Australian National University

Handover Document

Prepared For

Advanced Instrumentation and Technology Centre

ANU College of Engineering and Computer Science

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Introduction

The purpose of this document is to enable a smooth continuation of the ANU Guide Star Laser Interface project. We provide a snapshot of our progress so far, outlining the challenges we have overcome, and the rationale for our design decisions. Finally, we outline the expected steps for continuing our work.

Contents

Acronyms

AITC Advanced Instrumentation and Technology Centre.

ANU Australian National University.

AO Adaptive Optics.

AOI Adaptive Optics Imaging.

AOTP Adaptive Optics system for space debris Tracking and Pushing.

EOS Electro-Optic Systems.

GSL Guide Star Laser.

GSLI Guide Star Laser Interface.

IDD Interface Design Document.

LGS Laser Guide Star.

OOS out of scope.

SERC Space Environment Research Centre.

SSS System Subsystem Specification.

1 Project Context

This section outlines the scope of this document, as well as the the context and scope of our Guide Star Laser Interface (GSLI) project. It also defines aspects of the system that have been deemed out of scope.

1.1 Document Scope

The scope of this document is to convey the current state of the GSLI project and potential for continuation activities to our current client, as well as to the current and future stakeholders.

1.2 Project Context

1.2.1 The Telescope

The Electro-Optic Systems (EOS) 1.8m telescope is currently used for satellite and space debris tracking at Mt Stromlo Observatory in Canberra. This telescope is also the site of the Space Environment Research Centre (SERC) project to build an Adaptive Optics Imaging (AOI) system for satellite imaging, and an Adaptive Optics system for space debris Tracking and Pushing (AOTP).

1.2.2 Guide Star Laser Optics

In Adaptive Optics (AO) a Guide Star Laser (GSL) is required to produce an artificial star in the atmosphere, which can be used to measure phase distortions caused by atmospheric turbulence above the telescope. This artificial star is known as a Laser Guide Star (LGS). Using a GSL is the current optimum method of creating a light source with acceptable return photon flux and manoeuvrability to track fast moving objects such as satellites.

1.2.3 Adaptive Optics Projects

The Advanced Instrumentation and Technology Centre (AITC) is in the process of developing multiple AO systems for various projects, including the SERC AOI and AOTP systems. They also have an invested interest in the demonstration of an Australian National University (ANU) GSL prototype, as it is predicted to be a cheaper and more effective product for AO systems around the world.

1.2.4 System Interface

The AITC has expressed a preferential preliminary concept for the System Interface that would enable all three GSL solutions to be interfaced to the telescope simultaneously. However, it has also been recognised that this may not be possible within the constraints of the 1.8m telescope and the three GSL systems. Note that simultaneous interfacing does not imply simultaneous propagation of the lasers.

2 Project Scope Review

The minimum project scope is to define and provide the requirements to interface the commercial Toptica GSL, the EOS GSL, and the ANU GSL on the EOS 1.8m telescope located at the Mt. Stromlo Laser Ranging Facility, ACT.

2.1 Out of GSLI Project Scope

The capabilities/attributes defined to be out of scope (OOS) of the project objectives and deliverables for the Interface System are outlined as below:

a. Beam transfer optics from the laser to the laser launch telescope.

b. Laser launch telescope.

3 Project Goals Review

3.1 Initial Goals

3.1.1 Main

Delivery of a complete set of requirements for the development of the interface in the form of a System Subsystem Specification (SSS) document.

3.1.2 Extension 1

Develop and specify characteristics of the interfaces in the form of high-level and detailed systems architecture diagrams. This was to be delivered as a Interface Design Document (IDD) with potential supporting CAD diagrams.

3.1.3 Extension 2

Development of conceptual design CAD models, and further investigation of the system interfaces.

3.2 Progress Toward Goals

3.2.1 Main

The SSS was released for a detailed review on the 21/04/17 and for final review and submission with this handover document on the 19/05/17. The requirements were explored in full with the occasional exception where insufficient information, or staff availability, prohibited a thorough investigation. A comment specifying the need for further investigation was added to each such requirement. Each requirement also has a link to the source document listed in the SSS references section for requirement confirmation, should additional investigation be required at a later stage.

Development of the requirements highlighted conflicts between four systems: the 1.8m telescope and dome, the EOS GSL, Toptica GSL, and ANU GSL. These were recorded in the 'Requirement Conflict Identification' table in the SSS. For each conflict there is a link to the requirements, a brief description of the issue, and a potential solution provided.

3.2.2 Extension 1

A high-level interface diagram was developed to summarise the interconnections between the four interface systems described within the SSS document.

It was initially proposed that the various laser-telescope systems would be discussed in an IDD document, separate from the main SSS. Throughout the development of the project, however, we determined that all the interfaces could be contained within one diagram. This single top-level diagram could then be used to provide context for the SSS, to elucidate relationships between the requirements and conflicts that we developed. Hence, a decision was made to include the high-level interface diagram in the SSS, and not to develop a separate IDD, to avoid duplication of work.

3.2.3 Extension 2

A set of CAD models have been developed to show the most likely laser combination: the ANU GSL and the EOS GSL. The design focuses on minimising rework of existing mounting designs for the EOS GSL. Scaled images from this design are located on the project Poster. High-resolution images and SolidWorks models have been handed over to Céline.

4 Project Documentation

Pro Forma: This document specifies the project goals, scope and initial project schedule.

System Subsystem Specifications: This document contains all of the developed design requirements, identified conflicts between the requirements, potential solutions to the conflicts, and system interface diagram.

Project Review 1: This review was prepared in the first third of the project and details a good background to the project pitched at a level appropriate for those unfamiliar with the project or AO in general.

Project Review 2: Review prepared two thirds through the project which details adjusted project objectives, the progress to date, and addresses feedback received on the project.

Project Review 3: Review prepared at the end of the project. Contains a good summary of the project results and hand over information which can compliment the information within this document.

Poster: Poster prepared for a research presentation evening. Contains a good summary of the project motivations, results and graphical conceptual designs.

5 Challenges

5.1 Challenges Resolved

a. Confirmed and updated the CAD model of the interface plate on the 1.8m Telescope. Including confirmation of the thread patterns of the available mounting holes. A diagram of this is attached to the SSS.

b. Developed requirements in situations where there was no up to date documentation available.

c. Developed a conceptual design which will allow for the ANU GSL and the EOS GSL to share a breadboard.

d. Handling limited, restricted and confidential requirements for the Toptica GSL.

5.2 Challenges Unresolved Within Scope

a. Many requirements for the ANU GSL have not been gathered as the system is still in development.

b. Not all requirement conflicts we have identified have been analysed, due to a lack of available information

c. Many of the requirements require further refinement, for example the exact amount of power available in the dome is not known and the cleanness of the air is not known.

5.3 Challenges Unresolved Out of Scope

a. There is currently no provision for water in the dome. A water interface may be required for heat exchange between the laser cooling equipment and external environment.

b. There is currently no provision for clean air in the dome. An air interface is required for the electronics cabinets.

c. For the final design solution, analysis of the accessibility and transport of equipment to the observation level must be performed. Hatches exist within the dome and the CAD model, but the current availability of these ports needs to be confirmed. All other equipment has to be manually transported up the internal stair case or lifted in via a crane.

6 Design Decisions and Notes

a. Conceptual designs of the Toptica and EOS laser mounted together were not considered as the Toptica will not be required should the EOS laser be on schedule.

b. Conceptual designs of all three lasers together were not considered beyond a simple 2D sketch due to the low probability of both the EOS and Toptica GSLs being functional at the same time.

c. The ANU and EOS GSL combination was developed first as it was deemed the most likely combination to eventuate.

d. A detailed analysis of requirements verification procedures was not completed beyond the requirements verification matrix in the SSS as this is part of the preliminary design stage and the conceptual design stage is not yet completed.

e. The electronics stacks are set to be installed on the observation level in the current conceptual design for reasons of convenience and ease of design communication.

7 Expected Next Steps

Our work on the GSLI formed the initial phase of the design process that will result in a combination of GSLs being mounted on the EOS 1.8m telescope at Mt Stromlo in Canberra. The aim is to demonstrate a GSL on this telescope by the time SERC ends in mid 2019. Prior to this, it is hoped that a GSL will be ready for on sky testing with a closed AO control loop by the end of 2018.

Further development of the project entails:

a. Finalisation of the requirements where insufficient information was available.

b. Continue development of the initial conceptual design for the ANU and EOS GSLs.

c. Addition of mechanical interface between EOS breadboards and mounting plate to conceptual design.

d. If necessary develop other conceptual designs for different GSL combinations.

e. Addition of optical, electrical, environmental, and logical considerations to conceptual designs.

f. Detailed investigation of dome access hatch locations and availability.

g. Design of clean air management system.

h. Design and layout of water access in dome for chillers.

i. Consider details of the ANU GSL implementation as they become available during its development process.

8 Acknowledgements

The team would like to thank our supervisor Céline for her time and guidance. We would also like to extend further thanks to the staff at AITC and EOS for incorporating us into their work environment, and for all the assistance that was provided to us.

9 Continuation of Project

9.1 Current Team Member Availability

Name	Availability	Contact Details
Alex Stuchbery	Possibility to continue work in the form of a PhD starting in 2018.	alex_stuchbery@hotmail.com.au 0416 280 082
Gerard Kennedy	Happy to continue the project as a part time job (roughly 10 hours per week) from now until mid 2018. Also happy to work full time during Summer 2017/18. I would be happy to work all Summer if I received the SERC scholarship.	gerardkennedy93@gmail.com 0418 179 602
Jordan Davies	Actively looking to continue project or comparable project work as part of a final year Honours Thesis. Working 10 hours per week for the duration of Semester 2 2017 and Semester 1 2018.	jordan_davies@live.com.au 0430 167 409
Markus Dirnberger	Seeking a 12 or 18 unit R&D Project for either/both Semester 2 2017 and Semester 1 2018. Activities could count toward my Honours Thesis. Can dedicate up to 20 hours per week to this project, or one of a similar nature.	markus.dirnberger@me.com +61 (0)490 458 770
Samson Nilon	My schedule for the rest of the year pretty tight so I won't be able to continue the project through uni or an internship. Otherwise I'm happy to help out occasionally.	samson.n@bigpond.com 0477 293 340

Table 1: Team Availability

10 Contacts

Name	Role	Contact About	Contact Details
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Table 2: Project Contacts

References