Product Assurance for the PLATO Telescope Optical Unit

Simonetta Chinellato*[a,b], Giovanni Postiglione[c], Timothy Bandy[f], Enrico Battistelli[c], Maria Bergomi[a], Federico Biondi[a], Francesco Borsa[e], Flavia Calderone[d], Virginie Cessa[f], Jacopo Farinato[a], Davide Greggio[a], Demetrio Magrin[a], Luca Marafatto[a], Francesca Molendini[f], Matteo Munari[d], Silvia Natalucci[g], Andrea Novi[c], Isabella Pagano[d], Daniele Piazza[f], Roberto Ragazzoni[a], Mario Salatti[g], Valentina Viotto[a]

[a]INAF – Osservatorio Astronomico di Padova, Vicolo dell'Osservatorio 5, 35122 Padova, Italy
[b]INAF – Direzione Scientifica, Viale del Parco Mellini 84, 00136 Roma, Italy
[c]Leonardo S.p.a., Via delle Officine Galileo 1, 50013 Campi Bisenzio (FI), Italy
[d]INAF - Osservatorio Astrofisico di Catania, Via S. Sofia 78, 95123 Catania, Italy
[e]INAF - Osservatorio Astronomico di Brera, Via E. Bianchi, 46, 23807 Merate (LC), Italy
[f]UBE - University of Bern, Sidlerstr. 5, CH-3012 Bern, Switzerland
[g]ASI, Via del Politecnico, 00133 Roma, Italy

ABSTRACT

We describe the main tasks of the Product Assurance process for the Telescope Optical Unit (TOU) of the ESA PLATO mission, that starts from the design phase and proceeds through all phases, up to the final product, with the aim of improving the likelihood of success of the mission. When dealing with the opto-mechanical components of the TOU, several aspects regarding safety and performance have to be analyzed and tracked. From the PA point of view, we focus in this paper on materials and processes selection that shall be suitable and robust enough for the space environment. Cleanliness and contamination control is needed to overcome loss of optical performance. Validations and qualifications on prototypes is fundamental to assess the reliability of the instrument for its purpose and for the lifetime of the mission.

Keywords: Product Assurance, PLATO, TOU, Materials, Processes, Cleanliness, Contamination, Validation

1. INTRODUCTION

PLATO (PLanetary Transits and Oscillations of stars) is the Cosmic Vision Program M3 mission selected by the Science Program Committee (SPC) for launch in 2026. The main goal of the PLATO mission is to detect terrestrial exoplanets in the habitable zone of solar-type stars and to characterize their bulk properties. [1]

The payload concept is based on a multi-Camera approach involving a set of 24 Normal Cameras (N-CAM) monitoring stars fainter than mV=8, plus 2 Fast Cameras (F-CAM) observing extremely bright stars with magnitudes brighter than mV=8. The 24 N-CAM are arranged in four sub-groups of six cameras, having exactly the same Field of View (FoV), and the lines of sight (LOS) of the four groups are offset by 9.2° from the payload mean LOS. This particular configuration allows surveying a very large field, with various parts of the field monitored by 24, 18, 12 or 6 telescopes. This strategy optimizes both the number of targets observed at a given noise level and their brightness. It is assumed that the satellite will be rotated around the mean line of sight by 90° every 3 months, resulting in a continuous survey of exactly the same region of the sky. The Cameras are mounted on an optical bench, which provides structural and thermo-elastic stability. Each Camera is composed by the Telescope Optical Unit (TOU), the Front End Electronics (that transmit to a corresponding Data Processing Unit), the Thermal Hardware and a CCD Focal Plane Array (FPA), comprised of 4 CCDs. The design status of the PLATO TOU is presented in [2]. The PLATO spacecraft model is shown in Fig. 1 where the 26 Cameras are visible in the upper part.

The TOU – Telescope Optical Unit – concept is based on a fully refractive optical system with 6 fully centered spherical lenses, except the first one with an aspherical surface, mounted inside the Opto-Mechanical Groups or OMGx (x=1 to 6) that are integrated inside the tube. A front window in quartz protects the lenses from the thermal and radiative

Space Telescopes and Instrumentation 2020: Optical, Infrared, and Millimeter Wave, edited by Makenzie Lystrup, Marshall D. Perrin, Proc. of SPIE Vol. 11443, 114434R · © 2020 SPIE
CCC code: 0277-786X/20/$21 · doi: 10.1117/12.2561031

environment and limits the sensitivity of the telescope. The inner pupil, which limits the measured photometric flux, is well delimited by a circular diaphragm. Other than this, an Optical Reference Cube and laser trackers for alignment are part of the TOU. Each TOU is equipped with a Baffle Assembly, working also as a radiator, composed by the mechanical baffle and the above mentioned optical window. The shape of the Baffle is due to the orientation of the TOU on the satellite.

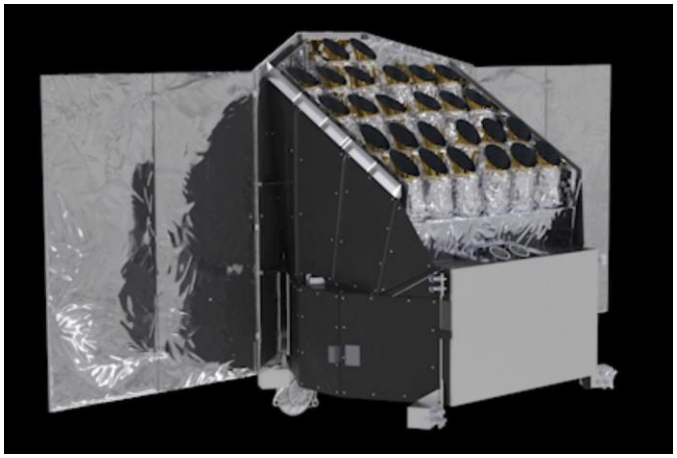

Figure 1. The PLATO spacecraft model: the payload concept is based on a multi-Camera approach.
Copyright: ESA/ATG medialab.

The responsibility of the TOU is taken by INAF and the industrial contractor appointed by the Italian Space Agency (ASI) is Leonardo that will deliver the final TOU flight models, together with Thales Alenia Space - Italy that is in charge of the Baffle Assembly and Medialario of the L1 aspherical lenses and of the uncoated windows. The University of Stockholm (UST) is in charge of the two F-CAM windows coated with blue and red passband filters respectively. The mechanical structure is designed and manufactured by the University of Bern (UBE). The TOU has passed PDR in early 2020 and is now heading towards CDR.

We will highlight the most important and in some cases critical aspects of dealing with an opto-mechanical unit from the Product Assurance point of view. Particular attention had to be addressed to the selection of materials and their processes, qualification and validations of the TOU opto-mechanics, and cleanliness and contamination that can jeopardize the instrument performance.

2. PRODUCT ASSURANCE WITHIN THE TOU

Product Assurance (PA) is the discipline that, always more involved in the design and development of a ground telescope or space mission, contributes to the Project Office, together with the Project Management and System Engineering, with the scope of increasing the success of a mission, here in the specific of the final product, the TOU.

The need to introduce controlled procedures in the various phases of the project from design to production to delivery of the final product originates from the always more complex projects in the current days with respect to the past. This is the consequence of the arrival and use of new technologies and the presence of always higher numbers of resources (people, institutes, countries) participating. From this complexity originates the request of having under control and keeping traceability of all the activities.

Main goal for PA is that of assuring that the design will fulfil functional and technical requirements and meet the required performance throughout all phases of the project, by guaranteeing that each item is designed, procured, manufactured, assembled, integrated, tested, verified, delivered and stored in the appropriate ways so that the required performances are met. Compliance to PA requirements shall be demonstrated, by monitoring that all standards and procedures are applied in house and among all subcontractors. In this way PA guarantees early detection of potential problems that could result in an unsatisfactory performance, and provide corrective actions.

The requirements that PA needs to deal with, among others, are related to PA Management, Quality Assurance, Critical Item Control, Dependability, Safety, Materials, Mechanical Parts and Processes, Cleanliness and Contamination Control. The output of the monitoring of all these disciplines are essentially recommendations on design trade-off and procurement choices, statements of risks or criticalities and identification of potential design weaknesses and failures.

Figure 2. The model assembly of the Camera: Telescope Optical Unit with its baffle are represented in the upper part. Copyright: ESA/ATG medialab.

Materials, Mechanical Parts and Processes (MMPP) selection is mandatory to keep under control when dealing with an instrument that will experience a particular space environment. For space projects indeed, since there is no possibility of maintenance, the aim is to assess the hardware quality and ensure the product's reliability. By considering all the components materials, both for the optical and mechanical parts, and the industrial fabrication processes to which they are subject to, it is possible to assess their conformity and reach the approval status for the specified environment in which the spacecraft will operate.

Cleanliness and Contamination Control is needed since contamination, both particulate and molecular, can jeopardize the instrument performance, particularly for optical elements, by introducing straylight or cause loss of transmissivity.

Among other tasks followed by PA in these phases, the tracking of Critical Items is mandatory, i.e. those not qualified or regarding new technologies, those leading to single point failures, in particular those items that need a risk evaluation. Critical items are those that could have undesired consequences over performance, quality and safety, so they need to be kept under control and mitigated. In dealing with projects whose design and development lasts some years, the long lead time of the items needs to be taken into account, to minimize the risks of a possible delay in the delivery of the TOU, some items have been identified for early procurement

Qualification of mechanical parts, verification of processes and validation of materials for the TOU opto-mechanical components include testing on prototypes to assess how these respond to the space environment (e.g. validation of coatings and verification of adhesive bonding).

In the vision of ensuring compliance for all the PA requirements, specific ECSS (European Cooperation for Space Standardization) [3] standards for space developed projects and related on-ground activities apply to the PLATO-TOU, providing regulations to ensure that procedures and processes are followed and applied.

3. MATERIALS AND PROCESSES

The selection of the Materials, Mechanical Parts and Processes (MMPP) for the flight hardware shall follow the ECSS-Q-ST-70C standard, where criteria are outlined for the validation of materials, verification of processes and the qualification of mechanical parts. Control of materials, mechanical parts and processes, and their approval provide appropriate evidence to guarantee the product's reliability with the final goal of eliminating or mitigating criticalities. Taking into account the MMPP selected for the project development, data are recovered at the supplier and customer level, to assess if they meet the requirements and whether they are suitable for the specific environment and intended use.

For instance, for each material selected specific information shall be recovered and analyzed with the aim of avoiding unsatisfactory performances or risk of failures:

- data on the environment in which they will be operating: temperature, thermal cycling to which they are subject, vacuum
- properties such as corrosion, stress corrosion for metals and their alloys
- properties of flammability, offgassing, outgassing, radiation, for not metallic materials
- id of the commercial material and nature/type
- manufacturer and supplier data
- processes to which they are subject
- justification for approval (if any)

The implementation of these records and their evolution during the different project phases provide the status of all materials, mechanical parts and processes to which all items are subject. All MMPP must meet the technical and design requirements and an assessment of final approval for use shall be provided.

The information recovered is reviewed and approval is eventually reached if they meet the requirements. Request For Approval (RFA) is mandatory when dealing with materials and processes that use new technologies needing testing, and/or when there is no heritage for space applications of the specific material or process. In fact, whether no heritage is recovered from other space projects, RFAs are issued and further analysis is required for the evaluation and final approval follow a qualification or validation process.

Materials are categorized in groups and since the TOU is basically a combination of optical and mechanical components, the materials contained in the TOU belong to the following groups: Aluminum and its alloys, Copper and its alloys, Titanium and its alloys, Stainless Steel, Miscellaneous metallic materials, Optical materials, Adhesive/coatings/varnishes, Paints and inks, Reinforced plastics, and Thermoplastics (see Table 1). A sketch showing the TOU materials used for lenses and mountings the opto-mechanics is shown in Fig.3. The tube structure containing the OMGs (not shown in Fig. 3), is made of AlBeMet.

In the same way processes are categorized in groups, and for the TOU we deal with the following: Adhesive bonding, Cleaning, Surface treatments, Plating, Machining, Forming, Heat treatment, Miscellaneous processes and Inspection procedures (see Table1). Also for processes, related information is needed (e.g. description, criticalities, supplier reference, etc) to reach the final approval status.

Table 1. List of groups of materials, mechanical parts and processes used in the TOU design.

Materials	Mechanical Parts	Processes
Aluminum and its alloys	Spacing parts	Adhesive bonding
Copper and its alloys	Connecting parts	Cleaning
Titanium and its alloys		Surface treatments
Stainless Steel		Plating
Miscellaneous metallic materials		Machining
Optical materials		Forming
Adhesive/coatings/varnishes		Heat treatment
Paints and inks		Miscellaneous processes
Reinforced plastics		Inspection procedures
Thermoplastics		

Among the materials selected, a mention has to be given to the AlBeMet material that is used in the structural tube manufacturing since AlBeMet and/or Berillyum is banned on standards for safety purposes, because of its toxicity. For some of the TOU structural components this material has been selected for its high thermal conductivity, heat capacity, Young's modulus, low density and moderate CTE, which makes it an ideal choice for the realization of thermally stable and lightweight structures for optical space assemblies. The use of Berillyum in the structure though, has heritage in other ESA programmes, so the hazardous risks, after evaluation, have been considered acceptable when using appropriate precautions and handling procedures.

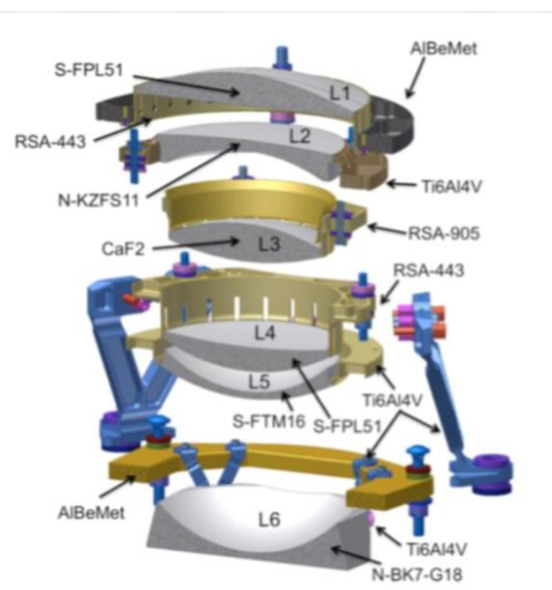

Figure 3. Model section of the TOU internal structure showing optical and mechanical materials used. The sketch of the six lenses is shown together with their holding structures materials.

In some cases where no heritage is present RFAs are issued to enable the supplier to request from the customer the permission to use a specified mechanical part, material or process. Examples of materials for which the analysis provided allowed to assess whether they are suitable for the intended application are discussed in the following Section 4.1 for the intrinsic resistance for the lenses and in Section 4.3 dealing with the qualification of the adhesive.

Nonetheless, in dealing with projects whose design and development lasts for some years, the lead time of the items needs to be taken into account, and so to minimize the risks of a possible delay in the delivery of the TOU early procurement of some elements has been identified. As LLI, the procurement of the glass blanks for the QM and FM models have been taken in consideration, therefore their manufacturing has already started. The raw material of AlBeMet blocks has a long lead time too considering the massive production required for flight models. Their procurement has also started and the manufacturing of the structure is on the way for the QM and the first set of FM models.

4. VALIDATIONS AND QUALIFICATIONS

With the aim of the final qualification of the instrument, a prototyping campaign is the main actor supporting the detection of potential risks and failures and for the identification of mitigations (e.g. changes in the design). By realizing breadboards and models of the TOU that allow to go through the possible criticalities from the opto-mechanical point of view and to verify the MAIV procedure at sub-system level, it is possible to qualify, in the subsequent phase, the thermal and structural stability and optical performances of the TOU at the upper level within the Camera.

The initial BreadBoard (BB) and Prototype were used for MAIV purposes to verify the TOU integration and alignment procedure and the optical performances along the optical axis before and on the overall FoV then, both in environmental conditions on-ground and in space ambience [4]. At subunit level, a number of BreadBoards for the Opto-Mechanical Groups (OMGs), composed by samples of lenses and related mechanical material, has been produced for design qualification. The OMG BB campaign has been done in order to validate the integration and alignment procedure within the dedicated AIT machine. All BBs underwent thermal cycles testing, and a second set will be used for shock to failure testing.

The TOU models to be developed for integration at upper level for Camera qualification purposes are the following:

- TOU Structural Model (STM) to qualify the thermo-mechanical design of the TOU. All of the OMGs reached acceptance levels and the model was successfully qualified at UBE and finally delivered for further integration within the Camera.
- An Engineering Model (EM) to qualify the optical performance of the TOU at Camera level.
- 26 TOU Mass Thermal Dummies (MTD) representative of structure to be integrated in the satellite STM for thermo mechanical qualification. The MTD TOU AIT has been done at UBE and already delivered.
- Finally, Qualification Models (QM) that will be identical to the flight models, for final qualification of performances at Camera level.

The selection of materials for the TOU derives from a series of stringent optical and mechanical (mass, volume) requirements, other than the fact of operating in a space environment with low temperatures. This leads to a restricted number of possible materials with a variety of CTEs, and some also sensible to radiation. Feasibility studies on the lenses and analysis on the performance of the OMG in their final environment have to be carried on to investigate on possible criticalities. At subsystem level, among the qualifications and validations, sections 4.1 to 4.4 highlight those that need to be tracked for PA to control over materials and processes for their approval.

4.1 Validation for radiation resistance of optics

One of the first investigations done during the optical design phase was that of assessing that the selected glasses for the lenses would be suitable for the space environment. In fact, a refractive system for space applications foresees the use of glasses with radiation resistance to avoid possible effects of reduction of transmittance during its lifetime, these glasses are known as Radiation Hardened (RadHard). This possible effect is dependent on the intrinsic properties of the material in terms of intrinsic resistance and on the environment to which is exposed during the whole mission.

The optical design of the TOU foresees glasses that are not fully insensitive to radiation environment, or for which the radiation resistance is unknown. Apart from lens L6 – the most exposed to radiation since not totally protected by the tube, but made of RadHard BK7-G18 – heritage was not available for four of the glasses (materials selected are S-

FTM16, CaF_2, N-KZFS11, S-FPL51), so dedicated tests were carried out to assess the resistance of the material that is normally not RadHard. At engineering level the analysis for such glasses has been made at the beginning of the design phase by evaluating the impact of the mission environment on the TOU optical performance and allowed to confirm the materials selected [5].

From a PA point of view, this information and analysis is mandatory since a justification for approval is requested when dealing with materials that were not used in previous space applications.

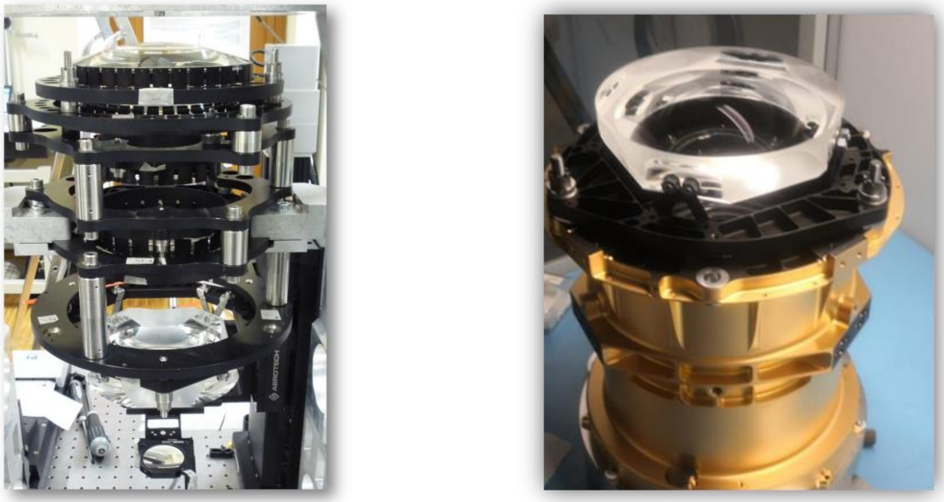

Figure 4. Two of the models for the TOU: on the left the initial BreadBoard and on the right the EM.

4.2 Validation for aspheric manufacturing

The optical design for a telescope is the starting point of a project and before moving to the more practical design, also the feasibility of the optics has to be envisaged. The refractive optical system is compose by six spherical lenses, except the first one, namely L1, that has an aspherical external surface that needs a particular manufacturing process. The identification of this critical technology, the particular material used (S-FPL51) and the size, led to investigations among the qualified supplier Medialario to investigate their capability and experience in the manufacturing of this critical item. These activities has been carried on at engineering level and with the manufacturing of prototypes of the lens that were subsequently tested, the final verification showed that the optical requirements are met for the EM model.

4.3 Qualification of OMGs

The use of materials with different CTE and the temperature gradient to which they are subject requires the opto-mechanical design to adapt to possible thermal and structural deformations. At the beginning, an extensive prototyping and testing campaign has been undertaken at LDO on the materials selected for the optical and mechanical items for the qualification of the OMGs design. The test campaign focused on all aspects, from CTE measurement to the characterization of the coupling of materials to dynamical and thermo-vacuum tests, other than the bonding process, including the selection of the adhesive, and cleaning procedures.

Not willing to go deep into this specific process carried on at engineering level, this led to the qualification of the bonding process: the main output for PA purposes is that the selected adhesive needs to be qualified for the specific coupling of materials used and is now under an RFA. The final approval will be possible to process basing the analysis on the above activities carried out.

4.4 Optical coatings qualification

All the TOU lenses are protected by and A/R coating that has heritage from previous space missions. On the other hand, the optical external window is coated with filters that are different for N-CAM and for the two F-CAMs, whereas these last ones have a red and a blue filter respectively. They both need to go through a qualification process that is ongoing at the moment.

5. CLEANLINESS AND CONTAMINATION

Cleanliness and Contamination (CC) Control sets a methodology in which the required cleanliness levels for the PLATO TOU are achieved and maintained during the lifetime of the program, from design phase to end-of-life. The purpose is to avoid failures or unacceptable degradation of the performance of the instrument due to the presence of contaminants. The process is driven by the ECSS standards as well, in the specific ECSS-Q-ST-70-01C.

As seen in the previous sections, the TOU is composed by opto-mechanical components and the most sensitive items are the optical elements that the light crosses, since contamination can lead to performance degradation. These sensitive items are the six lenses and the optical window. But also the mechanical structure, especially the surfaces adjacent and facing the optics, has to be taken in consideration at the same level as the sensitive optical elements, since they can potentially lead to a re-distribution of the contamination (e.g. during vibration tests, launch), so they must be treated as sensitive items as well.

Particulate Contamination (PAC) and Molecular Contamination (MOC) are the two main sources that could lead to performance degradation: contaminants deposit on all accessible surfaces of the optical system and can thus degrade the performance of the instrument. These sources of contamination can originate during all phases of the design and development, i.e. manufacturing, integration, and test phases, transportation, storage, during launch and afterwards in orbit. Therefore, during on-ground activities, the requirements concern not only flight hardware, but also personnel, tools and facilities, clean room environment, TVC, tools and materials used, vibration test, GSE, and, nonetheless, to human and handling activities. The CC requirements are defined also on material and process selection, integration and test conditions, including ways of measuring and controlling the contamination of working areas, of cleaning the surfaces, and finally on packing and storing hardware.

Contamination budgets are flown down from upper level requirements of the payload, allowing to allocate budgets for PAC and MOC at delivery of the Camera, then delivery of the units – and from this level on is where we focus - and down to the single items at the various integration stages and at delivery.

A first rough approximation for PAC and MOC budgets is assigned to the units from a breakdown of top-level requirements, requiring then iteration between the parts. The total cleanliness budget breakdown with respect to the payload, its budget allocation to the unit as well as the capability to reach the requested level of cleanliness, have been questioned: the uncertainty in the ability of the units to match the cleanliness levels has provoked an assessment to consider a possible relaxation of the requirements. A top-down approach allocates cleanliness budgets of the payload based on the performance needs in terms of quantum efficiency and transmissivity. And a bottom-up approach takes into account the input with actual contamination values from the units derived from a detailed outlook of all the activities in MAIV.

Consolidation of cleanliness and contamination budgets at TOU unit level (see Table 2) allowed the flow-down of the requirements to the sub-units. As mentioned, optical components have very stringent requirements, and so do the mechanical surfaces facing them; on the other side, a cleaning and then verification process has to be identified for the sub-units: the Baffle Assembly and the mechanical Structure. An extensive and iterative process took place before finalizing the budgets for the TOU and its sub units. Cleaning inspections methodologies evaluated up to PDR were not considered capable of verifying such low levels of PAC an MOC required for the sub-units, mostly due to the fact that the TOU Structure AlBeMet tubes geometry does not allow the application of traditional verification methods for PAC. Investigations took place to characterize specific verification methods and recover a reliable process for cleanliness and contamination verification.

Finally, after fine tuning, a final contamination budget for the TOU EM/QM/FM/FS models of 200 ppm for PAC and 1.7 x 10-7 g/cm2 for MOC at its delivery to the Camera was assigned. This translates into a flow down of the requirements to the suppliers of the Mechanical Structure and Baffle assembly that are required to respect a budget of 100 ppm level for PAC and 0.8 x 10-7 g/cm2 level for MOC at their delivery to the customer.

Table 2. Contamination budgets for the TOU opto-mechanical components, both for external surfaces and for internal surfaces, a.k.a. those facing the optical surfaces, at delivery to higher levels for the TOU, the mechanical structure, mainly the tube, and the baffle.

Contribution	**TOU**	**Structure (Tube)**	**Baffle**
PAC external [ppm]	200	100	100
PAC internal [ppm]	200	100	100
MOC external [g/cm2]	1.7 x 10-7	0.8 x 10-7	0.8 x 10-7
MOC internal [g/cm2]	1.7 x 10-7	0.8 x 10-7	0.8 x 10-7

Cleanliness requirements up to the STM do not need a strict cleaning process since inspection method is visibly clean. The first model subject to CC control, with the same process as foreseen for the flight models, is the EM. During the integration and alignment phase of the EM model (shown in Fig. 4 on the right), the TOU EM tube and all the OMGs were iteratively controlled and cleaning has been done under laminar flow bench ISO 5. The TOU was then positioned in the automatic centering machine, all alignment and focusing operations were performed in a tight cleanliness environment, reaching at least the ISO 6 CR levels or lower, even though the reference environment is ISO 7.

6. CONCLUSIONS

We have presented PLATO's Telescope Optical Unit from the Product Assurance point of view and gone through the most important tasks that need to be processed. Among these, we focused on Materials and Processes selection, Cleanliness and Contamination Control, Validation and Qualification processes. Mainly collaborative and iterative processes with engineers are the activities for the PA to follow and have consciousness and control over the overall project. In parallel, Quality Assurance is carried on and tasks as critical items control, non-conformances, review boards for manufacturing and delivery of items are the tools supporting PA in tracking all the issues. All essential processes whose goal is to enhance the likelihood of success of a project: outputs are essentially recommendations on design trade-offs, a statement of risk, a procurement choice, or identification of potential design weaknesses.

REFERENCES

[1] Rauer, H.; Catala, C.; Aerts, C.; Appourchaux, T.; Benz, W.; Brandeker, A.; Christensen-Dalsgaard, J.; Deleuil, M.; Gizon, L.; Goupil, M.-J.; Güdel, M.; Janot-Pacheco, E.; Mas-Hesse, M.; Pagano, I.; Piotto, G.; Pollacco, D.; Santos, Ċ.; Smith, A.; Suárez, J.-C.; Szabó, R.; Udry, S.; Adibekyan, V.; Alibert, Y.; Almenara, J.-M.; Amaro-Seoane, P.; Eiff, M. Ammler-von; Asplund, M.; Antonello, E.; Barnes, S.; Baudin, F.; Belkacem, K.; Bergemann, M.; Bihain, G.; Birch, A. C.; Bonfils, X.; Boisse, I.; Bonomo, A. S.; Borsa, F.; Brandão, I. M.; Brocato, E.; Brun, S.; Burleigh, M.; Burston, R.; Cabrera, J.; Cassisi, S.; Chaplin, W.; Charpinet, S.; Chiappini, C.; Church, R. P.; Csizmadia, Sz.; Cunha, M.; Damasso, M.; Davies, M. B.; Deeg, H. J.; Díaz, R. F.; Dreizler, S.; Dreyer, C.; Eggenberger, P.; Ehrenreich, D.; Eigmüller, P.; Erikson, A.; Farmer, R.; Feltzing, S.; de Oliveira Fialho, F.; Figueira, P.; Forveille, T.; Fridlund, M.; García, R. A.; Giommi, P.; Giuffrida, G.; Godolt, M.; Gomes da Silva, J.; Granzer, T.; Grenfell, J. L.; Grotsch-Noels, A.; Günther, E.; Haswell, C. A.; Hatzes, A. P.; Hébrard, G.; Hekker, S.; Helled, R.; Heng, K.; Jenkins, J. M.; Johansen, A.; Khodachenko, M. L.; Kislyakova, K. G.; Kley, W.; Kolb, U.; Krivova, N.; Kupka, F.; Lammer, H.; Lanza, A. F.; Lebreton, Y.; Magrin, D.; Marcos-Arenal, P.; Marrese, P. M.; Marques, J. P.; Martins, J.; Mathis, S.; Mathur, S.; Messina, S.; Miglio, A.; Montalban, J.; Montalto, M.; Monteiro, M. J. P. F. G.; Moradi, H.; Moravveji, E.; Mordasini, C.; Morel, T.;

Mortier, A.; Nascimbeni, V.; Nelson, R. P.; Nielsen, M. B.; Noack, L.; Norton, A. J.; Ofir, A.; Oshagh, M.; Ouazzani, R.-M.; Pápics, P.; Parro, V. C.; Petit, P.; Plez, B.; Poretti, E.; Quirrenbach, A.; Ragazzoni, R.; Raimondo, G.; Rainer, M.; Reese, D. R.; Redmer, R.; Reffert, S.; Rojas-Ayala, B.; Roxburgh, I. W.; Salmon, S.; Santerne, A.; Schneider, J.; Schou, J.; Schuh, S.; Schunker, H.; Silva-Valio, A.; Silvotti, R.; Skillen, I.; Snellen, I.; Sohl, F.; Sousa, S. G.; Sozzetti, A.; Stello, D.; Strassmeier, K. G.; Švanda, M.; Szabó, Gy. M.; Tkachenko, A.; Valencia, D.; Van Grootel, V.; Vauclair, S. D.; Ventura, P.; Wagner, F. W.; Walton, N. A.; Weingrill, J.; Werner, S. C.; Wheatley, P. J.; Zwintz, K., "The PLATO 2.0 mission," Experimental Astronomy, Volume 38, Issue 1-2, pp. 249-330, (2014).

[2] Magrin, D.; Ragazzoni, R.; Pagano, I.; Viotto, V.; Farinato, J.; Munari, M.; Chinellato, S.; Calderone,F.; Marafatto, L.; Dima, M.; Cessa, V.; Molendini, F.; Bandy, T.; Piazza, D.; Benz, W.; Brandeker, A.; Novi, A.; Battistelli, E.; Burresi, M.; Capuano, E.; Marinai, M.; Nebiolo, M.; Salatti, M.; Rauer, H.; Mas Hesse, J., M; Marliani, F.; Levillain, Y.; Alvarez, J., L; " PLATO telescope optical units: An update on working status", 11443-80 in these proceedings.

[3] European Cooperation Space Standardization https://ecss.nl/

[4] G. Umbriaco, F. Biondi, J. Farinato, V. Viotto, L. Marafatto, M. Bergomi, E. Portaluri, E. Carolo, D. Greggio, R. Ragazzoni, D. Magrin, D. Vassallo, S. Chinellato, M. Dima, L. Lessio, G. Farisato, D. Piazza, T. Bandy, I. Pagano, G. Piotto, A. Novi, M. Marinai, "The telescope optical unit prototype AIV in the framework of the PLATO ESA mission"" Proc. SPIE 106984A (2018)

[5] Corso, A., J.; Tessarolo, E.; Baccaro, S.; Cemmi, A.; Di Sarcina, I.; Magrin, D.; Borsa, F.; Ragazzoni, R.; Viotto, V.; Novi, A.; Burresi, M.; Pellowski, F.; Salatti, M.; Pagano, I.; Pelizzo, M., G.; "Rad-hard properties of the optical glass adopted for the PLATO space telescope refractive components", Optics Express Vol. 26, Issue 26, (2018)

ACKNOWLEDGEMENTS

The activity was carried out under PLATO ASI-INAF agreements n.2015-019-R0-2015 and n. 2015-019-R.1-2018.