Keck Near-Infrared Tip-Tilt Sensor
Preliminary Design Review

Review Committee Report

May 9, 2011 – v3

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1. INTRODUCTION

1.1 Scope

This document is the report of the review committee established by the Keck Observatory to evaluate the preliminary design of the Near-Infrared Tip-Tilt Sensor to be implemented with the Keck I LGS AO system. The report is based on documentation provided to the panel before the review, and on presentations and discussions given during the review April 25, 2011.

The review panel members were:

- Antonin Bouchez (GMT), abouchez@gmto.org
- Corinne Boyer (TMT), cboyer@tmt.org (Chair)
- Randy Campbell (Keck), randyc@keck.hawaii.edu

1.2 Review documentation

The Near-Infrared Tip-Tilt Sensor Preliminary Design Review documentation is available at: http://www.oir.caltech.edu/twiki_oir/bin/view/Keck/NGAO/PreliminaryDesignReviewNIRTTS.

The review documentation was made available to the review panel on March 28, 2011 apart from the Systems Engineering Management Plan document, which was provided on April 13, 2010.

The review members provided a list of discrepancies, questions and comments (RIXes) to the Near-Infrared Tip-Tilt Sensor System team by Monday April 18, 2011 using the "SDR Reviewer Question Form". The RIXes were answered by the Near-Infrared Tip-Tilt Sensor System team on April 22, 2011. RIXes and associated answers are also available on the twiki web site linked above.

2. CHARGE TO THE REVIEW PANEL

The panel is asked to determine whether the project meets the success criteria and to make one of the following recommendations:

- The success criteria were completely met and the project is recommended to proceed as planned.
- The success criteria were partially met. The committee recommends that the project complete specific actions identified by the panel before proceeding.
- The success criteria were not adequately met. The committee recommends that the project should undergo a delta review to address the specific areas identified by the panel.

The success of the design is judged by whether the following have been accomplished:

1. The science cases developed for the system are compelling and competitive *(This does not apply to this project and will not be addressed in this report)*,
2. The scientific and technical requirements established for the system are sufficiently complete and consistent, to guide the development of the system,
3. A reasonable design that meets the scientific and technical requirements has been developed,
4. The risks associated with the design concept have been adequately assessed and the mitigation strategies are satisfactory,
5. The management plan, including cost and schedule, to complete the project, with emphasis on the next project phase, is viable and appropriate.

The review panel is requested to provide comments at the conclusion of the review, and a final written report of findings, comments, and recommendations by May 11, 2011.

3. EXECUTIVE SUMMARY

First of all, the review panel wishes to commend the Keck and Caltech design teams for their excellent work during the Preliminary Design phase of the Near-Infrared Tip-Tilt Sensor system. The quantity and quality of the work that has been accomplished since the System Design Review is impressive and very clear from the documentation and the answers to comments, questions and concerns posed by the panel. The presentations given during the review were excellent and focused on the topics requested by the review panel.

Most of the System Design Review recommendations have been addressed during the Preliminary Design phase:

- The component requirements, including the interfaces have been consolidated and developed to a preliminary design level with a few exceptions described below,
- A preliminary version of the observing operations concept document has been written,
- Complexity has been reduced in some areas by de-scoping requirements to goals,
- Design recommendations regarding access, thermal dissipation and vibrations were carefully studied, and adequate solutions were proposed,
- The contingency has been increased, although it is still considered too low at this stage of the design.

There are, however, still some areas of concerns, which have not been addressed during the preliminary design or which are new:

- The expected sky coverage will be limited by the Low Bandwidth WFS, whose performance must be understood under the full range of operational conditions. We recommend addressing this issue during the detailed design phase.
- There are still some uncertainties regarding the method of centroid gain optimization, which should be addressed during the detailed design phase.
- Finally, the detailed design schedule seems very tight, in particular in the context of the potential lack of availability of key personnel.

In spite of these findings, we believe that the success criteria were completely met and the project is recommended to proceed with the detailed design phase.

The design in all areas is very well developed and generally at or above Preliminary Design level. This is particularly true for the camera sub-system and the real time and high-level software.

The review panel detailed comments are summarized in the following sections organized according to the review panel charge.

3.1 Scientific and Technical Requirements Status

The committee believes that the system and component requirements have been well developed and, that they adequately cover the technical parameters that will be needed to guide the detailed design. The team has effectively identified the trade off between goals and requirements. The design has been adapted to leave the hooks in for some of the higher-level goals to be achieved if time/budget allow having them implemented later. We note also that the traceability of the components requirements is well documented.

Below are some more detailed comments and recommendations regarding the system requirements document and associated spreadsheet:

- We want to reemphasize the need to concentrate on core requirements.
- The requirement that the camera be serviced in position or be removed for service without a realignment requirement was added since the system design phase.

- The flow down of the error budget to camera specifications such as Strehl requirements and optical tolerance has not yet been fully established. We recommend that this work be performed in the detailed design phase.
- A requirement for minimizing stray light from encoders, electronics, etc, such that the visible and infrared sensors of the AO system and instruments are not affected, should be added.
- Weight requirement, lifting and service and flexure were discussed but should be completed during the detailed design.
- Cool down and warm up timing requirements need to be better developed in the detailed design phase.
- The full frame readout time of 6 sec overhead does not meet the camera functional requirement #9. We think it is ok, but the requirement should be updated.
- A dark current versus bias experiment needs to be done in order to better establish the operating temperature requirement.
- The raw telemetry requirement for the RTC needs to be developed further and communicated to Microgate.

The interface control documents (Camera to AO interface control document and keyword interface spreadsheet) have been developed to a preliminary design level. We look forward to see more details in the next phase.

A first version of the observing operations concept document has been written during this phase and is used to guide the high-level software design. We recommend that the team further detail the operational procedures during the detailed design phase, in particular to address the issue of bad pixels on the infrared detector and exceptional cases such as guide star with high proper motion, binaries and/or galaxies. We recommend integrating the control of the IR Tip Tilt System into the existing AO user interface for field / guide star star identification, alignment, acquisition, and general control.

3.2 System Design Status

The opto-mechanical design has been further developed during this stage of the design. The location of Near-Infrared Tip-Tilt Sensor system has been finalized and the modifications to the AO bench and cover described in great detail. The eDrawing provided by the team was very helpful to help visualize and understand the interfaces of the Near-Infrared Tip-Tilt Sensor system with the AO bench. We recommend finalizing the mass estimates of the different sub-systems from the SolidWorks Model and analyzing the impacts of adding additional weight at the edge of the AO bench early during the Detailed Design phase.

The optical design has been optimized during this phase (one less optics and fewer different glasses), but the manufacturing risks and associated costs have not yet been addressed and the alignment procedures have not been updated. We recommend addressing these issues early during the detailed design phase. The effects of ghosting should be studied in the context of tip tilt performance and as a possible source of confusion. If considered to be a significant issue, anti-ghosting techniques such as tilting the filters should be employed.

The design of the camera has been revised and the new design is very detailed and well beyond a preliminary design level. The risk of vibrations generated by the camera compressor and/or associated hoses and then transmitted to the AO bench is still a concern for the reviewers. However, the design team has done an excellent work to address this issue and the proposed solution sounds adequate, although we strongly urge that the team select a cooling solution that does not require flammable gas. We also recommend that more detailed thermal modeling of the camera be undertaken during the detailed design phase.

We are pleased to see that the ARC timing board was modified to add a dedicated link to the RTC. This new interface was successfully demonstrated on the camera side during the Preliminary Design Phase and will be tested with the Microgate RTC during the detailed design phase.

The RTC modifications are described in great detail in the RTC as built design document provided by Microgate. The correlation algorithm computation times have been estimated and met the requirements.

A lot of work has been done as well in the areas of camera software, control software and high-level software. We recommend re-evaluating the use of MAGIQ as an integrated acquisition tool. Finally, micro dithering as described in the design document could help with efficiency but is not considered a core requirement by the committee. Small offsets should continue to work with high precision with the existing system of handshaking between the AO system, the telescope and the instrument. Redesign of the supervisory control offset function to allow micro dither without the loops opening would likely be a significant amount of software work and on sky testing. Thus, we consider this a good area for de-scoping.

3.3 Risks and Mitigation Strategies

The committee believes that the risks associated with near-infrared tip-tilt sensor project are being adequately addressed. In particular, the mitigation strategies proposed for most of the technical risks appear reasonable. Early procurement of the detector, and testing of ROI self-heating effects and the camera-RTC interface have built confidence that the project's requirements can be met.

Since the system design review, the observatory has succeeded at finding additional resources to raise the budget contingency to 10.6% for the detailed design phase and subsequent phases. While this is still deemed by the committee to be insufficient, it is a marked improvement over situation at the system design review.

The risk of delays to the Near Infrared Tip Tilt Sensor project due to lack of personnel and AO system availability (due to delays in related projects) appears to the committee to have risen and we feel that the risk register should be changed to reflect this. We recommend that project management remain vigilant of potential cost increase due to externally imposed delays.

Finally, we are still concerned by the overall complexity of the system, in particular the number of ROIs. We recommend that the design proceed, but not the implementation and commissioning of this functionality, which could be done at a later date outside the scope of this project.

3.4 Management Plan

First of all, the project manager and the design teams have to be commended for keeping the project mostly on schedule (couple of months of delay) and on budget (minimum and well-identified overruns) during the preliminary design phase.

The development plan and cost estimates for the remaining phases of the project were found to be reasonable overall, although the schedule of the detailed design phase looks very tight considering the amount of work to be performed during this phase and the potential lack of availability of key personnel due to delays in other Keck projects (Keck I Free Space Transport for example).

The organization chart of the project has been revised to deal with key personnel non-availability during the next phase of the project. Peter Wizinowich will act as the project manager and the opto-mechanical system leader. Chris Neyman is now the system engineer and the operation software system leader. Again, we recommend that the team members are not overcommitted and that the observatory consider including additional AO experts to support the many development projects at Keck.

The contingency has been increased to a 10.6% level, which is a great improvement in comparison to the 3% level contingency at the end of the System Design Level. This has been achieved mainly by some additional budget identified and allocated to the project by the Keck top-level management. We would prefer to see the contingency around a 20% level, but we understand the constraints of the observatory.

Configuration control is in place for the requirements and interface documentation via the mechanism of Engineering Change Request (ECRs). Several ECRs for the opto-mechanical modifications and the control and operation software of the AO bench have been already submitted and will be reviewed early during the detailed design phase.

We recommend that Keck consider developing a general AO performance prediction tool outside the scope of this project.

Finally, a first version of the Acceptance, Integration, Test and Commissioning plan has been developed. We recommend that the risks associated with the two options proposed for modifying the AO bench cover be carefully analyzed during the next phase of the project.

4. APPENDIX: LIST OF REVIEWER TOPICS DISCUSSED DURING THE REVIEW

This section contains the list of topics submitted to the design team on April 21, 2011 by the reviewers. These topics were discussed during the review in great detail, thanks to the team.

- System design:
    - Location of the compressor on the telescope is still a concern for the committee - Can you discuss further the trade study leading to the current design including the risk of vibration transmissions to the AO system?
    - We are still concerned that the performance of the LBWFS on faint stars might limit the overall system performance. Can you describe the plans to address this issue during the next phase?
    - Centroid algorithm: How do you plan to estimate the centroid gains?
    - Software: why not using existing tools such as MAGIQ for adjusting the guide star selection during observations and for centering the science object?
- Risk and mitigation strategies & management plan:
    - We are still concerned about the overall complexity of the system in particular with the number of ROIs - You may want to consider de-scoping implementation and commissioning, but implementing all the hooks (design) for future implementation and/or commissioning.
    - Budget and schedule:
        - We are concerned by the very tight schedule for the detailed design considering the amount of work to be done in a short period of time and still a low contingency.
        - We are concerned that delays in other Keck projects (Beam transfer Optics system for Keck I, OSIRIS relocation) and availability of key people may impact the next phase but also the development and commissioning of the NIR TTS system.