PLATO payload breakdown

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1 Brief payload description

The PLATO payload is made of 28 small telescopes. The 28 telescopes are identical in terms of optics, structure and thermal control. Two of them may include in addition a broadband filter. Each telescope illuminates its own focal plane, made of 4 large size CCDs. Twenty-six out of the 28 focal planes work in the same mode (full frame, 25sec-tbc exposure, 1.89sec-tbc readout), while the remaining 2 focal planes work at higher cadence (1sec-tbc), in frame transfer mode.

A front-end electronics (FEE) box is associated to each focal plane. It includes CCD control electronics, as well as a DPU devoted to some basic data treatment : aperture photometry, star centroiding, dark window monitoring, local housekeeping, local light curve corrections, ... The 2 high cadence focal planes have a special software running on their DPU, in particular to deliver high cadence depointing information to the AOCS loop.

All data processed by the telescope DPU are transmitted to the instrument control unit (ICU) or central onboard calculator, where they are post-processed : intelligent averaging of light curves and centroids, compression, transmission.

2 Payload consortium

We need to setup soon a payload consortium, whose task will be to organize the work for the design and construction of the payload. The members of this consortium will be laboratories and agencies from ESA member states, with scientific and/or technical expertise in the various elements of the PLATO science and instrumentation.

In addition, international partnership may be developed for some elements of the payload. When preparing the PLATO proposal in 2007, we have initiated discussions with colleagues from the US (C. Beichman, Caltech), from India (R. Sagar, ARIES), from Brazil (E. Janot-Pacheco, U. of Sao Paulo). Recently, we have been approached by chinese colleagues (J. Fu, Beijing University).

The payload consortium needs to be set and ready to answer a payload AO near the end of 2009, but is also expected to participate to the assessment study which will be primarily conducted in the industry in 2008 and 2009. The level of participation of the payload consortium to the assessment study is not clear for the moment. In particular, it is not clear how we can define an efficient interface between the two industrials studies and the work that can be done in our laboratories, because of the non disclosure rules we have to comply with. Some guidelines from ESA will be needed for the payload consortium to organize its work during the study phase.

3 Detector procurement

The classical scenario for ESA missions assumes that ESA is responsible for the overall mission management, launch, service module procurement, communications, and ground operations, while national agencies and other collaborations are responsible for payload procurement. This usual scheme can naturally be followed in the case of PLATO. The payload is indeed easily identified as the ensemble of telescopes, equipped with their focal plane arrays, their thermal control system, and their front-end electronics.

The payload includes in particular two major, costly components : procurement of the 28 telescopes, and procurement of about 150 large format CCDs ($3584^2 \times 18\mu$).

The procurement of the CCDs by national agencies, which would a priori seem a natural solution, may lead to severe problems :

- due to the well-known monopoly situation in Europe concerning CCD fabrication, it is difficult to envisage that member states outside the UK can accept to fund this procurement, which will result in an industrial return in the UK only; considering the overall cost of the CCD procurement, it is also unlikely that the UK alone can take this task;
- in order to be ready for a launch in 2017, early pre-development must be started at least one year before the mission is selected. If national agencies are responsible for CCD procurement, they will have to take a serious risk by funding this early development without knowing if the mission will be selected;
- most likely several other mission candidates will be in the same situation, so that the national agencies responsible for detector procurement will have to make their selection as to which mission they will support for these early developments. And at the time of final ESA selection, there will be no choice left, ESA will have to select the mission for which early development has been funded by national agencies. In this scenario, national agencies will influence severely the final choice.

The situation would therefore be much clearer is ESA was responsible for detector procurement, for all candidate missions, including PLATO.

4 Payload elements

The major elements of the payload are listed below. This list is simplified, and intended to initiate discussions about how to construct the payload consoritum and how to share the work within it.

1. **Overall payload architecture and system studies** : this work package should be under national agency responsability. It requires the identification of an overall PI, working with the support of his (her) national agency. The PI will head a payload consortium, involving laboratories from several ESA member states, as well as international partners, such as US, India, Brazil, China (all tbc). The payload architecture and system studies may be performed by a prime industrial contractor, funded by the national agency of the PI, in close collaboration with the PI and other members of the payload consortium.

2. **Telescopes** : developed under national agency responsability. It is assumed that national agency responsibility is limited to the delivery of the set of 28 individual telescopes, fully integrated and tested. The integration of all telescopes on the common optical bench, as well as the tests of the fully integrated payload, are assumed to be under ESA responsibility.

   The development of the telescopes will likely be conducted under industrial contract. Various sub-items can be developed independently by sub-contractors in different countries, under responsibility of various agencies:

   (a) *Optics:* The basic design is a catadioptric telescope, including two off-axis mirrors, and two correcting lenses with aspheric surfaces. The pupil is elliptical and the collecting area is of about 0.01 m^2. One particular issue to study in more detail is the straylight and the baffling of the ensemble of 28 telescopes. The two telescopes devoted to bright star studies at higher cadence will also include broadband filters in the optical train.

   (b) *Mechanical structure of elementary telescopes:* Needs to be light, but also to ensure a high level of stability for the lines of sight of all 28 telescopes with respect to one another.

   (c) *Thermal control of elementary telescopes:* The telescopes will work at room temperature. Thermal gradients between elements of a same telescope must be minimized.

   (d) *Integration and tests of elementary telescopes:* This will include optical alignement and tests, integration of FPA on telescope structure, structural tests, functional tests, thermal tests.

3. **CCD procurement**: we believe it should be under ESA responsibility (see Sect. 3). This procurement will likely be achieved via a single industrial contract. Procurement should include basic chip characterization by the industrial contractor. As soon as delivered, the CCDs must be transferred to the partners responsible for fine characterization (see below).

4. **Focal plane assemblies**: under national agency responsibility. This work package includes:

   (a) *fine characterization and calibration of CCDs for the 26 identical focal planes* : this includes all fine measurements that cannot be performed by the CCD procurement prime contractor (pixel response non uniformity, temperature dependence of quantum efficiency, of dark current, ...). This work will be done preferably through industrial contract, or else shared among several participating laboratories. If the last option is chosen, each participating lab must characterize fully a given subset of CCDs, rather than performing a subset of the measurements on all CCDs, in order to avoid unnecessary shipping of the chips during development.

   (b) *fine characterization and calibration of CCDs for bright star telescopes* : these CCDs, working in a different mode, may require a special characterization procedure, which may be separated from the rest.

   (c) *FPA mechanical structure and thermal control* : this includes the structures supporting the CCDs mosaic, the thermal hardware (cold fingers, heaters,...) and the radiation shields required to protect the CCDs. The FPA will work at 170 K, while the nearby FEE will work at 230 K.

(d) *front end electronics and digital processing units*: the FEE/DPU will include both detector control and basic data treatment at individual telescope level (see Sect. 1). The two FPA devoted to bright stars will need a special treatment, and the development of their FEE/DPU may be separated from the rest.

(e) *focal plane integration:* this will include the integration of the chips on the FPA cold plate, integration of FEE/DPU, integration of thermal control hardware.

(f) *focal plane tests and calibration:* this work package will include all necessary tests of the ensembles CCDs + FEE/DPU + thermal control, as well as some tests of the software running on the individual telescope DPUs.

5. **Instrument control unit and software**: The ICU will have the task to control the whole payload, and deliver the final data to the transmission system. Its role in terms of data treatment will be to collect individual light curves and centroid curves from individual FEE, to apply instrumental corrections to individual light curves, to eliminate outliers from the set of time series, to perform the average of the individual time series, and to compress the resulting average light curves and average centroid curves before ground transmission. The ICU will also include image recognition software to determine the exact position of the stars in the PLATO field and calculate the corresponding sets of photometric masks to be transmitted to the individual telescope DPU for applying aperture photometry.

6. **On ground post-processing software**: After ground reception of the light curves, centroid curves, and ancillary data, such as jitter restitution or temperature monitoring data, on ground post-processing algorithms will have to be run in order to correct the final data from known effects, such as *e.g.* global jitter a posteriori corrections.

5 PLATO science consortium

The PLATO payload consortium will be included in a wider world-wide science consortium, whose tasks will include the scientific preparation and exploitation of PLATO. In particular, the PLATO science consortium will conduct the following activities, some of them in close collaboration with the PLATO payload consortium:

- evaluation of the scientific performances of the PLATO mission,
- preparation of the science programs,
- preparation of input source catalogues,
- preparation of ground based follow-up observations, including high resolution spectroscopy, high precision radial velocity measurements, high angular resolution photometry, interferometric observations, etc...

The PLATO science consortium may be placed under the leadership of a global PI, independent from the PI of the PLATO payload consortium.