation of an outreach plan (Section 9).

2 MISSION OVERVIEW

2.1 Science Objectives

The PLATO mission will detect and characterise a large number of extrasolar planetary systems, including terrestrial exoplanets around bright solar-type stars orbiting in the system, also in the habitable zone. PLATO will provide accurate determinations of the planet radii, stellar irradiation, architecture of planetary systems and evolutionary ages/stages. In combination with ground-based observations, PLATO will provide accurate planetary masses and mean densities.

The overall scientific questions that PLATO will investigate are:

- O1. How do planets and planetary systems form and evolve?
- O2. Is our Solar System special or are there other systems like ours?
- O3. Are there potentially habitable planets?

The scientific objectives that PLATO will address are the following:

- *Determine the bulk properties (mass, radius and mean density) of planets in a wide range of systems, including terrestrial planets in the habitable zone of solar-like stars*

  PLATO will determine planet bulk properties to explore the diversity of planets which in turn allows us to constrain planet formation models. Furthermore, terrestrial planets in the habitable zone will be identified that will be prime candidates for being potentially habitable planets.

- *Study how planets and planet systems evolve with age*

  The age of planetary systems provides new constraints on planet formation models and allows the planetary (system) properties to be correlated with temporal evolution processes when the ages of planet hosts are accurately determined. Furthermore, the seismic characterisation of a large sample of bright stars across the HR diagram will lead to improved stellar models, allowing for substantially more reliable age characterisation of stars in general.

- *Study the typical architectures of planetary systems*

  The architecture of planetary systems includes parameters such as the distribution of planet masses and types (terrestrial or gaseous) over orbital separation, the co-planarity of systems, and orbital parameters in general. These provide constraints on planetary system formation and evolution processes.

- *Analyse the correlation of planet properties and their frequencies with stellar parameters (e.g., stellar metallicity, stellar type)*

  The correlation of planet parameters with stellar properties provides constraints on planet formation and allows the planetary diversity to be characterised. Stellar properties are furthermore key parameters in the study of the potential habitability of planets.

- *Analyse the dependence of the frequency of terrestrial planets on the environment in which they formed*

  Planets form in different regions of our Galaxy, in clusters and around field stars. Correlations of planet occurrence frequency with their environment will provide constraints on planetary formation processes.

- *Study the internal structure of stars and how it evolves with age*

  Determining planet host star parameters requires improving today’s stellar models and stellar evolution in general by measuring asteroseismic pulsations of stars. Well-known stellar models from asteroseismology and cross-calibration with classical methods will be key in obtaining planet host star parameters to address the overall science goals.

- *Identify good targets for spectroscopic follow-up measurements to investigate planetary atmospheres*

  Planets identified around the brightest stars will represent the “Rosetta stone”-like objects for spectroscopic follow-up. This will allow their atmospheric structure and composition to be investigated. These planets will provide a wealth of information by which to study planetary formation and evolution and, for terrestrial planets, study potential habitability.

In addition, PLATO will address a large number of complementary and legacy science topics. Asteroseismology analyses of massive stars and compact stars at the end of their lives will be undertaken. Due to its capability to observe in many directions of the sky, PLATO will sample a much wider variety of time-variable phenomena in various populations of the Galaxy than hitherto. PLATO's asteroseismic characterisation of stellar ensembles, binaries, clusters and populations will be a significant addition to the Gaia data. For example, PLATO will be able to determine accurate ages of red giant stars up to 10 kpc in our Galaxy which, together with the information on distances and chemical composition obtained by the Gaia mission, will significantly enhance our knowledge of the structure and evolution of the Milky Way.

2.2 Mission Description

In order to achieve its scientific objectives, PLATO will perform uninterrupted high precision photometric monitoring of large samples of stars during long periods (up to several years) to detect and characterise planetary transits. The PLATO photometric data or light curves will also contain information on the seismic activity of the stars. The analysis of the light curves will lead to the determination of planetary radii, ages and orbital inclinations. Candidate planets detected by PLATO will be confirmed with ground-based observations. Planetary masses will be determined through the study of transit time variations, or through radial velocity measurements carried out in ground-based observatories.

PLATO is planned to be launched from Kourou. It will perform its scientific observations in an operational orbit around the Earth-Sun Lagrange Point 2 (L2). The duration of the nominal mission operations is 4 years, but the satellite will be built and verified for an in-orbit lifetime of 6.5 years and will accommodate consumables for 8.5 years operations.

The PLATO spacecraft is three-axis stabilised and has a mass of approximately 2000 kg.

The instrument consists of four groups of cameras with CCD focal planes, operating in white light and providing a very wide field of view (FoV). The CCDs will monitor stars with $m_V > 8$. This multi-telescope design enables a large FoV, dictated by the paucity of bright stars, and the collecting area required to achieve high sensitivity. Two additional “fast” cameras will be used for observing stars with m_V ~4–8, and as fine guide sensor for the spacecraft attitude control system. The cameras are based on a fully dioptric design with 6 lenses and will be mounted on an optical bench.

Planned mission phases and milestones are as follows:

- Launch (L): T_0
- End of Launch and Early Operations Phase, Transfer and Commissioning phase: L + 3 months
- End of nominal science operations: L + 4.25 years
- End of post-operations phase: L + 7.25 years

2.3 PLATO measurement plans and expected results

The scientific objectives mentioned in Section 2.1 will be achieved by carrying out the measurements summarised in Table 1 where also the expected results are indicated.

Table 1. Measurements and expected results for the PLATO mission

Overall scientific questions (see Section 2.1)	**Scientific objectives**	**Measurements**	**Expected results**
O1, O2, O3	S1. Determine the bulk properties (mass, radius and mean density) of planets in a wide range of systems, including terrestrial planets in the habitable zones of solar-like stars	Photometry of ~>15,000 (goal 20,000) solar-like stars with $m_V \leq 11$ and precision of 50 ppm in 1 hour. RV spectroscopy for >100 (goal: 400) planets.	A sample of >100 (goal: 400) exoplanets, characterised for their orbits, radii (accuracy better than 3% for m_V=10, and better than 5% for m_V=11) and masses (accuracy ~10%) over a wide range of physical sizes and mean densities, including >5 (goal: 30) (super-)Earths in the habitable zone of solar-like stars.
O1, O2, O3	S2. Study how planets and planet systems evolve with age	Asteroseismology for > 5,000 stars with $m_V \leq 11$ and photometric precision better than 50 ppm in 1 hour.	A sample of >100 (goal: 400) bright planetary host stars with accurate ages (~10%) and planets with accurate densities.
O1, O2	S3. Study the typical architectures of planetary systems	Photometry of >245,000 stars with $m_V \leq 13$. RV spectroscopy for >100 (goal: 400) planets Mass determination from TTVs when possible, and upper mass limits.	Planet distribution of orbital parameters for >4,000 (goal: 7,000) planetary systems (with less accurate masses than S_1); for >100 (goal: 400) planets, with accurate masses (~10%); for a sub-set of planets, with TTV determined masses.
O1, O2, O3	S4. Analyse the correlation of planetary properties and their occurrence rates with stellar parameters (e.g., stellar metallicity, and stellar type)	Photometry of >15,000 stars with $m_V \leq 11$ and precision of 50 ppm in 1 hour; observations of 245,000 stars with $m_V \leq 13$. Observations of cool late-type dwarf stars with $m_V \leq 16$ Observations of 300 stars across the HR diagram with two-colour measurements. RV spectroscopy for >100 (goal: 400) planets; Mass determination from TTVs when possible, and upper mass limits.	Well-known stellar parameters (age accuracy ~10%) for >5,000 stars, leading to improved stellar models. Characterised host stars of hundreds of planetary systems.
O1	S5. Analyse the dependence of the frequency of terrestrial planets on the environment in which they formed	Photometry of >245,000 stars with $m_V \leq 13$.	A sample of >4,000 (goal: 7,000) detected planetary transits from different regions in the sky.
O1, O2, O3	S6. Study the internal structure of stars and how it evolves with age	Asteroseismology for > 5,000 solar-like stars with $m_V \leq 11$.	A sample of >5,000 bright solar-like stars for which asteroseismic modes can be

			analysed with high precision to improve stellar models (age accuracy ~10%).
O1, O3	S7. Identify good targets for spectroscopic measurements to investigate planetary atmospheres	Photometry of ~1,000 stars with $m_V \leq 8$ and precision of -50 ppm in 1 hour. Photometry of 5,000 cool late-type dwarf stars with $m_V \leq 16$.	A sample of >10 (goal: 30) planets around bright stars and >100 planetary transits around cool late-type dwarfs from different regions in the sky.

The PLATO mission will rely on successful operations of the PLATO spacecraft and on the support of ground-based observations for the confirmation of candidates (filtering observations to eliminate false-positive from the planet candidate list) and the characterisation of planets (radial velocity, RV, observations to derive the planetary mass for the confirmed planets). All scientific objectives listed in Table 1, with the exception of S6, rely on the availability of space-borne and ground-based data.

The best estimates of the number of nights for ground-based telescopes of different sizes, needed to fulfil the PLATO requirements, are reported in Table 2.

An appropriate strategy of access to ground-based facilities will be put in place in order to guarantee the achievement of the PLATO mission objectives (see Section 5.2.3).

Table 2. Estimates of ground-based telescope resources.

Telescope Class	**Candidate Confirmation**		**Radial Velocity Measurements**		**Total Nights**
	(Nights/year)	(Total nights in 7 years)	(Nights/year)	(Total Nights in 9 years)	
1-2 m, low-resolution spectroscopy	~ 35	~ 245	-	-	~245
1-2 m, high-resolution imaging	~ 15	~ 105	-	-	~ 105
1-2 m, on-off photometry	~ 10	~ 70	-	-	~ 70
1-2 m, high-resolution spectroscopy			~ 3	~30	~ 30
4 m, high resolution spectroscopy	~ 20	~ 140	~ 100	~ 900	~ 1040
8 m, high resolution spectroscopy	~ 5	~ 35	~ 80	~ 720	~ 755

Note 1: The observations for candidate confirmation are dimensioned to include all transiting candidates in the "prime sample" as defined in Section 4.2. Confirmation observations would be needed for a 7-year period. The time span assumed for the radial velocity observations is 9 years.

Note 2: The numbers reported in the Table are global for northern and southern sky visibility.

3 OVERVIEW OF THE MISSION MANAGEMENT SCHEME

This section illustrates the overall management scheme for the PLATO mission. The key participants contributing to the PLATO mission are identified and their relations sketched in Figure 1. Their responsibilities and tasks are introduced here below and are described in more details in the following sections of the document.

The overarching responsibility for all aspects of the PLATO mission rests with ESA's Directorate of Science**.** Details on ESA's responsibilities are reported in Section 6 and Section 7.1.

During the development and commissioning phases, ESA-appointed Project Managers will be responsible for implementing and managing ESA's activities. After a successful In-Orbit Commissioning Review, a Mission Manager will take over the responsibility for the mission.

The PI and CoPIs of the PLATO Mission Consortium (PMC) will act as the formal point of contact between the PMC and ESA. Details on PMC's responsibilities are reported in Section 6 and Section 7.2.

In preparation for and during the operation of the mission, the PMC will be responsible of generating, according to the strategy and the timeline described in Section 4.2, the PLATO Input Catalogue (PIC), containing the list of targets to be observed for each spacecraft pointing, and of defining a "prime sample", consisting of PIC targets to be observed with high PLATO accuracy.

In order to fulfil the PLATO scientific objectives, the Ground-based Observation Programme (GOP) will play an important role, as it is necessary for the confirmation and characterisation of planets (see Section 2.3). For this, the PMC will be responsible for the establishing and managing the activities of the GOP Team(s), who will have to respond to calls issued by ground-based facilities (e.g., ESO) to grant observing time for the confirmation and characterisation of the candidates in the "prime sample", as detailed in Section 5.2.3.

A Science Working Team (SWT) will be appointed by ESA after the PLATO mission adoption. The SWT will be asked to review and endorse top-level requirements (in all areas of the project) that impact science return. In particular, the SWT will supervise the preparation and periodic update of the PIC and "prime sample" list (see Section 4.2). Details of the SWT composition and responsibilities are reported in Section 7.1.2.

The ESA PLATO Project Scientist (PS) will chair and coordinate the SWT activities and will be the agency's interface with the PMC PI and co-PIs for all scientific matters.

The space- and ground-based observing strategies, including planet ranking approach, PIC and "prime sample" definition, and parameter validation process will be reviewed under the responsibility of the ESA Advisory Structure before launch and in the course of operations as needed, e.g., following updates of the PIC and of the "prime sample" and/or based on the findings of PLATO.

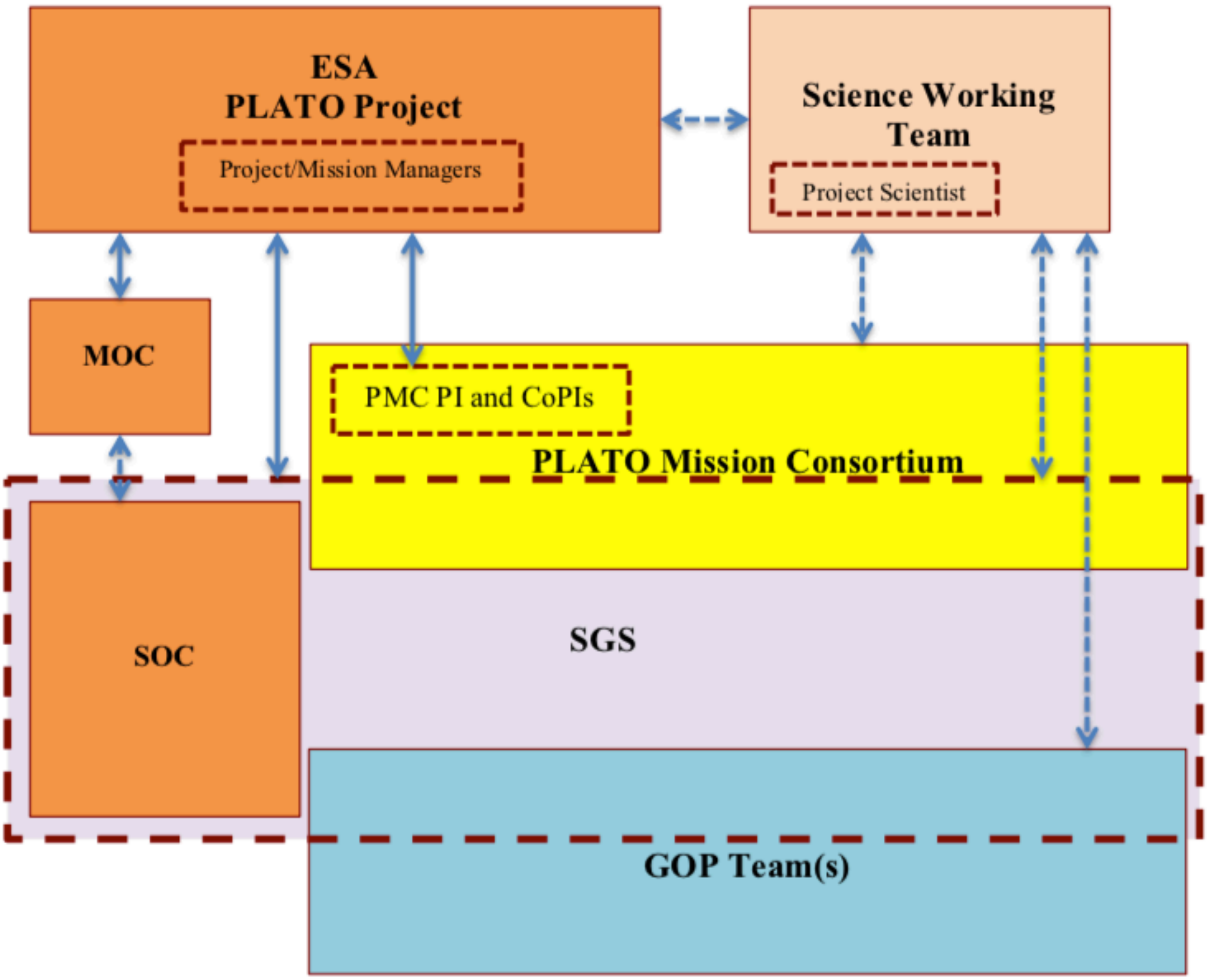

Figure 1. Overview of the PLATO mission management scheme.

Note: Arrows indicate main reporting (solid) or coordination (dashed) lines.

4 OPERATION STRATEGY AND DATA PRODUCTS

This section defines the different levels of data products (Section 4.1) and how they are obtained from PLATO and the necessary ground-based observation programme (Section 4.2). The timeline for data delivery is also reported (Section 4.3).

4.1 Data product definitions

PLATO data products are divided into the following categories:

Level-0 (L0):

- The imagettes[1] of selected targets for all individual telescopes.
- The validated light curves and centroid curves of selected targets for all individual telescopes. These are all the downloaded light curves (one each from each star and from each telescope) as well as the centroid curves, validated by assessing the quality and integrity of the data. They do not include instrument corrections other than those already applied on-board.
- Housekeeping data.
- Ancillary data, e.g., pointing information.
- Quality control data

Level-1 (L1):

- The calibrated light curves and centroid curves for each target, corrected for instrumental effects such as those related to temperature sensitivity, some specific CCD corrections, and a posteriori jitter correction. Level-1 treatment includes the derivation from the imagettes, when available, of the light curves and centroid curves. Moreover, for the normal telescopes and for each star, the Level-1 light curves and centroid curves are (suitably) averaged, and an associated uncertainty is provided.
- Processed imagettes of selected targets and images of sky regions.
- Ancillary data, e.g. pointing information.
- Associated calibration data.
- Quality control data

Level-2 (L2):

- The planetary transit candidates and their parameters, as a minimum target identifier, planetary ephemeris of the system, depth and duration of the transit, estimated radius, and their corresponding uncertainties.
- The results of the asteroseismological analysis, and their corresponding uncertainties.
- When possible, the stellar rotation periods and stellar activity properties inferred from activity-related periodicities in the light curves.
- The seismically-determined stellar masses, radii and ages of stars, (and their formal uncertainties), obtained from stellar model fits to the frequencies of oscillation.

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[1] Each assigned target star will be allocated a CCD window around it from which all the pixel values will be read out and transmitted to ground, forming a small image called an "imagette".

- The list of planetary systems confirmed through the detection of Transit Time Variations (TTVs), which will be characterised by combining information from the planetary transits and the seismology of the planet-hosting stars.

Level-3 (L3):

- The list of confirmed planetary systems, which will be fully characterised by combining information from the planetary transits, the seismology of the planet-hosting stars, and the results of ground-based observations.

Ground-based observations data (Lg):

- Ground-based observations for filtering false planet transit detections include:
  - Low-precision spectroscopy (1-2 m telescopes);
  - High-resolution imaging (2 m telescopes);
  - On and off transit photometry (1-2 m telescopes);
  - High-resolution spectroscopy (4-8 m telescopes);
  - Rossiter-McLaughlin (RM) observations (8 m telescopes).

From these ground-based observations, false-positives will be identified and the number of targets for the next steps reduced.

- Ground-based observations for the characterisation of planets include:
  - High-resolution spectroscopy (1-2 m, 4 m and 8 m telescopes);
  - Rossiter-McLaughlin (RM) observations (8 m telescopes).

For these ground-based observations raw, calibration and processed data will be made available. From these observations, high precision measurement of radial velocity variations of the central star will be obtained. Cross-correlation function results (or equivalent products used for RV estimates) will be available together with the spectra and derived radial velocities.

4.2 Operations and baseline ground-based observations strategy

PLATO's baseline observing strategy during nominal science operations foresees two Long-duration Observation Phases (LOP), consisting of continuous observations of two sky regions, lasting 2 years each, and filling the nominal operations.

The present baseline scenario will allow the PLATO mission to achieve the objectives described in Section 2.3, and can be reassessed later in the mission development if required by the evolution in the scientific context, without affecting the mission design.

For each LOP, the list of targets to be observed will be identified and compiled in the PLATO Input Catalogue (PIC). A first version of the PIC with the targets in the first LOP sky field will be delivered by the PMC to the SWT two years before launch. Updates of the PIC are planned nine months before launch and six months before the start of each LOP. Other fine tunings on the PIC are possible at any time during mission operations following the mission planning cycle (see Figure 3).

A "prime sample" will be defined by the PMC consisting of PIC targets to be observed with high PLATO accuracy. It is expected that the size of the "prime sample" will not be larger than 20,000 stars. The “prime sample” with the targets in the first LOP sky field will be defined nine months before launch and updated six months before every satellite sky field pointing (see Figure 3). A ground observation programme (GOP) will be performed for planetary candidates within this sample during the course of the mission. The best estimate of the ground-based observation time needed for these planetary candidates is given in Table 2.

Before launch, the final observation plan, the PIC and the definition of the “prime sample” will be prepared by the PMC, under the supervision of the SWT and reviewed under the responsibility of the ESA Advisory Structure. Reviews will be done in the course of operations as needed, following updates of the PIC and of the “prime sample” and/or based on the findings of PLATO.

As indicated in Section 3, to fulfil the PLATO scientific objectives, the Ground-based Observation Programme (GOP) will play an important role, as it is necessary for the confirmation and characterisation of planets (see Section 2.3). For this, the GOP Team(s) will perform the observations, as illustrated in Section 5.2.3.

The planet ranking approach, ground-based observation strategies and parameter validation process will be reviewed, under the responsibility of the ESA Advisory Structure, 1 year before the PLATO launch and, then, regularly during the operation phase of the mission.

The flow diagram for PLATO operations, ground-based observations and data generation is summarised in Figure 2 and the timeline described above is shown in Figure 3.

ESA will implement and populate the PLATO Science Archive to make the PLATO products available to the community.

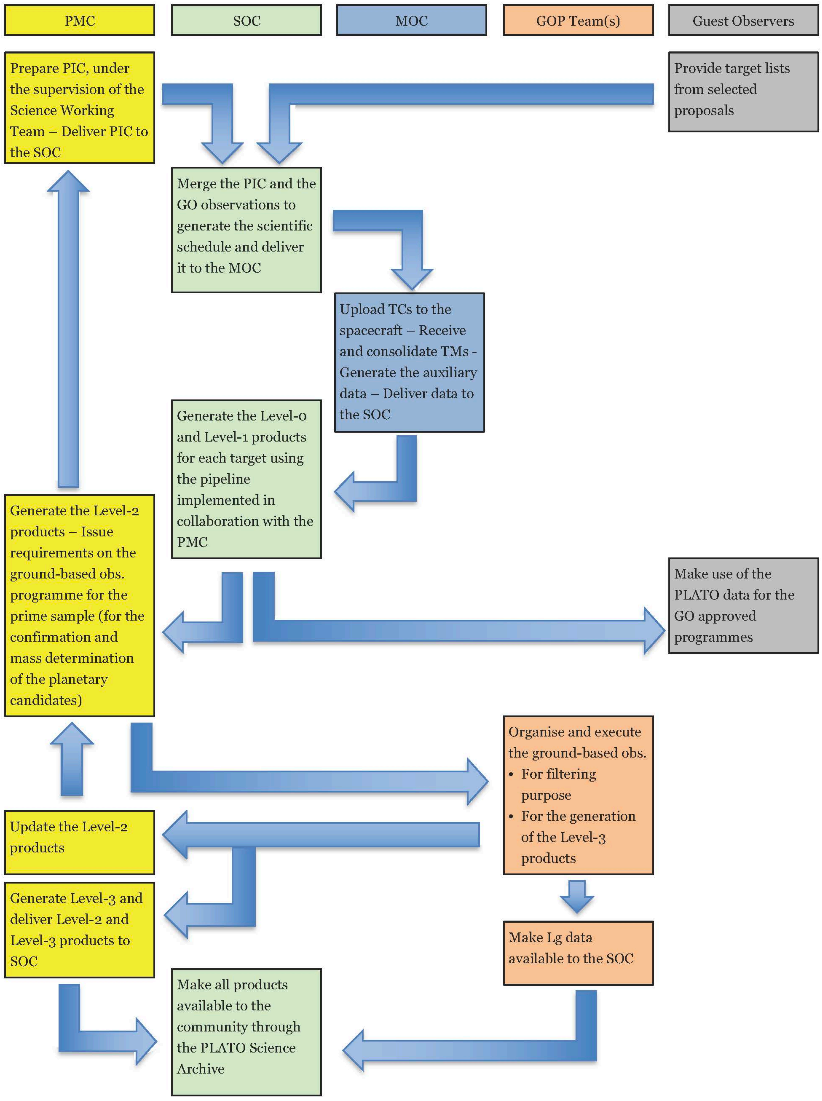

Figure 2. Flow diagram of PLATO operations, ground-based observations and data generation.

<u>Note</u>: *The SWT will monitor the development of PLATO operations as detailed in Section 7.1.2.*

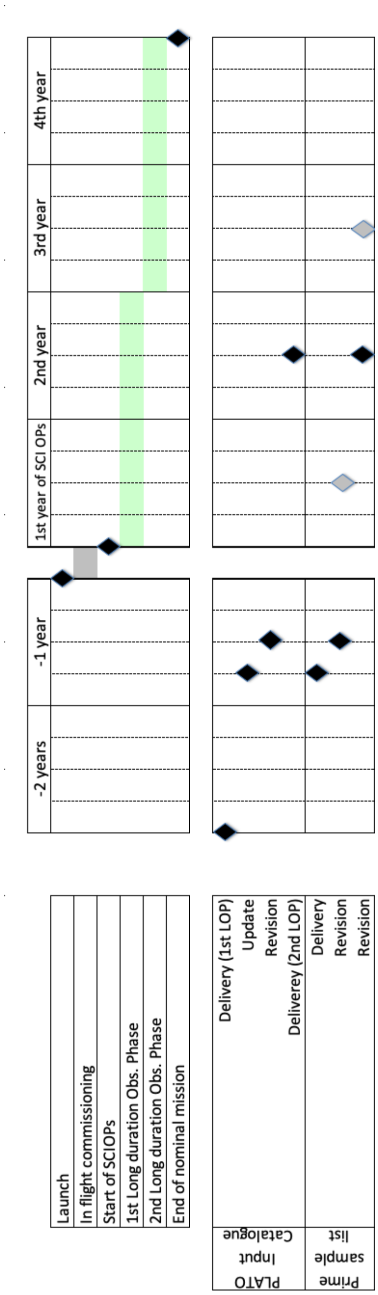

Figure 3. Timeline for operations, PLATO Input Catalogue generation and "prime sample" list generation.

4.3 Data product releases and rights

The ownership, access, use, and dissemination of PLATO raw and calibrated data and of information, data, and intellectual property produced by the analysis of data is governed by Chapter III, Sections II and III of the Rules on Information, Data and Intellectual Property, ESA/C/CLV/Rules 5 (Final), as adopted by the ESA Council Resolution on the Rules concerning Information, Data and Intellectual Property, ESA/C/CLV/Res. 4 (Final).

Level-0 and Level-1 products for all PLATO observed targets, including the Guest Observer (GO) programme observations will be generated by the SOC.

Level-2 products will be generated by the PMC and delivered to the SOC for all observed targets, excluding those from the GO programme (see Section 5.2.2).

Level-3 products for the planets of the “prime sample” (see Section 4.2) will be generated by the PMC with inputs from the GOP Team(s) (see Section 5.2.3).

The ground-based observations for the remaining candidates may be carried out by the scientific community at large as part of the PLATO legacy. ESA will invite these observers to provide their data and results, to make them accessible also through the PLATO Science Archive.

The release of PLATO data products of the “prime sample” will be as follows:

1. After delivery of Level-0 and Level-1 products for the first three months of observations by the SOC to the PMC, Level-1 data validation (and updating of the pipeline) will last for six months;
2. After delivery by the SOC to the PMC of Level-0 and Level-1 products for subsequent three months observing periods, the Level-1 data validation will last for three months;
3. Level-0, Level-1 and Level-2 products for each observing quarter will be publicly released via the PLATO science archive as soon as possible after scientific validation, but no later than one year after each Level-1 validation period, to allow for the consolidation of the planet candidate list and the initiation of the ground-based observations by the GOP Team(s).

The three months period of observation and of data processing correspond to the time interval between the 90° rotations of the spacecraft. The “data delivery” timeline is shown in Figure 4.

Data products up to Level-2 of targets not included in the “prime sample” will be publicly released within three months of the corresponding Level-1 validation period.

The identification of the planet candidates and, therefore, the kick-off of the ground-based observations for each target will depend on the quality of the transit detection and on the period of the planet. For the most challenging cases of planets with ~1-year period, it may take ~2 years to observe and confirm the transit. After that, ~1 year will be needed for confirmation of the planet by ground-based observations and ~2 years to carry out the radial velocity observations. For shorter period planets, the timeline will be correspondingly shorter, as shown in Figure 4. Ground-based observations will continue after the end of nominal science operations, for planet confirmation and for radial velocity measurements as indicated in Table 2.

Level-3 data of the “prime sample” (delivered by the PMC), and their ground-based associated observations (provided by the GOP Team(s)), will be publicly released immediately after the publication of the planetary parameters, or as soon as possible but no later than six months after the completion of the ground-based observations (see the examples in the “prime sample” in Figure 4). When papers are published by the PMC and/or GOP Team(s) using data from proprietary targets, the validated data associated with those targets will be simultaneously publicly released in the PLATO Science Archive.

Ground-based observations data for targets in the “prime sample”, which are not confirmed to be planets, will also be made publicly available in the PLATO Science Archive as soon as possible but no later than six months after the ground-based observations for each target have been performed.

The previous approach excludes all the products associated with the proprietary targets allocated to the GO programme (see Section 5.2.2) and to the PMC for which the following approach will be followed:

1) The proprietary targets allocated to the PMC will be selected using the first three months of PLATO observation of each field, in the following way: from the "prime sample" with brightness $m_v < 11$ for each sky field, the stars belonging to the lowest quartile (25 %) of the noise distribution will be identified. Of these, 25% will be selected, with a noise distribution similar to that of the original sample;
2) The maximum number of proprietary targets allocated to the PMC will not exceed 2000 in total over the 4 years of nominal mission duration. The proprietary target list will be submitted by the PMC to ESA for review and approval by the ESA Advisory Structure;
3) The GOP Team(s) will be fully involved by the PMC in the scientific exploitation of the proprietary targets.

For GO and proprietary targets, the following proprietary times will be granted:

1) The proprietary period of the targets selected through the GO programme call will be one year, starting at the time of the delivery to the observer of the last portion of the relative Level-1 data. During the execution of the observations, the SOC will deliver Level-0 and Level-1 products to the observer every three months (see "Guest Observers" timeline in Figure 4).
2) The proprietary period for each proprietary target allocated to the PMC will end six months after the completion of the ground-based observations for the confirmation and characterisation of the associated planet, as defined in the plan of the ground-based observations (see examples of "proprietary target" timeline in Figure 4). The proprietary period will finish in any case at the end of the mission post-operations phase (see Section 2.2).

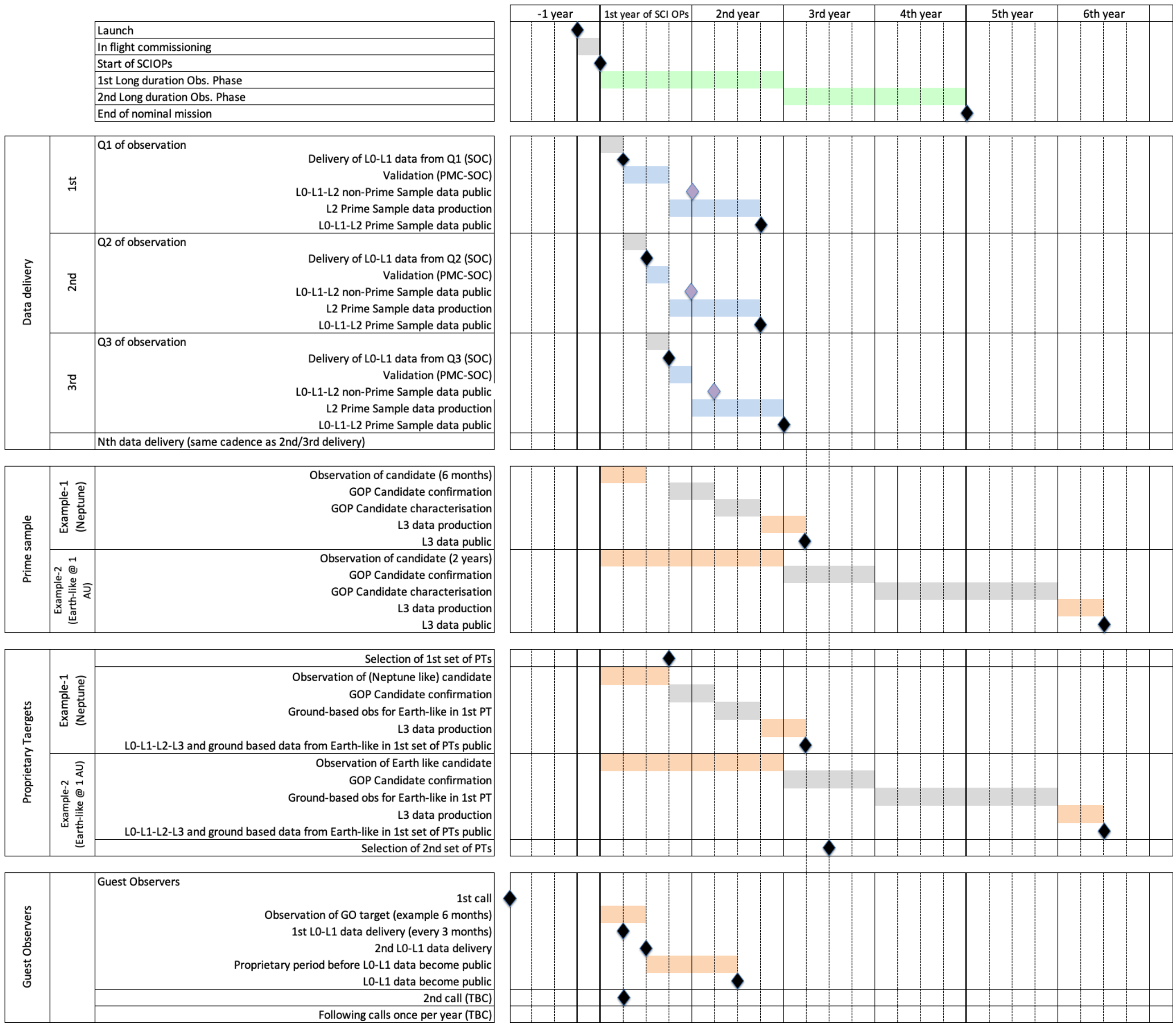

Figure 4. Timeline of data product generation and release.

<u>Note</u>: *The data delivery sequences for the 2nd LOP will follow the same cadence as illustrated in the figure for the 1st LOP.*

5 PROGRAMME PARTICIPATION

5.1 PLATO Mission Consortium

As indicated in Section 7.2, the PLATO Mission Consortium (PMC), under the leadership of the PI and the CoPIs, will provide key payload hardware and software according to the agreed interfaces and schedule, support the operations of the instrument throughout the mission lifetime, and provide the contributions to the SGS as listed in Sections 6.2.2 and 7.2.

The PMC internal structure and participation mechanisms are not regulated by ESA. Members of the scientific community interested to become members of the PMC for scientific purposes can submit a request through a PMC member. They should:

- Provide a well-defined contribution to the PMC,
- Accept to maintain confidentiality of PLATO non-public data,
- Adhere to the PMC publication policy.

The requests will be evaluated by the PMC,-based on the proposed contribution.

A list of PMC members is publicly available on the PMC web-site.

5.2 The Scientific Community

The scientific community will be able to participate in the PLATO mission as:

- Member of the PMC (see Section 5.1);
- Community and Ground-based observations scientists in the Science Working Team (SWT) (see Section 5.2.1);
- Guest observer (see Sect. 5.2.2).
- Member of the GOP Team(s) (see Section 5.2.3);

In addition, the science community will be able to access all science products available in the PLATO Science Archive, after any proprietary period has expired.

5.2.1 Community and Ground-based observation Scientists in the SWT

To gather independent advice for optimising the exploitation of the PLATO mission by the general scientific community, two Community Scientists will be appointed by ESA to the SWT**.** Their main responsibility will be to advise ESA on the optimisation of the use of PLATO data by the general scientific community, including the interests of the scientific community that will be involved in the PLATO complementary science programmes (see Section 5.2.2). The Community Scientists are expected to provide support to the communications activities of ESA.

In addition, one ground-based observations scientist will be appointed by ESA to the SWT . The role of the ground-based observations scientist will be to advise and support ESA and monitor the preparation and implementation of ground-based observations in coordination with the PMC and the GOP Team(s) (see Section 5.2.3).

The Community Scientists and the ground-based observations scientist will have the same publication rights and rules as the members of the PMC (see Section 7.1.2).

The Community Scientists and the ground-based observations scientist will be selected through an ESA Announcement of Opportunity (AO) to be issued after the PLATO mission adoption and open to scientists in the ESA Member States. Scientists involved in PMC management (programmatic, scientific, or technical) or responsible for hardware or software development and procurement activities are not eligible. Candidates will have to describe in the proposals their expertise, the relevance of their contribution to the mission, their time commitment to the SWT activities and their willingness to take up specific and time-limited tasks as assigned by the SWT. The proposals should include the explicit endorsement and support from their institutes.

The proposals will be evaluated by ESA and the appointments will be made for three years, renewable. With the exception of expenses incurred while travelling to SWT meetings, ESA will not fund any other Community Scientist or Ground-based observations Scientist activities. At the end of each year, Community Scientists will have to submit a report on their PLATO related activities to ESA. At the end of each interval, ESA will decide whether to extend the appointment. Should a Community Scientist or Ground-based observations Scientist position become vacant, it will be filled by competitive selection via an AO process.

5.2.2 Guest observers

Members of the scientific community may participate in the PLATO mission by becoming Guest Observers (GOs), selected by ESA through calls for proposals. The calls will solicit for complementary science programmes not covered by the PLATO core science objectives listed in Section 2.1, and targeting objects within the PLATO sky fields defined by the SWT, that is, without requiring dedicated repointing of the spacecraft. The duration of the proposed observations cannot exceed the observation durations of the corresponding fields. ESA will appoint a Time Allocation Committee (TAC) for the evaluation and selection of the proposals.

The first call will be issued nine months before launch, after the publication of the PIC and of the “prime sample” (see Figure 4). More calls will be issued during the mission (once per year, TBC) at the discretion of ESA, following the advice from the SWT. Over the mission lifetime, an average of 8% of the science data rate (excluding calibration data) will be allocated to the GOs. This percentage will allow for an extended complementary science programme, while preserving the resources for an optimal observation of the core science targets. The total number of objects that may be observed with this allocation will range from thousands to tens of thousands, depending on the type of observations (e.g., imagettes or light curves) and sampling times requested.

The data delivery approach for GO programmes is indicated in Section 4.3 and shown in Figure 4. GO programmes can contain targets that are part of the PIC, but not of the “prime sample”. For targets in common with the PIC, access to the associated Level-0 and Level-1 data will be granted with the condition that the observations are exclusively used in relation with the science objectives of the proposal. Exploitation for complementary science of non-public PIC target data will only be carried out through approved GO programmes.

GO programmes can include the observation of Targets of Opportunity (ToO). GO programmes for ToOs may contain objects which can be identified in advance but which undergo unpredictable changes (e.g., recurrent novae), as well as objects that can only be identified in advance as a class (e.g., novae, supernovae, gamma ray bursts). The TAC will prioritise the ToOs with respect to on-going GO programmes, to permit the interruption of lower priority targets observations if required by the ToO. However, ToOs will be observed only on a best effort basis, if their observation can be implemented during the nominal mission cycle.

ESA will require the GOs to provide their data and results, to make them accessible through the PLATO Science Archive.

5.2.3 Ground-based Observations Programme Team

A Ground-based Observations Programme (GOP) for the confirmation and mass determination of planets will be needed to achieve the scientific return of the PLATO mission.

The PMC will be responsible for the activities of the GOP Team(s), who will have to apply for observing time for the confirmation and characterisation of the planetary candidates in the "prime sample". The GOP Team(s) will have to follow the approach indicated in the present section for the execution of the ground-based observing programmes and for the data generation, handling and delivery.

As reported in Section 4.2, the PMC will be responsible to generate requirements for the execution of the ground-based observations programme, in view of the confirmation and the characterisation of the planetary candidates.

The GOP Team(s) will have to adhere to the following requirements:

- The GOP Team(s) will organise and execute the ground-based observations dedicated to filtering and necessary for the generation of the Level-3 products, for the candidates indicated and following the requirements issued by the PMC, according to a timeline compatible with the release approach illustrated in Section 4.3.
- Ground-based data products (Lg, see Section 4.1) produced by the GOP Team(s) will be provided to the PMC for filtering and production of L3 products. The ground-based data products will be made accessible to ESA, for their release according to the approach illustrated in Section 4.3, in parallel with the data release requirements applied by the ground-based facility(ies) used to acquire the data.
- Authorship of scientific papers resulting from activities of the selected GOP Team(s) will be subject to the scientific publication policy guidelines reported in Section 8.

Using the deliveries from the GOP Team(s), the PMC will be responsible to routinely update the Level-2 products and generate and deliver the Level-3 products of the "prime sample" to SOC, in line with the release approach illustrated in Section 4.3 and Figure 4.

The SWT (see Section 5.2.1), will be tasked to monitor and verify the correct execution of the GOP Team(s) activities; ESA will be responsible to make the data products and scientific results of the ground-based observations accessible to the community through the PLATO science archive.

6 GROUND SEGMENT AND OPERATIONS

As indicated in Section 3, ESA will be responsible for the launch, early operations, commissioning and operations of the spacecraft.

ESA will establish a PLATO Mission Operations Centre (MOC) located at ESOC and a Science Operations Centre (SOC) located at ESAC. ESA provided ground station(s) will ensure the necessary telecommanding and telemetry capabilities.

6.1 Mission Operations Centre

The MOC is responsible for the operation of the spacecraft, and in particular of the following tasks:

- Performing uplink of the satellite and payload telecommands and receiving telemetry.
- Monitoring the spacecraft health and safety.
- Monitoring the payload safety and reacting to contingencies and anomalies according to procedures provided by the PMC.
- Performing mission planning of spacecraft activities.
- Alerting the SOC of all significant anomalies or deviations from nominal behaviour of the satellite for onward transmission to PMC as relevant.
- Executing predetermined procedures to safeguard the spacecraft and payload, and preserve data integrity.
- Performing maintenance of the satellite's on-board software.
- Performing uplinks of payload on-board software as generated, validated and delivered by the PMC via the SOC.
- Providing flight dynamics support, including determination and control of the orbit and attitude of the satellite.
- Handling provision of the telemetry to the SOC.
- Producing and providing ancillary data to the SOC (e.g., orbit files and pointing information).

6.2 Science Ground Segment

The Science Ground Segment (SGS) consists of the SOC, the PMC provided elements and the GOP Team(s).

ESA will capture SGS requirements and monitor their implementation through the Science Implementation Requirements Document (SIRD) to be answered by the Science (operation) Implementation Plans (SIPs) of the SOC and the PMC, for their respective areas of responsibility.

The responsibilities of the GOP Team(s) are summarised in Section 5.2.3.

Software developed specifically for PLATO jointly by ESA and its partners is put under a worldwide license such as LGPL. In accordance with SPC(2009)6 approval is first sought from the Agency’s technology transfer board (ATB).

6.2.1 Science Operations Centre

The SOC is the only interface to the MOC during routine operations and is responsible for the following tasks:

- Planning scientific, calibration and engineering observations and the construction of optimised schedules.
- Supporting the issuing of GO calls for proposals with the provision of tools and expertise, in cooperation with the PMC.
- Providing quick-look analysis development, implementation and operation, performed in partnership with the PMC.
- Issuing payload configuration change requests to the MOC as appropriate to optimise the quality of the PLATO data.
- Developing, implementing and operating the data processing pipelines to produce validated Level-0 and Level-1 (see Section 4.1) data products. This includes the necessary calibration information. This task is performed in partnership with the PMC.
- Generating, validating, archiving and distributing Level-0 and Level-1 (see Section 4.1) products.
- Performing quality control of the Level-0 and Level-1 products.
- Supporting and monitoring the PMC activities for the generation of the Level-3 data.
- Providing support to the scientific user community and to the Time Allocation Committee.
- Providing low-level, ancillary and housekeeping data to the PMC.
- Developing and operating the PLATO Science Archive to make the data products and scientific results of the mission available to the community.
- Making data processing tools available to the community, with the support of the PMC.

The SOC will take the lead in the overall design and engineering of the SGS: it will support the integration and validation of the commonly developed software (Level-0 pipeline, Level-1 framework and quick look analysis) and will organise and manage the end-to-end tests that are needed to validate the SGS uplink and downlink systems, interfaces, and operational processes.

6.2.2 PMC and Science Ground Segment

The PMC will take responsibility of the following tasks relevant for the SGS:

- Providing and maintaining the PIC.
- Providing the necessary instrument operational procedures.
- Performing instrument calibration and providing calibration files to the SOC (this task is performed in partnership with the SOC).
- Supporting the development of the quick-look analysis software and procedures.
- Providing instrument related software and procedures for the Level-1 and Level-2 data processing pipelines and scientific analysis software.
- Providing the documentation necessary for the operation, calibration, and instrument specific data processing and archiving.
- Generating, delivering and routinely updating the Level-2 products (see Section 4.1).
- Generating and maintaining a ranked target list and requirements for the execution of the ground-based observations programme, in view of the confirmation and mass determination of the planetary candidates.
- Generating and delivering to the SOC the Level-3 products for the "prime sample".

- Supporting the SOC with access to tools for the data analysis, the provision of GO call expertise and of tools for the GO calls, and with responding to user requests on instrument specific matters.
- Participating in pre-flight SGS integration and testing.
- Establishing and managing the GOP Team(s).

7 SCIENCE AND PROJECT MANAGEMENT

7.1 ESA responsibilities

The overall mission management, spacecraft, launch vehicle and launch services, payload CCDs, mission operations, ground station(s), and the SOC and MOC will be provided under ESA responsibility.

7.1.1 ESA provisions

ESA will be responsible of the overall mission design and implementation and of the scientific outcome of the mission, in particular ESA will lead the following activities:

- The overall PLATO mission definition and space segment development;
- The development, procurement, manufacturing, assembly, integration, test, verification and timely delivery of a fully integrated spacecraft capable of accommodating the PLATO scientific payload, fulfilling the mission requirements and achieving the mission objectives;
- Managing all elements of the PLATO payload, in particular regarding systems engineering and product assurance for all payload hardware, and on-board software, elements, including those procured by the PMC;
- Procuring the CCDs chips for the Focal Plane Arrays to be integrated in the payload.
- Procuring the Ancillary Electronics Units (AEU), comprising the camera power supply and synchronisation signal distribution units to be integrated in the payload and related GSE;
- Designing and procuring the accommodation and layout in the spacecraft of the payload harness (e.g. for data, synchronisation, high performance computing), based on specifications provided by the PMC; the harness between the Front-End Electronics and Focal Plane Assemblies and within each physical payload electronics box remains fully under the responsibility of the PMC;
- Providing engineering support related to the development of the Normal and Fast Cameras;
- Providing the centralised parts procurement service;
- Leading the assembly, integration and functional testing of the scientific payload;
- Integrating and verifying the spacecraft, and testing and verifying the overall system;
- Overseeing the mission scientific performance, in close collaboration with the PMC;
- Developing, procuring, integrating, and verifying the MOC activities, according to the tasks described in Section 6.1;
- Leading the overall design and validation of the SGS;
- Developing, procuring, integrating, and verifying the SOC, part of the SGS, according to the tasks described in Section 6.2.1;
- Providing for the launch and launch operations;
- Performing the in-orbit commissioning;
- Controlling and operating the PLATO spacecraft.

During all phases of the mission the PS will provide advice on scientific issues within the Project. During the development phase, the PS will advise the ESA Project Managers on technical matters affecting scientific performance, including the ability of the spacecraft to support achievement of the mission's goals. The PS will monitor the state of implementation and readiness of the instrument operations and data processing systems.

After the in-flight commissioning phase, the PS will continue his/her activity as the main interface with the community on scientific aspects and will provide scientific advice to the Mission Manager. The PS will monitor the creation of the scientific products, their archiving and distribution to the scientific community.

7.1.2 Science Working Team

A PLATO Science Working Team (SWT) will be appointed by ESA after the PLATO mission adoption. The PLATO PS will chair the SWT.

The SWT will consist of:

- The PMC PI, co-PIs and up to nine members from the PMC, covering main areas relevant for the scientific objectives of the mission
- Two "Community scientists" and one "Ground-based observations Scientist"
- Up to two GOP Team(s) representatives

The actual number of members and composition of the SWT may change according to the different phases of the mission development.

The SWT will advise ESA on all aspects of the mission potentially affecting its scientific performance. It will assist the PS in maximising the overall scientific return of the mission within the established boundary conditions. It will act as a focus for the interests of the scientific community in PLATO.

The SWT will be asked to review and endorse top-level requirements (in all areas of the project) that impact science return.

Members of the SWT are expected to monitor and give advice on all aspects of the PLATO mission which affect its scientific performance. They perform specific scientific and/or technical tasks, as needed during development and operation, and are invited to participate in major project reviews as observers.

The SWT will be in charge of:

- Maximising the scientific return of the PLATO mission within programmatic constraints, while ensuring that the development and operations of the mission remain compatible with its main scientific objectives;
- Advising on the optimisation of the scientific performances of the instrument and spacecraft;
- Supervising the preparation and periodic update of the PIC and "prime sample" list;
- Monitoring and advising on the space- and ground-based observation strategies and plans and the calibration strategy;
- Monitoring, advising on, and supporting the plans and execution of the ground-based observations required for the PLATO mission success;
- Reviewing and optimising the reduction, analysis and exploitation of the PLATO mission data;
- Optimising access to the data via the mission archive(s);
- Supervising and advising on the release of scientific data products to the community;
- Within the data right rules established in this document (see Section 4.3), monitoring publications of results by proprietary data holders (see Section 8);

- Promoting public awareness and appreciation of the PLATO mission, and supporting ESA in the outreach efforts.

7.2 PLATO Mission Consortium responsibilities

Funded by national Funding Agencies, within the remit of a Multi-Lateral Agreement (MLA) including ESA and the national Funding Agencies, the PMC, under the leadership of the Principal Investigator (PI) and the Co-Principal Investigators (CoPIs), is responsible for:

- Contributing to the payload management activities, including system engineering and product assurance, under the responsibility of ESA;
- Developing, building, integrating, testing, calibrating and delivering to ESA the PLATO cameras;
- Developing, building, integrating, testing, and delivering to ESA the on-board Data Processing System;
- Developing, integrating, testing, and delivering to ESA the algorithms for L0 ground data processing and the modules for L1 ground data processing;
- Providing post-delivery support including integration, test and calibration at payload module and at spacecraft level;
- Providing to ESA the necessary support for commissioning, instrument in-flight calibration and operations during the routine and any extended phases;
- Analysing the mission scientific performance and reporting to ESA;
- Providing the PMC elements of the SGS according to the tasks specified in Section 6.2.2.

ESA will review the PMC contributions, including the SGS elements and science preparation activities, at each main project review and/or with dedicated scientific reviews.

7.3 Steering Committee

A Multi-Lateral Agreement (MLA) will be established between ESA and the Funding Agencies (FAs) to formalise the commitments and deliverables of all parties. A PLATO Steering Committee with representatives from the FAs and ESA is then set up as stipulated in the MLA.

8 PUBLICATION POLICY

The following publication policy does not apply to GO data and works based on public PLATO data, but authors should acknowledge the PMC, and ESA in the acknowledgement manuscript section.

For publications dedicated to planetary system detection and characterisation of the “prime sample” and generated by the PMC and/or the GOP Team(s), including the final L1, L2, L3 and Lg data products, the following publication rules apply:

1. The PLATO SWT must approve the authorship of the papers.
2. The PLATO SWT must approve the paper before final submission.
3. ESA, PMC, and GOP Team(s) relevant for PLATO will be acknowledged in the Acknowledgement section according to standard formats.

9 PUBLIC OUTREACH

ESA will have overall responsibility for the science communications, educational and outreach activities related to PLATO. ESA will have the right to use any data acquired by PLATO for outreach purposes, in coordination with the holders of the data rights as applicable, as covered by the ESA Rules on Information, Data and intellectual Property (ESA/REG/008).

An active public outreach activity will be established in close collaboration between ESA, the relevant bodies funding the provision of the scientific payload in the Member States and other institutions involved in the mission. Such outreach activity will be based on a regular flow of science results from the mission presented in a manner suitable for communication and public outreach purposes. Such an outreach activity necessitates the timely availability of suitably processed data and the full involvement of the various scientific teams engaged.

Formal dedicated agreements regarding public outreach activities will be established between ESA, the relevant funding authorities, and other institutions involved in the mission. The terms and conditions contained in these agreements will be applicable on the relationships between the funding authorities and the various scientific investigators. These agreements will take account of any necessary project-specific science-to-public-outreach balance. The implementation of such agreements will be tracked by the Steering Committee defined in Section 7.3 and as part of the standard project reviews.

The authorities funding the provision of the payload in the Member States (Funding Bodies) and other institutions involved in the mission and in ground-based observations dedicated to PLATO will prepare a public outreach agreement involving ESA, the relevant Funding Bodies, the PMC, and the GOP Team(s). Interactions between these parties will have to guarantee consistency between all applicable documents and policies.

ACRONYMS

AO	Announcement of Opportunity
ATB	Agency's technology Transfer Board
CCD	Charge Coupled Device
ESA	European Space Agency
ESAC	European Space Astronomy Centre
ESO	European Southern Observatory
ESOC	European Space Operations Centre
FoV	Field of View
GOP	Ground Based Observation Programme
GO	Guest Observer
HR	Hertzsprung-Russell
FA	Funding Agency
LEOP	Launch and Early Operations Phase
LGPL	Lesser General Public Licence
LOP	Long-duration Observation Phase
L2	Earth-Sun 2nd Lagrangian Point
MLA	Multi-Lateral Agreement
MOC	Mission Operations Centre
MoU	Memorandum of Understanding
m_v	Visual magnitude
PI	Principal Investigator
PIC	PLATO Input Catalogue
PLATO	PLAnetary Transits and Oscillations of stars
PMC	PLATO Mission Consortium
ppm	Parts per million
PS	Project Scientist
RM	Rossiter-McLaughlin effect
RV	Radial velocity
SGS	Science Ground Segment
SIP	Science (operation) Implementation Plan
SIRD	Science Implementation Requirements Document
SOC	Science Operations Centre
SMP	Science Management Plan
SWT	Science Working Team
TAC	Time Allocation Committee
TC	Telecommand
TM	Telemetry
ToO	Target of Opportunity
TTV	Transit Time Variations