Plan for a Post-doc (PD) Scholarship in Astronomic Instrumentation
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Systems Engineering applied to Astronomy Instrumentation Projects

1. Summary

This project intends to form a professional with unique expertise in the area of Systems Engineering (SE) for Astronomical Instruments. Its immediate goal will be to work on one of the Giant Magellan Telescope (GMT) [3] instruments projects and/or on the SAMplus project, both currently in the GMT Brazil Office.

2. Introduction

The GMT Brazil Office (GMTBrO) is working in several instrumentation projects. The four instruments that the PD will have to familiarize himself/herself with are SAMplus, GMACS, G-CLEF and MANIFEST.

SAMplus project is the upgrade of the adaptive optics system of SOAR Adaptive Module (SAM), installed on the Southern Astrophysical Research Telescope (SOAR) [7]. The upgrade involves the replacement of the deformable mirror and the wavefront sensor CCD camera to achieve a better overall system performance [6]. SAMplus is an extremely complex multidisciplinary system that requires appropriate management of the project present and future information and configuration. The PD candidate will have to thoroughly analyze SAM's documentation in order to be able to prepare the SAMplus documentation for the phases of assembly, integration, tests and commissioning of the new instrument.

GMACS is the GMT Multi-object Astronomical and Cosmological Spectrograph project, a multi-object moderate resolution optical spectrograph to be installed on the GMT [1][2]. GMACS will be the first member of the GMT's first generation instruments, which must be operational when GMT starts operating. Due to the broad range of application of GMACS to different astronomical studies, GMACS will probably be the most widely used instrument in the early years of GMT operation. Recently, due to changes in GMACS requirements, its opto-mechanical subsystem must be redesigned after the the Conceptual Design (CoD) phase [5]. Because this process

requires a new opto-mechanical design [4], updating the PBS will be mandatory, prior to the phase of Preliminary Design.

G-CLEF, the GMT-Consortium Large Earth Finder, is a high-stability, high-resolution, echelle spectrograph operating in the visible range of the spectrum. [8]. Because of its resolution and expected stability, it will be mounted inside a thermally-stabilized and vibration-isolated room on the gravity invariant platform in the GMT [9]. G-CLEF is the only high-resolution spectrograph planned to be operational during the first decade after the three Extremely Large Telescopes (ELTs), currently under construction, enter operation. GCLEF project is well managed in terms of SE, and the PD candidate will likely be required to work on the Critical Design (CD) phase of the project.

MANIFEST is the GMT MANy Instrument FibEr SysTem, a robotic fiber-optic positioning system, which will allow the use of the full GMT's field of view of 20 arcmin circular, by some instruments. Its field plate glass will be used by several so called starbugs, small robots carrying optical fibers that collect sky-targets light at the focal plane and carry it to an instrument. MANIFEST can even split the light into more than one instrument, at the same time. MANIFEST has just submitted to the pre-CoD (pre-Conceptual Design) phase documentation, and the PD candidate is likely to work on the entire CoD (Conceptual Design) phase over all the SE required documents. The instruments for this new generation of ELTs present challenges predicted by experts, such as the suitability regarding the components size, instrument operation stability and metrology [10]. All of them are part of the SE process, where the PD candidate will participate actively on instruments systems and subsystems requirements, requirements management and life-cycle management.

3. Objectives

The primary objective of this PD scholarship project is to give the PD candidate the necessary expertise to develop the SE for astronomical instruments, and to integrate areas such as mechanical, opto-mechanical, electrical and detectors, under the concept of requirements. The PD will be able to provide traceability solutions related to requirements, translating the science requirements into instrument requirements. The immediate application of this PD scholarship project is the study of requirements issues in large ELT instrumentation and to propose a solution for the management and the flow-down of requirements.

4. Details of the plan of work

The first task of the PD will be to carry out a critical and detailed review of the instruments concepts of operations. Life-cycle can then be analyzed, followed by the identification of interfaces to the environment. Requirements management is to start as soon as the needs of the stakeholders are defined and captured, and will naturally require planning for tests for their verification and validation. Identification of risks, and their mitigation, is present during the whole project.

Regarding the project activities, the PD will participate directly in several subareas (main areas labeled inside []), such as:

- Requirements flow-down from higher level documents, such as Science Requirements Documents (SRD) and the Observatory Architecture Document (OAD); [requirements]
- Control the interfaces between the instrument and the observatory between the instrument and the environment, identifying the resulting requirements; [interfaces]
- Capture the concept of operations; [concepts]
- Analyze if the proposed life-cycle is appropriate; [life cycle]
- Identification of risks that can jeopardize the project ; [risks]
- Analyze requirements with respect to the instrument and its subsystems; [requirements]
- Management of all the identified requirements; [requirements]
- Identification of an appropriate tool for managing the instrument requirements; [requirements]
- Contribute to the requirements verification and validation plan; [tests, V&V]
- Prepare test plans and test procedures, as well as their results acceptance criteria. [tests, V&V]

One activity that may appear later on the project will be the study of causes and effects of failures, which could compromise the instrument operation and the overall scientific data quality. Failures may arise from technical causes, or even due to human causes. In both cases the ultimate effect is the degradation of the image quality. This activity will require constant interface with the system design team.

For the development of the work described, the PD candidate should have basic knowledge in mechanical, opto-mechanical, electrical and fluid analysis, as well as in FMEA (Failure Mode, Effects and Criticality Analysis).

5. Methodology

The proposed methodology consists of defining, developing, and analyzing requirements based on stakeholder needs. The initial inputs for this project are the current documents and CAD drawings of the instruments presented in their respective phases design reviews. Updates, changes and new requirements will require from the PD candidate expertise for the proposal of solutions and impact of changes, consequently, the refining of the system requirements that meet the scientific needs of the project.

The software work tools that will be available to the PD candidate will be Solidworks and OpticStudioZemax, respectively, for CAD modeling and optical modeling, design and analysis. Both of them are available at the Institute of Astronomy, Geophysics and Atmospheric Sciences (IAG), and serve as support for the activities. Additional software licenses dedicated to opto-mechanical design are planned to be acquired, also with the purpose of supporting the projects.

Requirements management tool, however, is expected to be selected by the PD candidate as the work develops. Further tools might be necessary in time, and the PD candidate must be open for additional learning.

6. Proposed work schedule

The proposed activities and schedule are presented in Table 1. The schedule is planned for a twelve month period, and can be extended for the same duration. During this period, the PD candidate can be involved in one or more projects, respecting the 160 hours/month limit.

Table 1. Proposed work schedule.

Main areas	Semester 1		Semester 2		Semester 3		Semester 4	
Concepts								
Life-cycle								

Interfaces								
Requirements								
Tests, V&V								
Risks								
Papers								
Final Report								

We intend to send the PD for training or internships in international IAG partner institutes that have experience in similar SE projects. These activities are not included in the schedule above.

7. Justification

This PD scholarship project proposal is only possible because IAG is directly responsible for the SAMplus project, and the GMTBrO is involved in Systems Engineering of GMACS, MANIFEST and G-CLEF. This plan of work is sustained by the need of training Brazilian instrumentalists that will be leaders of future astronomical instrument development projects. This project is inserted in the context of the GMTBrO activities for the GMT.

8. References

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