GEMINI

8-M Telescopes Project

Laser Launch Telescope Requirements Document

MCAO Conceptual Design Review Material

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1. Introduction

1.1. General

The Laser Launch Telescope (LLT) is a subsystem of both the Cerro Pachon and Mauna Kea Laser Guide Star (CP LGS and MK LGS) systems. This document describes the Laser Launch telescope performance specifications and requirements.

1.2. Acronyms

AO	Adaptive Optics
AOM	Adaptive Optics Module
BTO	Beam Transfer Optics
CP	Cerro Pachon
FoV	Field of View
FWHM	Full Width at Half Maximum
LGS	Laser Guide Star
LGS CS	Laser Guide Star Control System
LLT	Laser Launch Telescope
MCAO	Multi-Conjugate Adaptive Optics
MK	Mauna Kea
NGS	Natural Guide Star
PF WFS	Prime Focus Wavefront Sensor
SALSA	Safe Aircraft Localization and Satellite Acquisition System
WFS	Wavefront Sensor

1.3. Design requirements

Both Cerro Pachon and Mauna Kea will have the same overall Laser Launch Telescope design.

The CP LLT will be designed in order to accommodate both the first-generation LGS AO system to be implemented at Cerro Pachon, (1) the proposed 85-element Hokupa'a South curvature system with a 2-W laser, and (2) the Multi-Conjugated Adaptive Optics system with 5 Laser Guide Stars and a total laser power of about 50 W.

2. Laser Launch Telescope Performance Requirements

2.1. Field of view

The LLT unvignetted field of view (FoV) shall be equal to **± 42.5 arcsec on the sky**. This corresponds to the baseline distance between the central LGS and each of the 4 LGS located at the corner of the X-shaped constellation on the sky. A FoV of ± 1 arcmin is set as a goal.

2.2. Focus

The LLT is an afocal beam expander that projects the laser beam(s) on the sodium layer. Its focus is stable enough so that the LGS spot(s) diameter do not vary by more than **0.1 arcsec** on the sky.

2.3. Image quality

The image quality of the LLT shall be better than **l /10 RMS @ 589nm**, with a goal of **l /15 RMS** (TB Reviewed) over the whole unvignetted field of view for guide star ranges between 90 and 200 km.

Note that this produces a beam quality degradation that is acceptable relative to the effects of turbulence and the laser beam quality itself.

2.4. Primary mirror pointing repeatability

The LGS 1-axis blind positioning accuracy requirement on the sky is **1.0 arcsec** (peak to peak). The LLT primary mirror repeatability goal is therefore half of that value. This specification being tighter than what is mechanically achievable, the actual repeatability requirement must be derived from the allowable dynamic range of line-of-sight corrections in the BTO (to be determined).

Note that the 1.0 arcsec criteria is also used to set the requirement on the Mauna Kea and first-generation Cerro Pachon BTO blind positioning accuracy after the open-loop pointing offsets applied to the laser beam during dither.

2.5. Optical transmission

The transmission at 589nm is equal or superior to **95%** (including the power loss due to aperture clipping of the gaussian beam). For a 300 mm $1/e^2$ diameter gaussian beam, the transmitted energy through a 450 mm diameter aperture is 98.9%. The overall transmission goal is 97%.

The average transmission in the visible is on the order of 80 %.

3. Functional Requirements

3.1. Laser Launch Telescope location

The Laser Launch Telescope is located inside the Gemini telescope secondary frame.

The LLT is envisioned as a standalone instrument, mounted inside a tube with specific interfaces with the secondary frame. It will be integrated and tested on a bench before mounting on the telescope.

3.2. Mechanical requirements

3.2.1. Diameter

The diameter of the LLT is constrained by the diameter of the secondary frame that supports the secondary mirror (see secondary frame interface). The Gemini telescope Prime Focus WFS (PF WFS) mounting points inside the frame limit the diameter to 550mm. Otherwise, the inside diameter of the frame is 610mm. An option is to cut the PF WFS mounting points to use the whole frame inside diameter. However, the LLT mechanical design should avoid cutting those tabs if at all possible**.**

3.2.2. Length

The vertical length of the LLT is limited by the length of the secondary frame (see secondary frame interface). The total length available is equal to 2148mm. However, due to the central baffle on the secondary assembly, the length inside the frame is limited to **1748mm max** starting from the top (see central baffle interface). If more space is needed, the central baffle could be removed and the LLT primary mirror would serve as baffle.

3.2.3. Distance to the dome ceiling

Some BTO elements will be positioned outside the secondary frame on top of the LLT structure. The space available is limited in height because of the distance of the dome relative to the top of the secondary frame. This distance has been measured in-situ in different places. From measurements made at the MK telescope (Jim Catone, 3/8/2000), there is a limit of **300 mm max**.

3.2.4. Mounting points

The LLT can be bolted to the secondary frame on the top and on the bottom. The top ring has no reference surface. An adjustable interface has to be designed to obtain a TBD mm positioning. On the bottom, new attachment points can be designed and added to the frame. They must be easily accessible. All bolts and mounting points will be provided with the LLT.

3.2.5. Retractable primary mirror

The LLT primary mirror has to be retractable from 0 to 90 degrees. The 90 degree position is the stored position with the mirror and the mechanisms out of the field of view of the telescope (the mirror is vertical when the telescope is pointing at zenith). In that position, the secondary central baffle is open. The 0 degree position is the open position looking at the sky (the mirror is horizontal) and the secondary baffle is closed. The mirror is mechanically blocked in these 2 positions.

If the secondary central baffle were removed, a cover above the primary mirror would be necessary to protect it when in open position.

3.2.6. Weight

The Gemini telescope was originally designed to allow for the implementation of some 125 ± 25 kg additional mass on top of the secondary frame. The center of gravity position of the additional mass would need to be close to the center of the secondary frame. It appears that probably more weight could be allocated because 900 kg of ballast weight are mounted on the ring. However a new analysis would be necessary to confirm this fact.

The baseline specification for all additional mass mounted on top of the secondary frame (BTO elements included) is **125 +/- 25 kg.**

3.2.7. Orientation

The laser beams will be injected from the telescope top-end ring, above the vane located between the –X and +Y telescope axis. The LLT has to be oriented accordingly.

3.2.8. LLT structure

The housing tube for the LLT must have openings at convenient places for maintenance and accessibility.

3.2.9. Handling points and integration on the telescope

The LLT will be installed in the secondary frame while the telescope is in a quasi-horizontal position, without significant disassembly of the secondary support structure or the telescope top end. The space between the dome and the top-end for inserting the LLT is 1830 mm (J. Catone, 3/8/2000). Therefore the LLT may need to be mounted in two parts inside the secondary frame. The LLT integration procedure must be investigated and the LLT delivered with the adequate handling equipment.

3.3. Electrical / electronics / control requirements

The only remotely controlled motion of the LLT is the primary mirror opening. This control is to be implemented by the MCAO Control System. All necessary electronics can be mounted on the telescope, preferably not on the secondary frame, but possibly on the top-end ring and/or the telescope center section. The use of long cables should be foreseen, with a maximum length of about 50 m.

If necessary, some electronics boxes can be mounted on the secondary frame. The volume allocated to the boxes is 100x225x800 mm (TBC). These electronics will be turned off when not in use.

The MCAO CS controls the opening/closing of the mirror using an EPICS interface. No software needs to be developed with the LLT. It receives voltages and on/off signals for motor driving. The power supply is also turned on and off from the MCAO CS. With these signals, the LLT drives the motor. It sends limit switch signals back to the MCAO CS to indicate the mirror position.

The limit switch signals are used also inside the LLT electronics for internal protection.

3.4. Heat dissipation

No more than 10 W of heat must be dissipated into the air from all the BTO and LLT elements which are located behind the telescope secondary mirror.

4. Applicable drawings

Interfaces with existing Gemini infrastructures are described by the following referenced Gemini drawings:

Secondary frame:	Drawing 87-gp-0212-0021
Secondary central baffle:	Drawing 85-gp-3000-0002
Electronics boxes:	Drawing ?

5. Integration and tests

A test rig will be designed together with the LLT for integration and testing in the lab. The LLT alignment and performance will be tested at different elevation angles (and tentatively temperatures).
After delivery at the summit, and once the LLT has been mounted in the secondary frame, final acceptance tests will be performed on the Gemini telescope.
All integration and test procedure must be fully detailed, and the required equipment described.

6. Transport

The LLT will be delivered in a container with its test rig. The container will have shock sensors but does not need to be reusable. The LLT has to be adequately protected inside the container to avoid any contamination. The electronics, cables and computer will be delivered in separate boxes.

7. Appendices

7.1. Primary mirror specs

The baseline specifications are the following (TBC):

Material:	zero thermal expansion ceramic (like zerodur)
Focal length:	1750 mm
Off axis distance:	280 mm
Total diameter:	457 mm
Clear aperture:	450 mm
Edge thickness:	450/6 = 75 mm
Surface accuracy:	0.1 or 0.05 lambda at 633nm (depending on price) PV
Surface quality scratch/dig:	40/20
Optical coating reflectivity:	> 98% at 589nm