Product assurance for instrumental projects in research laboratory: galaxies, etoiles, physique, instrumentation (GEPI)

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ABSTRACT

Product Assurance is an essential activity to support the design and construction of complex instruments developed for major scientific programs. The international size of current consortia in astrophysics, the ambitious and challenging developments, make the product assurance issues very important. The objective of this paper is to focus in particular on the application of Product Assurance Activities to a project such as MOSAIC, within an international consortium. The paper will also give a general overview on main product assurance tasks to be implemented during the development from the design study to the validation of the manufacturing, assembly, integration and test (MAIT) process and the delivery of the instrument.

Keywords: Product Assurance, MOSAIC, Risks, Specifications, validation, Quality management.

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1. INTRODUCTION

MOSAIC [1,2] is a Multi Object Spectrograph (MOS) for the Extremely Large Telescope (ELT) of the European Southern Observatory (ESO). The instrument will both use the collecting power and the resolution of the 39m aperture provided by the ELT. This very widest field of view will be combined with Adaptive Optics (AO) correction system to provide unique capabilities. This allow also to cover major science cases [3] related to: First light galaxies, inventory of matter (incl. mass assembly), extragalactic stellar populations, evolution of dwarf galaxies...

MOSAIC conceptual design [4] currently includes the following operating modes: a high multiplex mode (HMM) covering the visible and near-infrared domain; a high definition mode (HDM) that will provide spatially resolved observations in the near-infrared; and a multi light bucket integral field mode for the Inter-Galactic Medium mode (IGM).

The project team has recently finished the Phase A conceptual design study and is preparing the phase B (Preliminary Design) that is to start early in 2019.

The Project office (PO) is leading the effort. This structure that includes Scientific, technical and managerial staff most of them from GEPI (Galaxies Etoiles Physique Instrumentation) Laboratory is hosted by Observatoire de Paris.

MOSAIC is a big international consortium with the implication of many institutes.

For the MOSAIC Phase A: 11 countries and 9 institutes involved in technical work packages are part of the project team. Important budget and 10 years will be needed to build the instrument from design to first light at the ELT.

Due to the consortium size as well as the complexity of the instrument, the control of the project needs a particular attention, clear and precise policy to cover different aspects part of Product Assurance: traceability of all relevant activities and tasks, management control, design control, communication, suppliers selection and monitoring, etc. In this paper, we will describe the application of Product Assurance policy to control the MOSAIC phase A, we will also indicate what is planned for the next phases and give a general overview on main product assurance tasks to be implemented during an instrumental development.

2. GENERAL AND DEFINITIONS [5,6]

Quality assurance QA: is defined, with respect to the ISO 9000, as planned and systematic process aimed at determining whether a product or service meets specified requirements.

Quality System: is the structure and organisation implemented to provide confidence and demonstrate that requirements are fulfilled.

Product and quality management system: an overall development and management process to ensure that the project is under control and that the product will meet the requirement as previously defined at the beginning of the project. The aim is to get the "right product from the first time" to avoid time and money consuming iterations"

Product Assurance: this terminology is usually used instead of QA to designate a set of activities to be carried out throughout the project life cycle, from the requirements definition to the product acceptance. The main objectives are: to avoid defect, ensure that the final product /instrument will meet the project goal with respect to the defined requirements and technical specifications. The importance of PA increases as the complexity, cost and risk of the projects also increases.

For space instruments, PA is well anchored since the effects of a problem in a satellite, launcher or ground support equipment can be devastating in terms of cost, time, public or private property and even human life. Product and Quality Assurance Management contributes here critically to the success of the mission.

Ground instruments become more and more complex, expensive, challenging and sometime can be very risky, so the PA applicable to those projects should be carefully planned and implemented in a rather similar way than space ones.

Nevertheless, unlike space projects, the teams involved in ground instrumentation are not always familiar with the different aspects of the product assurance activities. This can sometimes, makes the implementation laborious.

The PA objective and methodology should be clearly formalised and respected throughout the project life cycle. Particular attention should be paid to communication at each project step to be sure that all the project members have the same understanding of what is expected and that they all agree with it.

3. PRODUCT ASSURANCE FOR MOSAIC PHASE A

During MOSAIC phase A, Product Assurance policy was defined and was part of the project management as required by ESO
In this preliminary stage of the study, the PA activities were focused on the following issues:

Organisation:

- Verify the quality requirements and negotiate with ESO if necessary to adopt the right level regarding the PA activities to be carried out for the Phase A conceptual design.
- Define and implement PA organisation and responsibilities within the consortium.
- Define methodology to implement the PA activities and identify how to follow the policy in such a way to avoid any issues / defects thus saving time, effort and money in the development of the instrument but also providing (ESO) with exactly what is required.
- Define and implement documentation management process to ensure traceability at any stage of the project during the overall development of the instrument.

Control:

- Project control in collaboration with the Project Manager (PM)
- Define and implement Risks and safety approach to optimise, identify and control design issues.
- Define and initiate configuration management control process
- Define and initiate the change request process monitoring

The aim at this stage of the project is to avoid at least the issues as listed hereafter that are the primary causes of project failure:

- Poorly Defined Requirements
- Inadequate Resources
- Lack of Change Management
- Poor (or no) Risk Management

3.1. Project control

The aim of adopting controls is to ensure that the project:

- Is producing the required product which will meet the requirements and the defined Acceptance Criteria
- Is being carried out to schedule and in accordance with the resource and budget as planned
- Remains viable

Management:

Regarding the size of the consortium, different levels of management are required and defined:

Work packages:

Work package (WP) Managers have sufficient autonomy to control and monitor the work progress related to the WPs which are under their responsibility. They are also responsible for the reporting to the project office on relevant information regarding any risks, or work or work progress issues.

Project Office:

The Project Office is the group of Relevant Staff managing the Project on a day-to-day basis providing project management, technical and scientific leadership. The Project Office includes the Principal Investigator (PI), Project Scientist (PS) and/or deputy, Instrument Scientist (IS) and/or deputy, Project Manager (PM) and/or deputy, Product Assurance Manager (PAM), System Engineer (SE) and/or deputy and, lastly, Project Assistant (PA).

The Project Office also assists the PI for communications, negotiations and meeting organisations towards the inside/outside world.

The Project office is responsible for the overall Management of WPs, for work progress monitoring and for deliverables on time delivery.

The PO requires monthly progress report from all WPs to get information about:

- Management progress
- Technical progress
- Difficulties encountered / Risks detected
- Outputs and deliverables
- Support and suggestion
- Next Steps

Regular conferences and meetings are also planned and organised by the PO all through the project life cycle.

The PO is also responsible for the organisation of internal reviews that are focused on the design progress and risks analysis during the phase A development.

Board:

The board acts as the executive level of management. It meets to discuss the project progress typically once every three months, and makes scientific, managerial and technical decisions at the various steps of the project. It consists of the PI and the CoIs

Steering committee:

This committee includes the persons nominated by the Partner and Associate Partner Agencies. The main role of the steering committee is to follow the milestones of the project in coordination with the PI, to review the Memorandum of Understanding (MoU) for the Construction Phase that will be prepared during Phase A, and to organise in Europe (and Brazil) the scientific and financial support of the ELT-MOS. It includes countries in the core of the project as well as other participating countries (including those interested in financially supporting the project in exchange for Guaranteed Observing Time, or their participation in Public Surveys).

3.1.1. Design control

During the MOSAIC phase A, the full MOSAIC concept as well as a description of four possible reduced alternatives were presented to ESO at the Mid Term Review (MTR).

From the Phase A initial estimates, the full concept will require important hardware budget as well as important FTE[1] for the scientific, management and technical work. Reducing the multiplex to say, e.g., 40% and 80% of the 'full concept' in visible and NIR, respectively, would significantly reduce the hardware costs by about 30% although it would only have a marginal impact on the needed FTEs. At the end of the Phase A both full and reduced multiplex concepts were presented.

When the baseline will be fixed the design will be under control to ensure compliance between the scientific requirements and the technical specifications as previously defined.

3.1.2. Design verification

Four methods [7] of verification will be applied to verify that the requirements of the Instrument are fulfilled:

Verification by Design

Verification by design consists of using approved records or evidence (e.g. design documents and reports, technical descriptions, engineering drawings) that unambiguously show that the requirement is met.

[1] FTE : Full Time Employment

Verification by Analysis

Verification by analysis consists of performing theoretical or empirical evaluation using techniques such as systematic and statistical design analysis, modelling and computational simulation.

Verification by Inspection

Verification by inspection consists of visual determination of physical characteristics (such as constructional features, hardware conformance to document drawing or workmanship requirements, physical conditions, software source code conformance with coding standards).

Verification by Test

Verification by test consists of measuring product performance and functions under representative conditions, or under conditions that can be clearly traced to operational ones. It includes the analysis of data derived from the test.

3.1.3. Configuration management and change control

The Configuration Management (CM) process consists in identifying each item, establishing the product configuration and the relation to the hardware and software at any time during the project. This process that was initiated during Phase A will be fully described in the CM plan and documented during the phase B.

The objective of the CM plan is to document and inform project stakeholders about the CM process that will be adopted throughout the MOSAIC project.
It defines the project's structure, tools and how they will be applied by the project to meet success. The procedure also defines methods to ensure:

- Identifying, defining, configuration items (CI)
- Controlling modifications and releases of CIs
- Reporting and recording status of CIs and any requested modifications
- Ensuring completeness, consistency, and correctness of CIs
- Controlling storage, handling, and delivery of the CIs
- During MOSAIC phase A, only configuration related to the management of information and documentation was applicable. The objectives were to ensure that:
  - The documentation management process is applicable and respected by the project team
  - Changes are not implemented without duly analysis and further approval
  - Requests for change or waivers are properly handled
  - Interfaces (internal and external) to the instrument are properly handled.

As a minimum all the deliverables are under configuration management process and listed in the Configuration Item Data List (CIDL).

3.1.4. Risk and safety hazard control

The aim of the risk analysis [8] file is to fully list the risks, to evaluate the weight of the risk, to foresee possible corrective actions and to analyse them and their impact on cost, specifications and schedule.

The risk management process includes five steps, as shown in the diagram below:

- identification,
- characterization,
- classification,
- analysis and management associated throughout the project life cycle.
- feed back

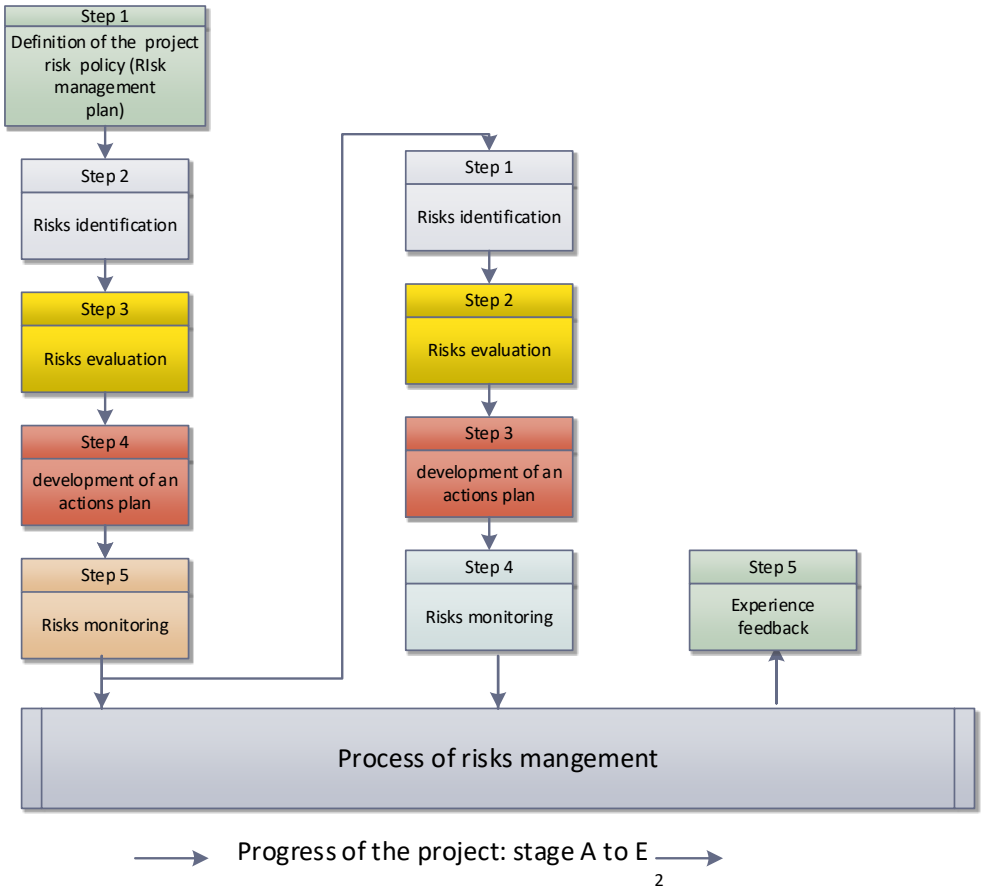

Figure 1 Risk management process

Attention is also paid to safety. A preliminary Hazard List (PHL) related to the design was delivered at the end of the phase A and this work will continue in the following phases.

4. GENERAL OVERVIEW ON PA DURING INSTRUMENTAL DEVELOPMENT

Product assurance includes many activities that shall be implemented and monitored during the project life cycle.

[2] A to E: different project phases from preliminary study to decommissioning

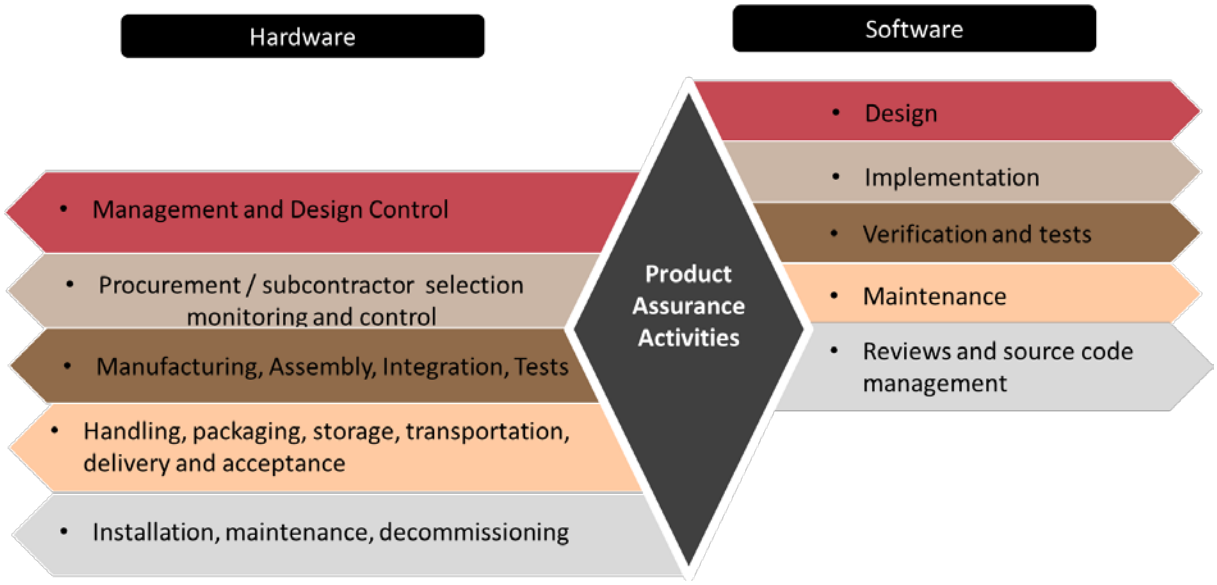

Figure 2 Product Assurance Activities during instrumental development

According to the project perimeter and the information given in the contract with the agency (ESO, ESA etc), all or most of the activities indicated above should be carried out during the project life cycle. We will not address in detail each item, this can be done in future work, the objective in this paper is to give a general over view.

In general, the Product Assurance Plan provides information about the organisation and the planned arrangement for the fulfilment of the requirements related to the different PA activities.

In case of subcontracting, the supplier shall provide documented information about the organisation and the planned arrangement to fulfil the requirements related to the system or sub-contracted subsystem. In this case, internal reviews and audits should be planned and implemented by the project Assurance Manager. The objective is to control the work progress and validate the product at each step of the fabrication, or following what is indicated in the contract.

5. CONCLUSION

Assuring quality and reliability performance for high complexity, high reliability equipment/ instrument, is not a trivial task. Although the practice of product assurance is not new and is presently widespread.

In fact, we all need to have confidence in the reliability, maintainability of an airplane, an elevator etc before it is used. PA insure that all steps of the process from requirements definition to the delivery has been correctly mastered with appropriate and qualified resources. For MOSAIC and any Instrumental Project in general, a lack of Product Assurance management and / or control can have serious impact on performance, cost or schedule.

During the MOSAIC, phase A, a general approach in adequacy with high-level requirements regarding PA was applied. The work initiated will go on in the next phases and tools like: Automated Systems Analysis using Executable SysML Modelling Patterns (ESEM) to support PA activities will be investigated.

SysML[9] is modelling language that is actively used in various domains like aerospace, defence and automotive. In the future, we will investigate how this approach can be applied to the project to support requirements traceability, verification and validation, design change control and FMECA analysis.

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