SOAR Adaptive Optics Module Design Review
Panel Response

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The review panel would like to preface its comments by commending the SAM team for producing a good overall design for a complicated system. The level of detail presented in the design review helped the review panel to understand the system and provide useful comments. The comments and concerns that the review panel has are contained in the following answers to the questions posed in the original *Charge to Review Panel.*

1. **Does the overall system design comply with the science goals?**

The science goals were not discussed in the documentation, and only briefly touched on during the presentations. Some simulation results showing the expected image PSFs were shown, but this data was not tied to a specific science case. Thus we are unable to comment on this aspect.

2. **Is the choice of laser appropriate for the SAM LGS, and should the team proceed to purchase the recommended laser?**

While there is data for a similar laser model in use at the MMT, the favored laser from JDS Uniphase has not been proven in a telescope environment. The laser is designed for use in an industrial setting and as such is advertised to be reasonably robust. The telescope environment is sufficiently different from a factory, however, for the review panel to have the following recommendations. The SAM team is encouraged to keep lasers from both vendors under consideration when addressing the following list, since while the JDSU laser is currently the leading choice this could change based on the response to the following items.

a) Some written guarantee that the laser will operate correctly at the telescope altitude and conditions is desirable since this has not yet been proven.
b) In support of point a), testing a loaner unit at a high elevation such as at Kitt Peak would provide useful information.
c) Confirm that the laser performance is not impacted by dynamically changing gravity loads.
d) Research what service agreement options are available and what the expected down time will be if a laser must be returned for service such as replacing the pump diodes. Also investigate the possibility of obtaining a loaner unit during this servicing and if replacing the pump diodes according to a service schedule would help prevent down time.

3. **Is the design of the Laser Launch Telescope appropriate to the needs of SAM and sufficiently mature to be ready to proceed to fabrication with only modest additional design detailing?**

A major concern is how vibration will affect the performance of the LLT and of the system as a whole. The LLT has some components with tight optomechanical tolerances and even a small amount of vibration could create problems in these critical areas. It is suggested that the team measure the actual amplitude and spectrum of vibration at the mounting position of the LLT to determine whether this would have significant impact requiring modifications of the design.
The LLT M1 support system does not provide a clear resistance to torsional forces, and it is not clear that the system performance is insensitive to this motion.
The resolution and positional accuracy of the actuators as described seems to be very close to their performance limit. Problems such as backlash and hysteresis could prevent the system from performing as designed.
If vibrations are deemed to be a problem and active compensation is desired, fitting the additional actuators could prove difficult given the very small amount of available space in the LLT. This is a major risk if the fabrication for the LLT is started before addressing the vibration issues.
It is known that the clearance between the top end of the SOAR telescope and its dome is small. It would be prudent to double check that the proposed LLT and any associated temporary alignment hardware placed outboard of the LLT does not interfere with the dome.
It is still unclear if a window is desired to seal the LLT output port. If a window is not used, the LLT optics will become dusty and need much more frequent cleaning. The hardness of the mirror coatings should be determined and the risks associated with cleaning quantified.

4. **For those components or subsystems not identified for early purchase or fabrication, are the designs ready to proceed with engineering design and specification for fabrication?**

This is answered for the laser head and the LLT in the previous questions.

5. **Are there any specific risk areas or weaknesses in the designs, schedules or resources that require changes to the designs, schedules or resource plans?**

a) Vibrations, as mentioned previously.
b) M1 support system torsional stiffness and actuator performance, as described above.
c) There is no staff solely dedicated to this project. As such, there could be a significant impact to the schedule if a key member was tasked to work on other projects.

d) Better communication between the team members and management is needed to optimize scheduling and resource planning, including updates as the project progresses.
e) There are other telescopes with GLAO systems that will come on-line in the near future. Given the current schedule these other telescopes will have been operating for some time when SAM is completed, which would reduce the scientific impact of SAM. This concern is presented in the spirit of encouraging an aggressive schedule to maximize the return from this project.
f) There currently seems to be no detailed plan for commissioning the instrument and then transitioning to scientific observations. This is necessary to start producing scientific data as soon as possible while ensuring that the instrument is ready and working properly.
g) It has not been decided yet if the laser beam transport tubing will be pressurized. This could impact the design and a decision should be made soon.
h) Since the box housing the lasers is at a different internal temperature than the telescope ambient atmosphere there is a concern about the output window forming dew. This issue should be addressed.

6. Are there any operational aspects of the proposed designs, especially aspects relating to safety, about which the panel can make comments or recommendations to the SAM team as builders or to SOAR as the end user of the LGS system?

While there was a good amount of detail in the laser hazard analysis, none of the review panel felt comfortable with the conclusion that the laser is relatively eye-safe.

a) There should be a designated Laser Safety Officer, and they should develop and enforce a written laser safety document.
b) All personnel that work at the telescope should go through basic laser safety training.
c) Eyewear should be required in the observing chamber at all times when the lasers are on. Since the laser is UV, the goggles are clear and there is no reason not to wear them.
d) Chamber door interlocks are strongly advised due to the presence of visiting astronomers who may not be familiar with the laser safety procedures and policy. Whether or not these may be overridden during laser engineering time and the procedures for doing so should be determined by the LSO.

7. Are there any other recommendations for improvements to the design?

a) RS485 is more appropriate than RS232 for long cable runs
b) Various pieces of heavy hardware are being added above the primary. Backup safety attachments should be investigated in case of mounting hardware failure or seismic activity.
c) An Interface Control Document was not mentioned, but could be useful.

8. **Are there parts of the system where the panel believes that a further design review will be necessary, either due to problems identified or changes recommended here or due to the current state of that part of the design?**

The laser safety aspects are the only portion that the review panel feels should be looked at by an outside party. The results of the vibration sensitivity analysis and the final choice of laser should also be reviewed by a group, but unless major problems are found these could be handled internally.

9. **Are the project plan, milestones, and schedule clear and realistic?**

There was a large amount of detail presented in the schedule. A summary of the main events would have made the schedule much more understandable. Also, it was unclear exactly when the system would be ready for scientific observations.

10. **Are the project resources adequate for the needs of the work and the schedules?**

As mentioned earlier, the team is small and not solely dedicated to this project. Losing even one team member could have a significant impact on the schedule. Also, to provide some continuity between the development and operational phases, having a staff member such as a telescope operator get involved during the end of the fabrication and the commissioning phases would help this transition.