Australian National University

Concept Design Report

Prepared For

Advanced Instrumentation and Technology Centre

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Document Identification

Document Revision Number	001
Document Issue Date	08/09/2017
Document Status	Drafting

By signing your name below, you approve the content of this document.

Alex Dalton (Team Representative) Date

Céline d'Orgeville (Client Representative) Date

Applicable Documents

ID	Source	Title	Version	Date
1		System_Subsystem_Requirements_Updated_Ver004.pdf	1	13 Sep 2017
2		Electrical Subsystem Design	1	15 Oct 2017
3		Environmental Subsystem Design	1	15 Oct 2017
4		Mechanical Subsystem Design	1	15 Oct 2017

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Acronyms

ANU Australian National University.

AO Adaptive Optics.

CF Carbon Fibre.

EC Electronics Cabinet.

EOS Electro-Optic Systems.

FEA Finite Element Analysis.

GSL Guide Star Laser.

LGS Laser Guide Star.

LH Laser Head.

OCS Observatory Control System.

OOS Out of Scope.

Abstract

1 Introduction

This report aims to summarise the concept designs developed throughout this iteration of the project. It also defines all high level interactions between subsystems with respect to the laser interface and 1.8m telescope system.

2 Project Context

A GSL creates an artificial star in the atmosphere known as a Laser Guide Star (LGS), which enables the measurement of light distortion caused by atmospheric turbulence. Adaptive Optics (AO) systems use these measurements to correct for this distortion and improve imaging quality.
The ANU and EOS are currently designing two GSL systems for Space Debris Tracking and Pushing. The objective of this project was to develop the concept design for the system interface with the 1.8m telescope at Mount Stromlo.

3 Concept Design

3.1 System Overview

The System Interface Diagram for the ANU GSL is presented in Figure 1. It provides a high level overview of the interfaces between the various components in the concept design. The numbers in the figure are a reference to the descriptions provided in Table 1.

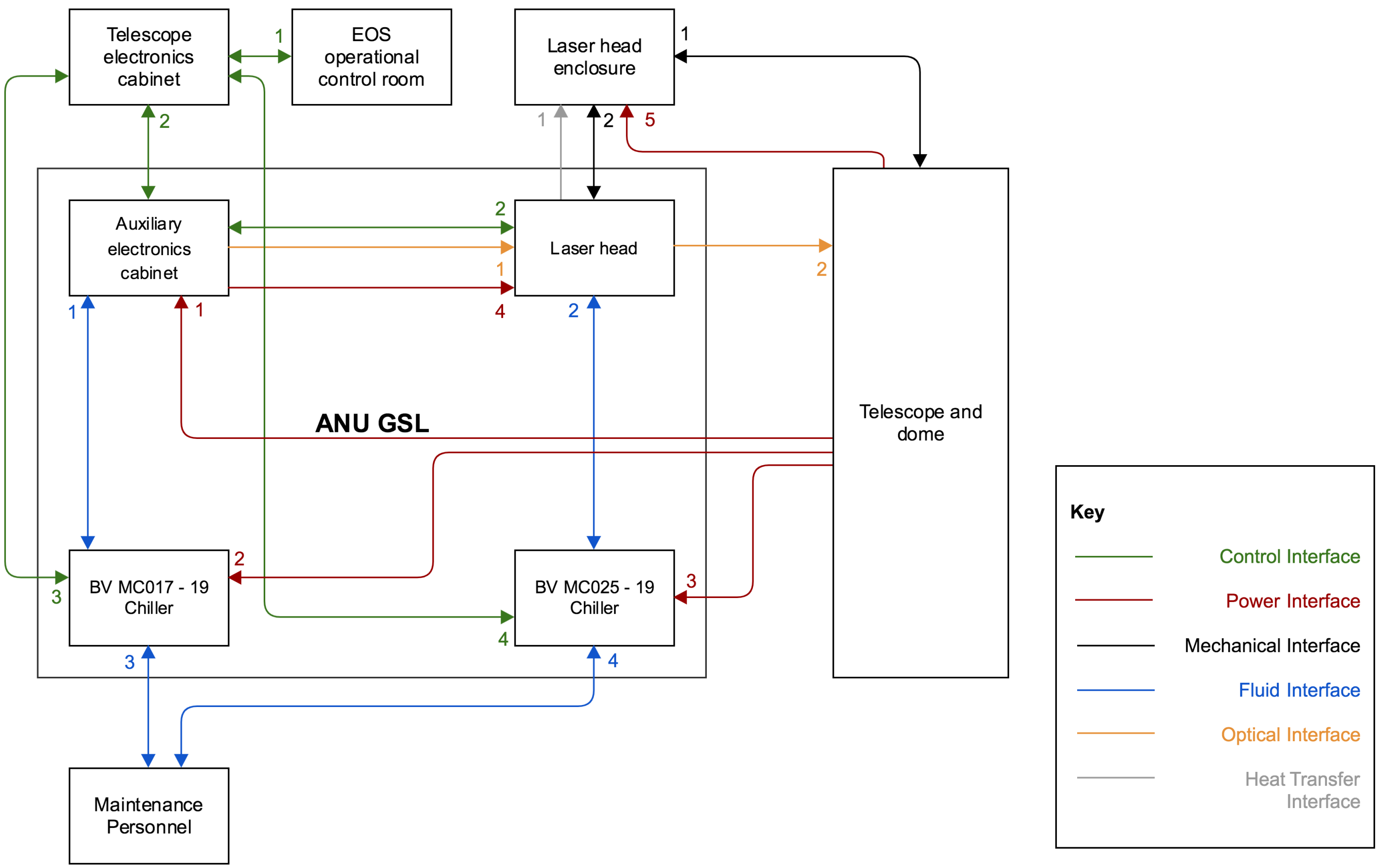

Figure 1: ANU GSL System Interface Diagram

Table 1: ANU Interface Description

1.	Control interface between EOS operational control room and telescope electronics cabinet.	Out of Scope (OOS)	N/A
2.	Control interface between ANU auxiliary electronics cabinet and telescope electronics cabinet. room	CAN interface via Ethernet	(??), (??), (??), (??)
3.	Control interface between ANU auxiliary electronics cabinet and laser head.	Currently unknown, to confirm with ANU GSL vendor.	N/A
4.	Control interface between ANU auxiliary electronics cabinet and BV MC017 - 19 chiller.	Serial interface via Ethernet.	N/A
5.	Control interface between ANU auxiliary electronics cabinet and BV MC025 - 19 chiller.	Serial interface via Ethernet.	N/A
1.	Power interface between Dome and ANU auxiliary electronics cabinet	1 socket,1 power cable, max 800W draw.	(??)
2.	Power interface between Dome and BV MC017 - 19 chiller.	1 socket, 1 power cable, max 720W draw.	N/A
3.	Power interface between Dome and BV MC025 - 19 chiller.	1 socket, 1 power cable, max 960W draw.	N/A

Reference	Description	Interface	Requirement
4.	Power interface between the ANU auxiliary electronics cabinet and laser head.	Unknown draw and number of cables.	N/A
1.	Fluid interface between ANU auxiliary electronics cabinet and BV MC017 - 19 chiller	Deionised water, combined 8L/min flow with BC MC025 - 19 chiller, unknown temperature.	(??) (??)
2.	Fluid interface between ANU laser head and BV MC025 - 19 chiller	Deionised water, combined 8L/min flow with BC MC017 - 19 chiller, unknown temperature.	(??) (??)
3.	Fluid interface between the BV MC017 - 19 chiller and maintenance personnel.	Coolant replaced as required.	N/A
4.	Fluid interface between the BV MC025 - 19 chiller and maintenance personnel.	Coolant replaced as required.	N/A
1.	Mechanical interface between telescope and laser head enclosure	Fastener (M8 bolts) interface at the mounting plate.	N/A
2.	Mechanical interface between ANU laser head and optical breadboard in the laser head enclosure.	Optical breadboard fasteners.	N/A
1.	Optical interface between ANU auxiliary electronics cabinet and laser head.	Preliminary laser outputs, OOS.	N/A

Reference	Description	Interface	Requirement
2.	Optical interface between ANU laser and telescope.	Final laser output, OOS.	N/A
1.	Heat transfer interface between ANU laser head and laser head enclosure.	Unknown heat output.	N/A

The System Interface Diagram for the EOS GSL is similarly presented in Figure 2, with interface descriptions provided in Table 2.

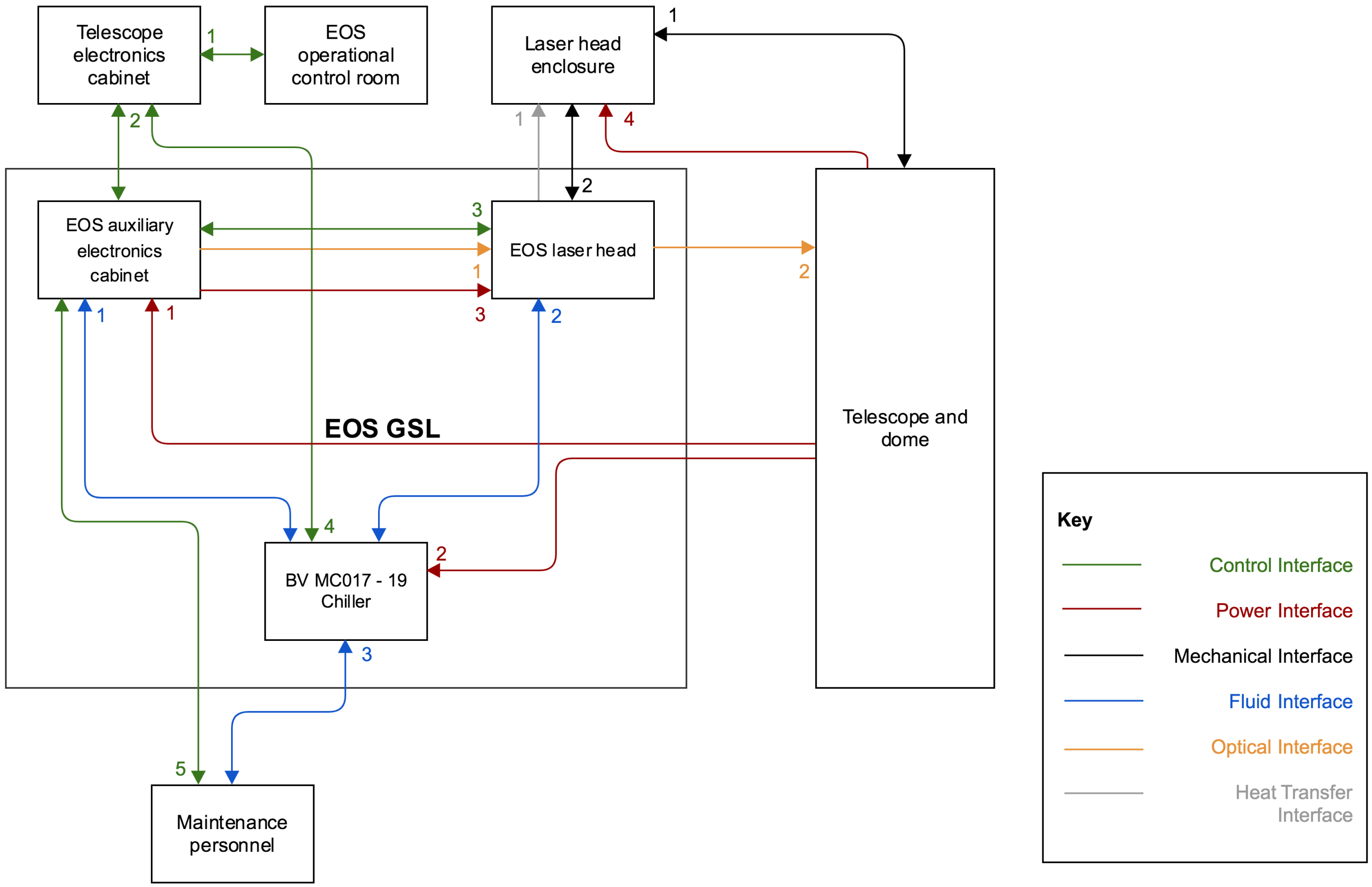

Figure 2: EOS GSL System Interface Diagram

Table 2: EOS Interface Description

1.	Control interface between EOS operational control room and telescope electronics cabinet.	OOS	N/A
2.	Control interface between EOS auxiliary cabinet and telescope electronics cabinet.	CAN bus via Ethernet	(??), (??), (??), (??)
3.	Control interface between EOS auxiliary electronics cabinet and laser head.	CAN bus.	N/A
4.	Control interface between the telescope electronics cabinet and BV MC017 - 19 chiller.	Serial interface via Ethernet.	N/A
5.	Control interface between EOS auxiliary electronics cabinet and maintenance personnel.	Ethernet.	(??)
1.	Power interface between Dome and EOS auxiliary electronics cabinet	1 socket, 1 power cable, max 2.4kW power draw.	(??)
2.	Power interface between Dome and BV MC017 - 19 chiller.	1 socket, 1 power cable, max 720W power draw.	N/A
3.	Power interface between the EOS auxiliary electronics cabinet and laser head.	Max 10 cables, unknown power draw.	(??)

Reference	Description	Interface	Requirement
4.	Power interface between Dome and laser head enclosure.	2 power cables for heating/cooling components, unknown power draw.	N/A
1.	Fluid interface between EOS auxiliary electronics cabinet and BV MC017 - 19 chiller	Deionised water and OptiShield Plus solution, 8.3L/min flow at 17°C.	(??)
2.	Fluid interface between EOS laser head and BV MC017 - 19 chiller.	Deionised water and OptiShield Plus solution, 8.3L/min flow at 17°C .	(??)
3.	Fluid interface between the BV MC017 - 19 and maintenance personnel.	Coolant replaced as required.	(??)
1.	Mechanical interface between telescope and laser head enclosure	Fastener (M8 bolts) interface at the mounting plate.	N/A
2.	Mechanical interface between EOS laser head and optical breadboard in the laser head enclosure.	Optical breadboard fasteners.	N/A
1.	Optical interface between EOS auxiliary electronics cabinet and laser head.	Preliminary laser outputs, OOS.	N/A
2.	Optical interface between EOS laser and telescope.	Final laser output, OOS.	N/A
1.	Heat transfer interface between EOS laser head and laser head enclosure.	Heat radiated to enclosure air, unknown heat output.	N/A

3.2 Mounting Frame

The ANU and EOS GSL Laser Head (LH)s are to be mounted on the EOS Carbon Fibre (CF) breadboards, which shall ideally be mounted on the mounting plate on the observation level.

A conceptual design was developed for a frame used mount the breadboards to the telescope. This forms the supporting structure for the laser head enclosure. The frame is constructed of DragonPlate CF components, steel inserts, and various fasteners. The model is presented in Figure 3

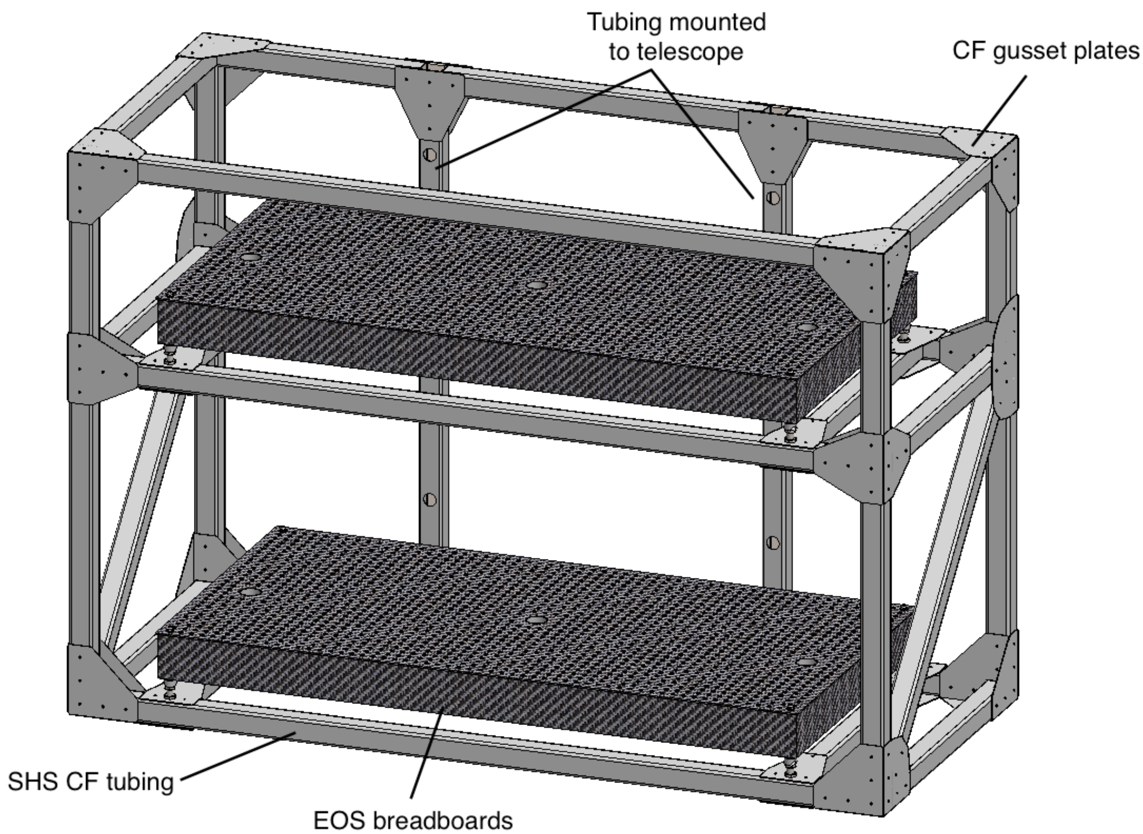

Figure 3: Model of the 2-tiered mounting frame

Preliminary Finite Element Analysis (FEA) was undertaken to assess the viability of the proposed design. The frame was modelled using 1D elements representing the DragonPlate tubing members. The CF/epoxy composite was approximated as a quasi-isotropic material. The simulation results indicated that the DragonPlate tubing was a suitable candidate material.

The proposed design and FEA analysis is further detailed in Mechanical Subsystem Report [1].

3.3 Vibration Reduction

Both ANU and EOS lasers contain vibration-sensitive components. The EOS oscillators will be placed in the clean room to reduce exposure to vibration, and the ANU laser head will be dampened on the optical breadboard in the laser head enclosure.

The vibration spectrum present in a stationary telescope dome was tested by [2], and the vibration of the telescope dome during a track was tested and detailed in the Mechanical Subsystem Report [1].

The next team will have to test the vibrational sensitivity of the EOS and ANU lasers, following the procedure detailed in [2].

3.4 Air Quality & Temperature Management

To maintain air quality to ISO class 7 standard, the system requires active filtration. This is minimal, as the laser head enclosure is mostly isolated from external air. To control the air quality, a closed-loop air filtration system was incorporated into the enclosure. This is to be a forced system, using a small fan to pull air through the HEPA filter.

To control the enclosure temperature, a heating element and a cooling radiator were included in series with the fan and filter. The heating element is capable of maintaining the temperature of the enclosure at the lowest acceptable temperature of 5°C. The cooling radiator is to be connected to the warmest of the coolers in the cooling loop, maintaining the temperature to a maximum of 30°.

The controller for this system is a simple PID controller with a temperature probe, that will measure the temperature within the enclosure and activate the required modules as necessary.

Insulating panels with a thickness of 75mm are to be installed on the sides of the enclosure, minimising minimising the work required by the heating and cooling elements, and also minimising the impact in the event of power loss.

This design is further detailed in the Environmental Subsystem Report [3].

3.5 Laser Cooling Systems

There are three different temperatures of cooling required for specific components within the system. This is one temperature for the EOS laser (at 17° celsius), and two different, as yet unknown, temperatures for the ANU laser. This specific cooling must be done through liquid cooling systems, with required flow rates and temperature stability of the water flowing through the lasers. As a very high temperature stability is required for these components, it is necessary to supply water at the temperatures with specialised chillers.

The proposed system is to install three separate liquid-air chillers on the entry level of the observatory, which draw heat from the components through water circulation and control the temperature, via pipes to the third floor, and vent the heat out into the air of the insulated first floor. The system is also designed for its operation to be remotely monitored.

The selection of the specific chillers was based on the current requirements and similarity to the current system in use at EOS; based on availability and updated requirements. It is possible that the number of chillers or the designs of chillers will change as the laser systems are further developed. An explanation of the proposed system, alternatives, and types of chillers are provided in the Environmental Subsystem Report [3].

3.6 Interior Configuration and Logistics

All elements in the laser interface system that intend to operate on the observation deck are required to be craned into the dome through the shutter. This includes all Electronics Cabinet (EC)'s, GSLs, heat exchangers if alternative designs are considered, and if the working bench isn't going to be assembled on the observation deck.

ANU GSL EC will be situated on the floor underneath the laser head enclosure, while the EOS GSL will be dependent on the size. Should the EC be a single box than it will need to be located on the entry level floor, but if it is split into two boxes then it can be situated on the work bench on the observation deck due to height requirements.

The chillers for both ANU and EOS GSLs are located on the entry level floor and will be carried into the telescope, while the anti-static and non-conductive mat can be rolled up and carried up to the observation deck. The cooling will have to be routed up to the observation floor along the side of the dome as there won't be a need to reduce pipe size.

The most cost effective option for this system will be craning all components in at the same time to prevent repetitive hiring of the crane, due to the EOS GSLs plan to be pre-assembled in lab onto the frame. This plan will be unlikely to occur due to the misalignment of project time lines between ANU GSL and EOS GSL.

3.7 Electronics and Communications

Both the ANU GSL and the EOS GSL are powered by their respective EC, each requiring at most 240V 10A AC via a standard power socket. Total power consumption of the system (including coolers and laser enclosure environmental controls) does not exceed 7.8kW, as detailed in the Electrical Subsystem Report [4]. The telescope dome is capable of providing 32 kW of power. To determine if enough power is available for both GSL to operate simultaneously, the power consumption of the systems already installed at the telescope needs to be determined, averaged over a number of days during summer (high temperatures will lead to increased air conditioning power consumption).

The control signals from the Observatory Control System (OCS) are routed through the already installed telescope EC located on the entry floor of the telescope dome, and patched through to the ANU EC on the observation deck and the EOS EC on the entry level. A CAN-to-Ethernet gateway is used to control the EOS laser.

The cooling system consists of 3 chillers, each maintaining a different temperature, thus needing to be controlled individually. The suggested chiller model in environmental design is the Bay Voltex Red Mount chiller. The datasheet of this product merely mentions that it can be remotely controlled but does not specify the protocol used. Since a serial port is found in the picture of this model, the current electronics preliminary design includes a Ethernet to serial converter, which splits 1 Ethernet into 3 serial lines.

Each EC is connected to the laser enclosure with 10 power cables and control buses. The cooling water is routed from the chillers on the entry level to the laser enclosure through the cable trays. The oscillators, located in the clean room in the other building, are connected to the enclosure through the cable wrap. The proposed design is further detailed in the Electrical Subsystem Design Report [4].

References

[1] "Mechanical subsystem design," October 2017.

[2] A. Stuchbery and E. Thorn, "Vibrational and Thermal Measurements of Laser Guide Star Adaptive Optics for Tracking Space Debris." AITC, Canberra, Australia, Jan. 2015.

[3] "Environmental subsystem design," October 2017.

[4] "Electrical subsystem design," October 2017.