The TOU of the PLATO mission from a Product Assurance point of view

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ABSTRACT

The TOU is the Telescope Optical Unit for the PLATO ESA mission, consisting of the opto-mechanical unit for each of the 26 Cameras of which PLATO is composed. The TOU is currently in the manufacturing, assembly, integration and testing (MAIT) phase for the Proto Flight Model (PFM) and for Flight Models (FMs).

We present the design processes as seen from the Product Assurance (PA) point of view: PA aims at monitoring the design and addresses specific issues related to, among others, materials and processes (these shall be suitable for the purpose and for the life-time of the mission), cleanliness and contamination control (to limit the loss of optical performance), safety, monitoring of qualifications/validations.

PA supports the project in failure-proofing aspects to mitigate criticalities, e.g. in the elaboration of non-conformances and deviations that can arise during the design and MAIT process, and/or are highlighted during the reviews for manufacturing, test, and delivery of the related hardware. PA ensures early detection of potential problems and risks for the TOU and arranges for corrective actions that aim at improving the likelihood of success of the mission.

Keywords: PLATO, Product Assurance, Quality Assurance, materials, processes, cleanliness, contamination, non-conformances

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1. INTRODUCTION

PLATO (PLAnetary Transits and Oscillations of stars) [1] is the Cosmic Vision Program M3 mission selected by the ESA Science Program Committee (SPC) for launch in 2026, will be put into orbit at the Lagrange point L2. The mission aims at detecting and characterizing terrestrial exoplanets orbiting nearby bright stars (mV <13), with particular interest for solar type stars.

PLATO's scientific payload is based on a multi-Camera approach consisting of 26 Cameras mounted on a common optical bench. Involving a set of 24 of 'normal' type (N-CAM), dedicated entirely to scientific observations, and two of 'fast' type (F-CAM), dedicated to the observation of very bright stars (mV <8) in two different photometric bands (one in blue 505-700nm and one in red 665-1050nm).

Each Camera is composed of the Telescope Optical Unit (TOU, including the Baffle), which is the subject of this proceeding, the Focal Plane Array (FPA), comprising 4 CCDs connected to the Front End Electronics (FEE), that transmits to a corresponding Data Processing Unit, and the Thermal Hardware.

To increase the probability of success, the project management is supported by Product Assurance (PA). This discipline, with a management transversal to the activities of the Project Management (PM) and System Engineer (SE), aims at verifying compliance with the requirements and addressing potential risks and failures. The primary objective is to obtain a performing and safe product [2].

In the next Sections we will briefly describe the Telescope Optical Unit (TOU) in Section 2. Then we will highlight the PA activities related to the PLATO TOU unit in Section 3. In Section 4 a more detailed PA support to the Manufacturing, Assembly, Integration, Test (MAIT) phase and for final delivery of the TOU unit is presented. Particular attention is addressed to the approval of selected materials and their processes (Section 5), and the cleanliness and contamination control (Section 6), to which optics are very sensitive and that could jeopardize the instrument optical performance. In the final Section 7, will present the ongoing activity for requirements verification (including PA) within the MBSE, an ongoing activity carried on by the CAM team System Engineering group that includes also the TOU unit.

2. DESIGN DESCRIPTION OF THE TELESCOPE OPTICAL UNIT

The TOU – Telescope Optical Unit – presents a fully refractive optical design [3]. The optical configuration consists of one entrance window, one aspherical lens (asphericity is only in one surface) and five spherical lenses. Each lens is mounted inside an Opto-Mechanical Group or OMGx (x=1 to 6) which are integrated inside the tube. A front window in quartz protects the lenses from the thermal and radiative environment and limits the sensitivity of the telescope.. Each lens, including the external window, has an A/R filter. The two Fast TOU (F-TOU) have a filter coating for the two different photometric bands in which they are working. The Straylight has to be also carefully minimized and this requires the introduction of a large Baffle positioned at the entrance of the TOU itself in order to mainly eliminate the contributions due to the Sun and Moon. [4]. From the point of view of the mechanical structure, each lens is glued to its mount (i.e. the OMGs), and together with the external window and the baffle, are mounted in an AlBeMet tube that guarantees the required stiffness, with the least impact on the budget available for the mass. Images in Figures 1 and 2 show the different configuration items of the TOU, made by the different partners.

The Italian participation in the PLATO-TOU unit, in addition to the scientific contribution, is concentrated on the optical design, including Straylight Analysis and Radiation Analysis, and on the realization of the TOU optical unit (Telescope Optical Unit), all the Manufacturing-Assembly-Integration-Testing (MAIT) phases for the TOU and the Product Assurance.
The responsibility of the TOU is taken by INAF-Italy and the industrial contractor appointed by the Italian Space Agency (ASI) is Leonardo Company that will deliver the final TOU Flight Models, together with Thales Alenia Space – Italy (TAS-I) that is in charge of the Baffle Assembly and Medialario of the L1 aspherical lenses and of the uncoated windows. The mechanical structure (mountings for the lenses and the tube) is designed and manufactured by the University of Bern (UBE) in Switzerland, in collaboration with their industrial suppliers. The University of Stockholm (UST) is responsible of the two F-CAM windows coated with blue and red passband filters respectively.

The TOU is currently in the MAIT phase for the Proto Flight Model (PFM) and for the Flight Models (FMs).

Figure 1. Tubes delivered by UBE. Left image shows the TOU Structure Tube after coating and the right image some of the Tubes after bake-out at UBE.

Figure 2. OMGs: mounting delivered by UBE and integrated with lenses at Leonardo Company on the left. The Baffle Assembly after painting delivered by TAS-I on the right.

3. PRODUCT ASSURANCE AT TOU LEVEL

The design of a scientific instrument sees the presence of key figures who, at the level of management and coordination, are responsible for various aspects and who, interacting with each other during all phases of the project, lead with method and control to the realization of the final product in the estimated times respecting the budgets and with the required performance. Among the Project Office, and in collaboration with Project Management (PM) and System Engineering (SE), Product Assurance (PA), especially for space missions, is a building block in the design of instruments. In fact, PA is a discipline that supports the project in monitoring critical processes and identifying discrepancies and non-conformities, thus managing them with the goal of achieving a system as much reliable as possible.

3.1 Space environment

With respect to ground-based telescopes, space missions are challenging for two factors, the launch into space and the space environment itself. Both issues need to be considered from the design phase and go through verification/validation/qualifications campaigns of all configuration items at all levels (e.g. system, sub-system, units).

The spacecraft is subject to the launch environment, in particular for the following: Accelerations and vibrations, Shock, Acoustic noise, Rapid depressurization.

The instrument in his operative lifetime will be subject to extreme conditions: extreme thermal conditions, vacuum, high radiation level.

Product Assurance plays a crucial role in the development of a space mission, and in particular for the TOU which is composed of an opto-mechanical unit, In fact, among the main activities to follow, are the approval of the chosen materials and the cleanliness and contamination control since optics are the most critical for particulate (PAC) and molecular contamination (MOC) that can be redistributed during launch and can thus degrade the optical performance in operation.

3.2 PA Activities and ECSS standardization

The contribution of the PA Manager to the project management consists in guaranteeing that all the deliverables related to the baseline comply with the requirements. And to verify that, at any release/delivery - whether it is the release of a design document, a new procedure, qualification and validation processes, the delivery of the TOU itself and its subunits, or requests for changes subsequent to the consolidation of the design - is duly processed, approved and implemented.

The principal Product Assurance disciplines are:

- Product Assurance Management
- Quality Assurance
- Safety and Dependability
- Materials, Mechanical Parts, and Processes.
- Cleanliness & Contamination.
- Critical Item Control
- Non conformance control

The need to introduce systematic and controlled procedures in the various phases from design to production and finally to the delivery of the final product, arises from the ever increasing complexity of the projects originating from the advent of new technologies and the increasing number of human resources (e.g. people / participating institutions / countries). From this complexity originates the request for a controlled procedures and the traceability of all the activities carried out of which evidence must be provided (e.g. through documentation).

PA bases its activities on a quality system that adapts to standards from the European Cooperation on Space Standardization (ECSS) that are tailored to the specific space mission [5].

3.3 PA Monitoring Tools

The most important factor from the PA point of view is traceability. All the design information must be contained in documents that describe the baseline and report any modification decided along the various phases of design, procurement, manufacturing, assembly, integration, testing, verification, and validation and delivery.

During the reviews, whether a milestone or a configuration item delivery, data packages must be reviewed and approved by all parties involved. Among the documentation that PA requires for monitoring the status of the project are:

- CIDL (Configuration Item Data List): is a document giving the current design status of a configuration item (CI), at any point of time in sufficient detail, providing its complete definition. It describes the As-designed status and reference of the known changes (e.g. Non conformances (NCR), Request For Deviation (RFD)) and, as mentioned, it is a 'living' document which will show a snap-shot of the current design Baseline that is valid at the time of issue.
- ABCL (As-built Configuration Data): provides a reporting instrument defining the as-built status per each serial number of configuration item subject to formal acceptance. It reports the as-built status of the item and reference of the changes/deviations (NCRs and Request For Waivers (RFW)) from the baseline CIDL issued during manufacturing.
- Non conformance (NC) control. When a nonconformance is detected, a NC report (NCR) is issued and the PA Manger analyses it to identify its extent and root cause to avoid recurrence. In addition takes immediate actions to prevent unauthorized use of the nonconforming item. The nonconformance is documented on the NCR form and

submitted to the internal NRB (NCR Board), in which corrective actions are determined to eliminate the causes of the non conformances. Preventive actions are also identified to avoid the occurrence of the nonconformance on similar items.

- MIP/KIPs. These inspection points are chosen at points of AIV where there is maximum visibility and accessibility of quality status before proceeding to next major steps. This is to avoid any time consuming problem rectification further down the manufacturing and verification flow.
- Reviews (e.g. milestone reviews, readiness for manufacturing, readiness of test, review of test)

3.4 EIDP

The End Item Data Package (EIDP) constitutes the basis for formal acceptance reviews, to be integrated into higher levels EIDP during integration and testing. It is a collection of data related to the MAIT of the deliverable configuration item, providing traceability of all the events.

PA Manger is involved since the documentation which is delivered with the hardware CI includes also PA related documentation, among other. Hence, the EIDP includes acceptance minutes, Certificate of Conformity and Certificates of Cleanliness to demonstrate compliance to specifications, NCR list and copies of major NCRs, status of the RFDs/RFWs raised and processed on the product, Logbook, Procedures for Packing, Handling, Storage, Transportation, Installation, Safety, Cleanliness; test procedures and reports, Inspections and KIP/MIP reports, Lists of materials and processes, Safety Data Package, Qualification Status List, Critical Item List, List of lower level EIDPs, Ground support equipment (GSE) and Loose item list.

4. PRODUCT ASSURANCE IN THE MAIT AND DELIVERY PHASES

With the aim of the final mission qualification to demonstrate that Flight Models are robust, reliable and compliant to their mission goal, an extensive prototyping campaign is carried out at all levels, starting from the TOU and its sub-units. These campaigns are aimed at identifying risks and minimizing them already during the design phase, by means of breadboards and prototypes at sub unit level. This, in order to have already addressed most of the possible criticalities related to the TOU opto-mechanical design, verifying the alignment procedure and arriving ready for the development of models aimed at qualifying both the structural and thermal behavior and the optical performance of the TOU, at the Camera level.

The TOU design has been qualified and currently has begun its series production. Figure 3 shows the PFM during AIV and three TOU ready for testing in Clean Room (CR). As a general comment, dealing with a series production is one of the criticalities of PLATO mission: all 26 TOUs, and hence all 26 Cameras plus the spares are required to reach the required performances and pass acceptance tests.

4.1 TOU Qualifications

Qualifications at TOU level at Leonardo Company have been done for low and high level sine, random vibrations, shock, TOU TCS (Thermal Control System) functional test, TV (Thermal Vacuum) Cycling, TOU Performance tests (at acceptance and qualification level depending on the model philosophy). The Optical Tube Assembly (OTA) went through qualifications on breadboards for all OMGs for TV cycling, low level sine and high level sine, random vibrations and shock TF (Till-Failure test). At subassembly level (also at Leonardo Company) qualifications have been done for the radiation environment on all six glasses, blackening of lenses edges for two glasses (as required by straylighht), OMG bonding process, coatings for A/R, N-filter and F-filter for the red and blue passbands (this last ones provided by UST). For the OMGs, TV cycling, sine test, random vibration, shock loads test have been carried on. Qualifications at TOU Structure level (by UBE) on the Structural Thermal Model (STM, used for the qualification process of the thermal structure at the Camera level) have been made for sine test, random vibration, TV cycling. On the OMGs the black coating on different materials has been qualified, along with cleaning processes (ultrasonic cleaning, ion beam cleaning). At Baffle Assembly level qualification has been provided for the passivation of the external surface.

4.2 PA within MAIT

Product Assurance supports the qualification phases in reviewing all aspects related to the configuration item under manufacturing, test and delivery. The following review and boards are foreseen.

The Manufacturing Readiness Review (MRR) has the objective of approving the relevant manufacturing documentation, i.e. the design status. The goal is to assess Material, Mechanical Parts and Processes (MMPP) and their approval status; whether the relevant facilities are ready for manufacturing; to identify all open issues (e.g. open RID (Review Item Discrepancy), NCR, RFD) and actions that could impact on manufacturing; to finally release manufacturing.

Figure 3. The PFM TOU during AIV at the Leonardo Company in the left. Serial production @ Leonardo Company in the right.

The release for any TOU test (e.g. those listed above), the Test Readiness Review (TRR) is needed to approve the test procedure; to assess CI readiness for testing and the test facilities readiness for testing, to identify any open issue (NCRs shall be closed), to release the test campaign.

After testing has finished, the Post Test Review (PTR) is planned to review the tests results; to identify any open issue; to authorize for the dismounting the TOU from test setup. The status of NCRs is reported and clarified if they have any impact on the specific testing. Also a cleanliness assessment must be included to verify that requirements are met.

A final Test Review Board (TRB) reviews the outcome of the test campaign of the TOU model, giving evidence of the achievement of the required performances, and the information required to integrate the TOU within the Camera model. The second objective is to achieve the approval for delivering the tested hardware. PA Manager reviews the Certificate of Conformity (CoC) delivered with the model. NCRs and RFDs. An outgoing inspection is foreseen on the hardware at delivery and cleanliness status is checked. Also safety aspect are included in the Data Package.

Delivery is driven by the Delivery Review Board to agree on the formal delivery and shipment to the customer of the hardware. CoC are delivered. NCR status and RFD/RFW are agreed by all parties. Reports on outgoing inspection and cleanliness reports are provided. Any open work and safety relevant information is reported. After agreement from all parties, the delivery is authorized.

Currently, the PFM (Proto Flight Model) has already completed the foreseen qualification tests. The related test reports are in preparation for the TRB which will allow to decide on the successful completion of these tests upon review of all test reports. Figure 4 shows the PFM under testing.

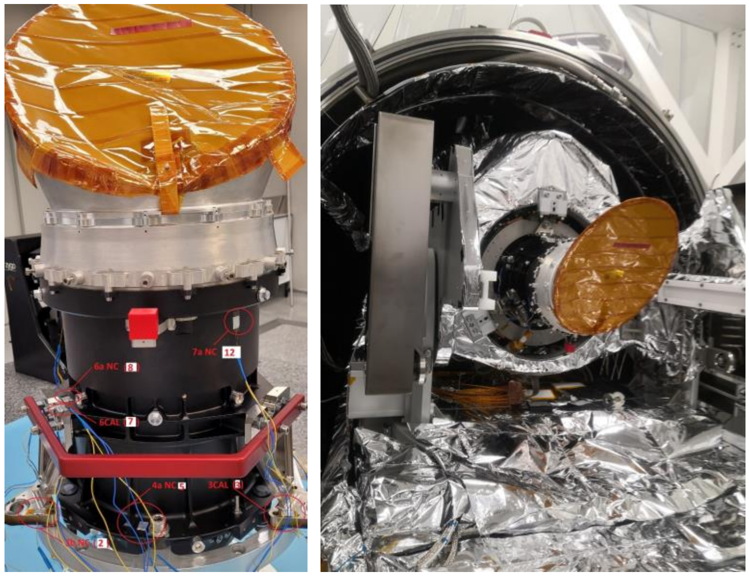

Figure 4. The PFM TOU performance test at the Leonardo Company

5. MATERIALS AND PROCESSES

Developing an instrument that will be working in orbit, and therefore in an extremely different environment from Earth, which combines vacuum and extreme temperatures, and potentially harmful radiation (as seen in Section 3.1), requires the use of out-of-the-ordinary materials that must be selected in the design phase and validated to face the hostile environment.

PA supports material and process selection: when a material or mechanical part, or process has no heritage, is out of specification or has a history of major problems an RFA (Request for Approval) needs to be issued, in which all involved parties up to higher level participate. The RFA process has two parts: the first part defines the qualification plan and the second part the qualification results. Both parts need to be approved and accepted by higher levels. In the following sections some examples of RFAs issued for the TOU are reported.

5.1 Selection of the adhesive bonding the optics to the mechanical structure.

The integration of the interface of the 6 OMGs of the TOU, composed by the lenses and their mounts, was considered the subject of a validation process through bread-boarding activities. In this regard, an extensive prototyping campaign has been carried out to verify the stability of the mechanical structure of the system as the temperature varies, its behavior during vibrations and to qualify the adhesives and gluing procedures. This last process involved the selection of the adhesives, in which the outgassing behavior of the material in vacuum needed to be considered. The campaign consisted in measuring the adhesive CTE (Coefficient of Thermal Expansion), its tensile strength and elastic modulus in dogbone shaped samples, the shear stress and tensile strength in bonded joints. Tensile and shear stress in bonded joints were also measured after TV conditioning and humidity ageing. For optical materials, the flexural strength was measured at T amb and cryogenic temperatures. Additionally an empirical trade-off on multiple adhesive systems behavior upon handling for pads production was performed and repeatability/stability of the process was verified. Pictures of samples after destructive tests are shown in Figure 5.

Figure 5. Samples after destructive tests.

5.2 Radiation hardened optical materials

The optical glasses selected for the TOU have been largely used by Leonardo Company in several space projects, yet some of them have no specific space heritage (glass melt tolerances), therefore they needed a dedicated justification for use and to demonstrate they will keep the expected performance during the lifetime foreseen for the instrument. The choice of the lens is mostly driven by the need to keep under control chromatic aberrations and resistance to radiation. Radiation analysis have been carried on to justify the selected materials: the optical components have been characterized by analyzing the wavelength-dependent transmission loss as a function of their thickness in dependence of the impinging radiation dose, by using Co60 gamma-rays source as probe [6]. We also developed a model to simulate the throughput of the whole TOU following irradiation, and used it to verify the instrument performance considering different types of stellar spectra.

Also the AR coatings to be applied on the lenses went through qualification test: the coatings mechanical and environmental performances are globally in specification, this meaning the AR coating designed and developed for the PLATO mission are successfully qualified according to the requirement specification.

5.3 Blackening of L2 and L6

A lesson learned from the EM (Engineering Model) was that of Analysis of straylight performed evidenced marginality versus one of the requirements. In order to mitigate the effect for the following models, the preventive action was that of implementing black painting on edges of two lenses, the most critical for straylight. From the PA point of view, an RFA has been issued, and test on samples of the same type of glasses of the lenses demonstrated that the coating is suitable for the intended use and environment. An epoxy based black paint was selected for the scope. Qualification tests were aimed at demonstrating the suitability of the black coating in terms of optical properties, mechanical resistance, solvent resistance, adhesion to substrate and contamination control (i.e. outgassing). It was also verified that the properties were kept unaltered after TV cycles and humidity ageing. Pictures of samples and OMGs with black paint applied are shown in Figure 6.

Final evaluation and approval of the RFAs is done through MPCBs (Material and Process Control Board) in which the supplier demonstrate the compliance of the chosen materials and processes and all items are revised and eventually approved by the customer.

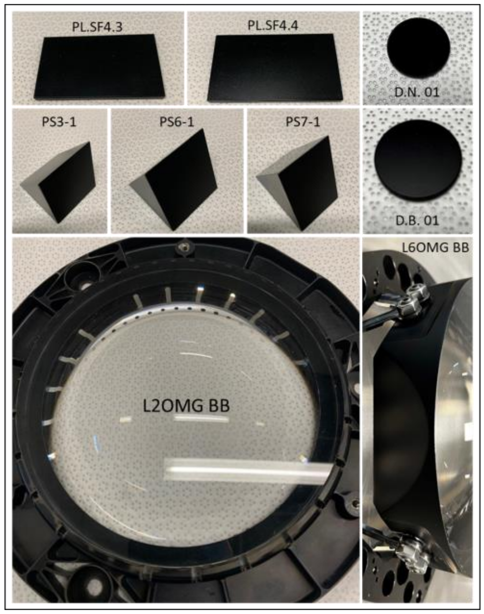

Figure 6. Samples and OMGs with black paint applied.

6. CLEANLINESS AND CONTAMINATION

Cleanliness is a very important factor in terms of the performance for a space instrument, and the most 'sensitive' elements affected by contamination are the optical surfaces: in the case of the TOU they are the entrance window and the six lenses. Not least, all the surfaces adjacent to the optics are equally subject to very stringent requirements as they are 'critical', since they can potentially redistribute the contamination to the sensitive parts. For the TOU this means all the internal surfaces of the tube that support the lenses and the baffle assembly.

During all ground activities in the MAIT, transport and storage phase, in the launch phase (e.g. caused by vibrations) and subsequently in orbit (e.g. caused by outgassing), the contaminants, both particulate contamination (PAC) and molecular contamination (MOC) can be redistributed and be deposited on all accessible surfaces, thus potentially degrading the optical performance. Additionally, optical surfaces in space are preferred condensation points for MOC because they are often among the coldest surfaces of a spacecraft.

At TOU level, the flowdown of the high level requirements foresees budgets for optical surfaces and for the structural components in their vicinity at TOU delivery to the higher level, for external and internal surfaces (those facing the optical surfaces), as reported in Table 2.

Table 1. Contamination budgets for the TOU opto-mechanical components, both for external surfaces and for internal surfaces, at delivery to higher levels for the TOU, the mechanical structure, mainly the tube, and the baffle.

BUDGET	TOU	TOU STRUCT	Baffle Assembly
PAC External [ppm]	200	100	100
PAC Internal [ppm]	200	100	100
MOC External [g/cm^2]	1.7 x 10^{-7}	0.8 x 10^{-7}	0.8 x 10^{-7}
MOC Internal [g/cm^2]	1.7 x 10^{-7}	0.8 x 10^{-7}	0.8 x 10^{-7}

The crucial requirement of contamination for the entire instrument translates for the TOU into a performance requirement that impacts the straylight. This last is verified in an analysis that takes into account the requirements in terms of manufacturing of the optical surfaces, the quality of the blackening of the edges of these, the characteristics of the coating, the mechanics that supports them, and the contamination of the optics. In fact, this contamination could cause scattering effects, generating a loss of transmissivity and an increase in the light background.

Contamination control involves a series of activities that must concern all the phases on the ground (incoming inspections, MAIT, storage and delivery). From the design (including processes and materials selection), through plans defining preventive precautions, inspection points and methods (e.g. visual, particle counters for PAC, measurements with FT-IR spectrometers for MOC), cleaning processes, continuous monitoring of PAC and MOC by the industry (e.g. the 'witness samples' as a tool to track contamination accompanying the hardware during all MAIT phases at all levels), see Figure 7; design of packaging / containers suitable and qualified for transport and storage; documentation to keep traceability (e.g. logbooks, PAC / MOC control sheet).

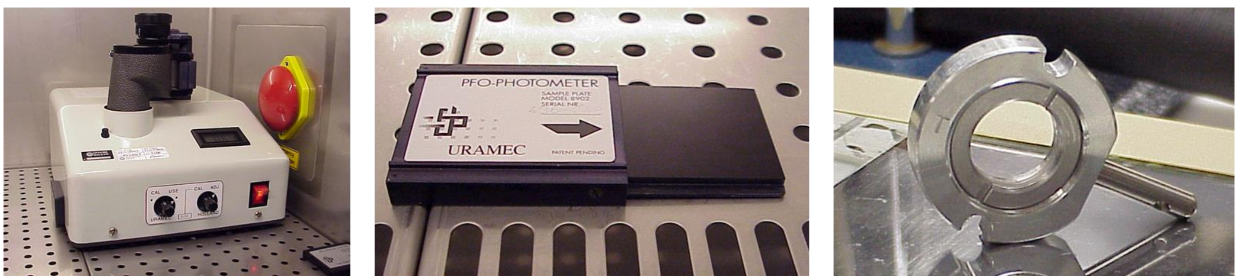

Figure 7. The PFO particle counter, a PFO sample for particulate contamination and a CaF2 sample for molecular contamination.

As a general approach all materials except black paint coated parts (that will be only cleaned at the end of the AIT campaign before packing and delivery), will be cleaned by IPA (Iso-propyl Alcohol) wiping for molecular or particulate contamination removal, and with nitrogen flushing or vacuum cleaner only for particles, to a highly sensitive visibly clean level every tine is needed to face a further production phase in the cleanest possible configuration. A much more challenging approach is applied to the very final cleaning steps. In order to achieve for PAC a level down to the TOU and subunits budgets, both for internal and external exposed surfaces, a several steps approach, under ISO 5 CR, will be followed. All activities will be carried out under dark conditions, under UV light: vacuum cleaning; dry wiping with dedicated, non-cross contaminating, wipes; ultra-pure gas blowing; particle by particle removal of all remaining particles ultra-sonic cleaning. Both lead to reduction of MOC and PAC. After the cleaning, a “highly sensitive visibly clean + UV + magnification” level inspection is foreseen (Figure 8).

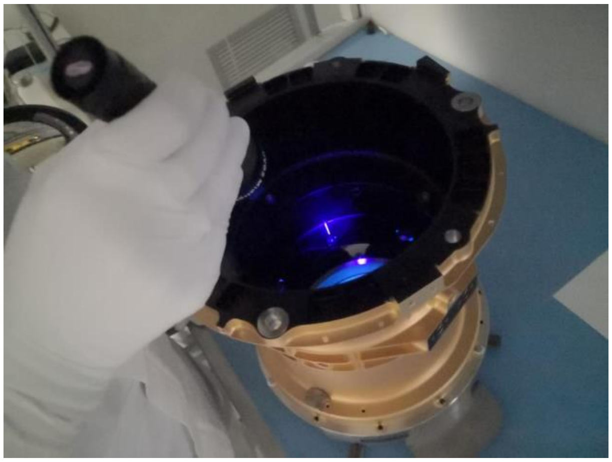

Figure 8. Shows an inspection with UV light of TOU.

In order to achieve the MOC level required at delivery by the customer the following two steps process, starting immediately before the Baffle Assemblies bake-out, has been implemented:

- First step: achievement of a highly sensitive visibly clean + UV on external surfaces (accessible and not covered) with high purity grade, compatible solvents. In this conditions, the hardware can be considered to be black paint, cannot be cleaned by means of solvents, but will be always kept covered from their integration by the red-tag covers until the bake-out;
- Second step: starting from the cleanliness conditions as per step 1, the thermal bake-out conditions will trigger the sublimation of the remaining organic compounds.

The effectiveness of this cleaning process will be certified by the "in-process witnesses analyses" that will constantly follow the TOU and its subunits during their lifecycle. This constant monitoring has been combined with a strict PA inspection approach. Contamination measurements on PFM both for PAC and for MOC comply with requirements. Figure 9 below shows that MOC measurement is within the expected budget.

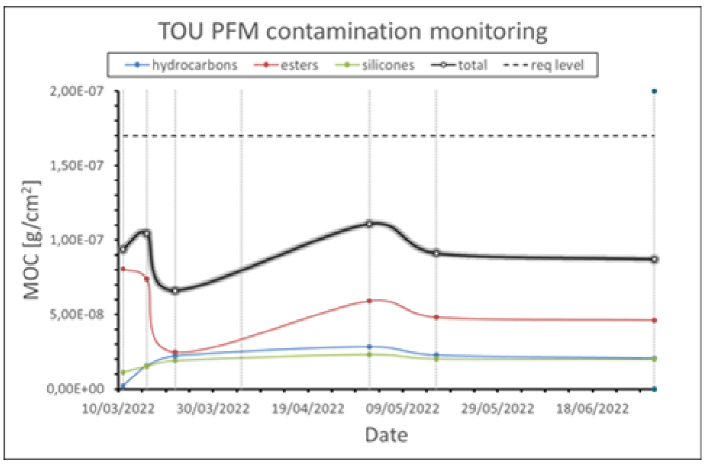

Figure 9. MOC monitoring for PFM.

The success of the contamination control strategy is not only related to the cleanliness level reached after the final cleaning, but also to the capability of maintaining these levels during the subsequent system level AIT phases. In order to protect and preserve the optics cleanliness high efficiency, red-tag protection covers have been developed (see Figure 10). These covers have been designed in order to be compatible also with the vibrational testing environment, allowing to protect the most sensitive hardware elements in the environments where the risk of cross contamination is higher.

Furthermore a heavier, more resistant, cover has been designed to offer mechanical protection during the whole ground segment satellite lifecycle.

Figure 10. BA during the final cleaning phase under ISO5 tent. On the left, a detail of the red-tag soft cover is visible. On the right the red-tag hard cover is visible.

7. VERIFICATION PROCESS AND MBSE

The Telescope Optical Units are a subsystem of the Camera, and among the common activities of the two levels (i.e. customer/suppler), there is also the VCB (Verification Control Boards) process chaired by the Subsystem team. The goal of each VCB meeting is to have the concurrence of all the parties on the close-out of each requirement applicable to the Unit (its verification is reached and evidence is properly reported in the documentation), then approved by the customer.

The verification process shall be considered completed when the Verification Control Board (VCB) confirms that:

- documented evidence is recorded in the VCD (Verification Control Document),
- identified requirements have been verified,
- associated product verification objectives have been reached.

In this context, the PLATO Camera Team has taken advantage of the MBSE (Model-Based Systems Engineering) methodologies using Enterprise Architect (EA) (by Sparx System) in support to this process of VCBs. A model of the whole mission is available from ESA and the Camera model will be integrated into it through requirement flow down from payload (or higher) to Camera system.

From PLATO Camera perspective, fields of main interest to be considered are Requirement ID, Requirement Text, Verification Method, Statement of Compliance, Test Block, Execution and Reporting Document. Currently, the verification process been developed for each requirement at System and Subsystem level by taking into account proper relationships between parent and child requirements, verification documents across external link to Eclipse and Confluence, and requirement deviations raised, i.e. RFDs-RFWs. This is an on-going activity since the process is constantly evolving during the development of the project; indeed, Verification Control Boards are still on-going and consequently diagrams will change based on further discussions.

The interaction with SE that are implementing the model, is of great interest for the PA team: by participating to the VCB for the PA, QA, Materials and Processes, Cleanliness and Contamination related requirements, the complete flow-down of requirements done at System to Subsystem level will be included through dedicated Specification and Verification documents also for PA/QA requirements in order to allow to easily identify and monitor any impact on the design due to changes, deviations and non-compliances, originated from e.g. manufacturing process and test/qualifications performed.

8. CONCLUSION

Product Assurance is a multi-disciplinary task covering a wide field of activities and challenges. This requires often support and advice of specialist. Product Assurance is an essential and critical part for achieving mission success. In fulfilling their tasks, PA Managers need to balance different, sometimes opposing interests, which is on one side challenging but at the other side also very interesting.

PA approaches the project, by participating in the monitoring and control of all the processes, providing confidence that the mission will be successfully completed, through standardized processes and review during project milestones and reviews.

An overview of the most important PA issues is given for the TOU otpo-mechanical design highlighting PA some of the principal activities that support a space mission project. Among these, we focused on PA monitoring tools, Materials and Processes approval, Cleanliness and Contamination Control. All essential processes whose goal is to enhance the likelihood of success of a project: outputs are essentially recommendations on design tradeoffs, a statement of risk, a procurement choice, or identification of potential design weaknesses.

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