Australian National University

PROJECT REVIEW - WEEK 5

Prepared For

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Introduction

This project review is set out by first providing a section orientating the reader with our project (Section 1). This includes providing the overall context, a description of the project, and why our project is valuable to our client. The project objectives and deliverables are also articulated, again so that the reader is familiar with our goals. Next, an overview of our progress, complete with links to the relevant documentation is provided (Section 2). The document ends with a summary of work that will be undertaken in the immediate future (Section 3).

All future project reviews will include this same orientation section (Section 1), in order to ensure that any reader understands our project specifics. Future reviews will then be augmented with a new, up to date summary of our progress (Section 2), and the relevant next steps (Section 3). It is thus Sections 2 and 3 that fulfil the bulk of the requirements for this report.

Contents

1 Project Overview

1.1 Context

When light from space reaches the Earth's atmosphere the wavefront is flat and unaltered. However, the Earth's atmosphere contains pockets of hot and cold air with different refractive indices, and this non-homogeneity causes wavefront aberrations as light propagates through it [1]. These aberrations result in a blurred image on telescope instrumentation. Adaptive Optics (AO) is the technique that is used to correct for these aberrations, by monitoring a light source propagating through the atmosphere, and manipulating a deformable mirror accordingly.

To apply AO a stable light source is required to determine how the atmosphere is distorting the incoming wavefront. Initially this was done using a natural guide star: a bright star in the sky close to the object to be imaged. However, this restricts the sky coverage achievable to areas near natural stars, and also does not work for monitoring fast moving objects like satellites or space debris.

To make up for the limitations of natural guide stars, a Guide Star Laser (GSL) is required. A GSL is created by propagating a laser at 589 nm into the atmosphere. The laser energy is absorbed and re-emitted in all directions by a sodium layer located between 9 and 10km above sea level, creating what appears to be a fake star. This GSL can be directed anywhere in the atmosphere, and moved as required, to allow AO tracking of satellites and space debris.

1.2 Description

The Australian National University (ANU), Advanced Instrumentation and Technology Centre (AITC) and Electro Optics Systems (EOS) are currently developing two different sodium GSLs at Mount Stromlo, which are to be mounted on EOS's 1.8m telescope by early 2019. The first of these lasers is a fourth generation semiconductor-based laser being developed by our client, Céline d'Orgeville of the ANU [1, 2]. The second laser is a third generation hybrid fibre laser being developed by EOS. These lasers will be mounted alongside the only commercially available sodium GSL: Toptica's third generation fibre laser [3]. These three lasers will be attached to the telescope with the aim of using them to track space debris orbiting around the Earth to implement collision avoidance [1, 2, 4].

Our project aims to utilise a systems engineering approach to design the interface between these three lasers and EOS's 1.8m telescope at Mount Stromlo. The system will structurally support the lasers and also provide the optical, electronic and logical interface between the telescope and laser systems. The precise requirements and deliverables of the project are outlined in Sections 1.4 & 1.5, and a summary is also provided here. The operational requirements of the three lasers, as well as the telescope and the surrounding dome will initially be collated. These requirements will then be analysed to determine any conflicts, which will in turn dictate the design requirements of the final solution. These design requirements are the main deliverable of this project. If time allows, a conceptual design, and perhaps a prototype will be constructed.

1.3 Motivation

The reason that we have been tasked with providing an interface for three lasers, when one would suffice for the purpose of debris tracking, is to allow for direct comparison between laser systems. This comparison is important for two key reasons.

Firstly, GSLs are being incorporated into plans for many major telescope projects, including the Giant Magellan Project (for which ANU is a partner), which will require six GSLs, and the 30 Meter Telescope, which will require six to nine GSLs [1]. GSL's have therefore got a big future, and an analysis of the best and most cost effective option is beneficial to a large number of parties. Furthermore, the Toptica laser is the only commercially distributed GSL, and its production is not guaranteed into the future [1]. It is therefore critical that an alternative laser be developed and compared to the Toptica laser.

Secondly, while a proof of concept for the Semiconductor Laser has been completed, it is yet to be prototyped. The interface being designed in this project will therefore allow for the first instance of testing and validation of a Semiconductor GSL to take place. This is particularly important as the Semiconductor laser is expected to be cheaper, smaller, and more efficient than any current alternative [1]. Should this system compare favourably to it's competitors, future commercialisation will become a viable option. It will also significantly decrease the cost of the major projects listed above, providing further value to our client [1, 4].

1.4 Objectives

During the initial client meeting on the 2nd of March the project approach summarised in Section 1.2 was outlined. This approach was subsequently broken down into objectives that were assigned to various categories based on their relative value to our client, and time constraints. The categories are: Minimum Objectives: the objectives that must be satisfied for successful project delivery, Extension Objectives 1: progress beyond the minimum scope for which there is still a reasonable chance of completion, and Extension Objectives 2: progress that has been deemed optimistic yet potentially possible given time constraints. These objectives are described in depth within the Project Pro Forma document, (discussed in Section 1.5), but are also summarised below.

The Minimum Objective for the project is a System Subsystem Specification document (SSS). This document will be compiled by first collating the operational requirements of each component (i.e. the three lasers, and the telescope within its dome). These operational requirements include, but are not limited to, the mechanical, optical, thermal, environmental, control, software and electronic requirements of each component. All the conflicts between components that these requirements expose will then be used to determine the design requirements of the final solution. The above operational requirements will form the core of the SSS, which will also outline the constraints, and include a Requirements Verification Matrix (RVM). The SSS was deemed to be the most valuable, and thus minimum objective of the project, as it will form the basis for any future design, whether it be done by us or future students/engineers.

The Extension Objective 1 for the project is a conceptual design that will take a form that is dependent on the outcome of the Minimum Requirement. For example, should the design requirements indicate that electrical I/O's will prove the most crucial aspect of the mounting system it is likely that the initial prototype would comprise of various circuit schematics. Likewise if space proves to be most important, a CAD design of the physical mount would be more appropriate.

The Extension Requirement 2 for the project is a design prototype. This will again be dependent on the outcome of the Minimum Requirement, but is likely to take the form of a CAD design with corresponding documentation.

1.5 Deliverables

The first deliverable is a Project Pro Forma document. This document contains all the preliminary project information, such as a scope definition, objectives and deliverables, a document tree, schedule, and a top level interface description. This document was delivered to the client on March 17, and is available here [5].

With the project preliminaries finalised, the next deliverable is the Minimum Objective: the SSS. The schedule that has been developed for this project includes three reviewing stages before the SSS is signed off. These stages are: a System Requirements Reviews Preliminary (SRRP), System Requirements Reviews Opening (SRRO) and System Requirements Reviews Closing (SRRC). The purpose of these stages is outlined in the Project Pro Forma document.

If and when the Minimum Objective is delivered, the project will proceed to Extension Objective 1, with the corresponding deliverables of an Interface Design Document (IDD) and a computer aided design. Likewise, if Extension Objective 1 is completed, the project will proceed to Extension Objective 2, with the corresponding deliverable of a computer aided design.

A document tree illustrating the full document/artifact structure is included as Figure 1 below. Each document will act as a free standing document, and as such will include a document scope, project scope and out of scope, project context, and other relevant project information before the specific content. A preliminary schedule indicating how the project is expected to progress through these deliverables is included in the Project Pro Forma document.

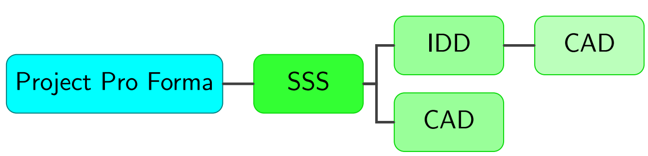

Figure 1: Document Tree - the complete document hierarchy.

2 Progress

2.1 Document Control

For convenience, we have created a Google Drive folder with all the relevant project documentation created and utilised thus far. This folder can be found here [6]. For navigational purposes, this folder contains a

Contents Page available here [7]. This drive also contains team organisation documents such as a Project Schedule [8], and a to-do list/time sheet [9].

2.2 Project Work Summary

During the initial project sign-up stage in week 1, we established contact with our supervisor via email. We arranged to meet at Mount Stromlo in week 2, to tour the Advanced Instrumentation and Technology Centre (AITC) and EOS facilities. We met with various staff members and scientists, including our supervisor Céline d'Orgeville from the ANU, and Mark Blundell, who is the project leader of the EOS team. The minutes for this initial meeting can be found here [10]. As these contacts will provide vital insights throughout the project their details have been collated into a 'Contact List' spread sheet available here [11].

Ongoing from this initial meeting, the group has spent working hours on Fridays at Mount Stromlo to have access to our client and other contacts. Thus far our interaction with these contacts has been conducted in order to develop the operational requirements of each component (the lasers, and telescope). These requirements have been initially compiled into the 'Operational Requirements' spread sheet available here [12], and are currently being translated to the SSS document as appropriate. A draft of the Verification Matrix within the SSS has begun, and is available here [13]. A technical drawing of the telescope mounting plate that our solution must attach to has been produced from EOS CAD documents. The drawing was also updated using on-site measurements of the telescope to include the thread and tap of holes which were not on the EOS model. This drawing was then reviewed by Craig Smith, the EOS CEO, and approved for public viewing, available here [14].

2.3 Tutor and Team Meetings

Aside from meeting our client and relevant experts at Mt Stromlo, we have conducted two team meetings and two tutor meetings. While the first meeting was conducted after the Team Formation Day with no formal record, the agenda/minutes for the subsequent meeting is available here [15]. Likewise, the agenda/minutes for the tutor meetings are available here [16, 17]. The above documents have been updated during and after the meetings to outline the content and results from the meetings.

2.4 First Deliverable: Project Pro Forma Document

As discussed in Section 1.5, the Project Pro Forma document was our first deliverable. This document was delivered to the client on March 17, and is available here [5].

3 Next Steps

Following the Project Pro Forma delivery, our task has been to continue compiling operational requirements. With a first iteration of requirements having been collected for the telescope and EOS laser, our next focus will be on the Toptica and Semiconductor laser. This will involve significant communication with Céline d'Orgeville, who is both the designer of the Semiconductor laser, and the point of contact for the Toptica laser. As these requirements are collated, the parallel task will be to input them into the RVM of the SSS.

References

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[6] Engn4221 guide star laser interface, 2017. URL https://drive.google.com/drive/folders/0B54pZi8oVvWXSEF0QkRWeUhiNWs. Google Drive folder Link.

[7] Drive contents page, 2017. URL https://drive.google.com/drive/folders/0B54pZi8oVvWXSEF0QkRWeUhiNWs. Google Drive Link.

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[13] System subsystem specifications, 2017. URL https://drive.google.com/drive/folders/0B54pZi8oVvWXa25OWUM0akNBbDg. Google Drive Link to Artifact.

[14] Mounting plate cad, 2017. URL https://drive.google.com/drive/folders/0B54pZi8oVvWXa25OWUM0akNBbDg. Google Drive Link to Artifact.

[15] Team meeting minutes, 2017. URL https://docs.google.com/document/d/1wdWQEpzxHDIqIkLn4NrIypjZigQNk-Tfir5R_sY4edo/edit. Google Drive Link to Meeting Minutes.

[16] Tutor meeting, week 2, thursday, 3:00pm - 4:00pm, 2017. URL https://docs.google.com/document/d/1pQfHj-uGxzepe6hyUUCgnUyQJt0jmAoy0YqmIC1jy-I/edit. Google Drive Link to Meeting Minutes.

[17] Tutor meeting, week 4, thursday, 1:30pm - 2:30pm, 2017. URL https://docs.google.com/document/d/1Y5Arwcu_D4zLcKo5G2wzb3uUC89bKgaqyqcuEBy_04Y/edit. Google Drive Link to Meeting Minutes.