Keck Adaptive Optics Note #320

KPAO Progress Report for February 2005-March 2005

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Introduction

This report focuses on the project activities during the period February 2005 up to and including March 2005.

I. Narrative

The project accomplishments and challenges over the past 2 months are presented in the following sections.

A. Summary

Management efforts were directed toward timely arrival of Ralf Flicker from the Netherlands. Ralf's first day at Keck was March 1, 2005. A KPAO reference design is underway. Computer simulations of the reference design show that a 150 nm wavefront error is possible with 5 Laser guide stars and 32 subapertures across a 10m pupil. For comparison the current Keck AO system has 20. The KPAO group purchased a Linux based workstation to enhance our capability to model the KPAO system; this computer arrived at the end of March. A KPAO webpage in now under construction it will be used to host information relevant to the Keck design. As the reporting period ended (week of March 27) Neyman and Flicker prepared to attend a CfAO sponsored workshop on the subject of modeling AO systems.

B. Technical Status

1. Overall Assessment of Scientific and Technical Status

Management efforts were directed toward timely arrival of Ralf Flicker from the Netherlands. Ralf's first day at Keck was March 1, 2005. It was an oversight on Neyman's part that CfAO funds could not be used to reimburse travel from a foreign destination if they were not called out as foreign travel in the original proposal to the center. Fortunately, the funds from the Thirty Meter Telescope (TMT) that will also be used to support Ralf could be used for his relocation travel from the Netherlands. Both parties, TMT and Keck, approved the reallocation of funds between the CfAO grant and the TMT subcontract. The CfAO funds will be used for domestic relocations between Pasadena and Hawaii.

The KPAO group purchased a Linux-based workstation to enhance our capability to model the KPAO system. After discussion with Jon Chock a Linux system from Sun Microsystems was selected. This system was seen as being easier to integrate into the Keck computer network.

Olivier Lai (CFHT) completed the draft science case document. Mike Brown is in the process of recruiting a KPAO science team from Caltech, University of California and University of Hawaii.

Work on a KPAO reference or "straw man" design began during this reporting period. As a first step in this process Neyman performed an emissivity trade study between KPAO system with an adaptive secondary, and an AO system cooled to -40 Celsius. The baseline system was a conventional AO system with optics at 0 Celsius. Neyman also produced draft throughput budgets for laser guide star (LGS) and natural guide star (NGS) systems. A draft optical design has also been started for the AO relay.

The cost of the laser will dominate the KPAO hardware costs. As such the group has attempted to determine the number of lasers needed to reach a given wavefront error. Using an analytical model for an AO system Neyman determined that the level of AO correction with 3 to 9 laser guide stars (one natural star to measure tip/tilt) improved as the number of lasers was increased but was ultimately limited to about 50 nm rms. Following a suggestion by Brent Ellerbroek, Neyman was able to show that the limit was caused by inability of the LGS constellation to measure low order wavefront modes such as focus and astigmatism accurately. This limitation can be removed by assigning the measurement of the low order wavefront to a natural guide star or stars. This discovery has significant implications for the KPAO architecture. Either a brighter guide star must be used to sense tip/tilt and focus modes or another approach is to use several stars in a variety of directions that sense only tip-tilt and then focus is inferred from the measurements. Otherwise, the KPAO system must live with this error limiting its performance. This behavior was also verified with independent Monte Carlo simulations done by Brent Ellerbroek of the TMT and Ralf Flicker at Keck.

As part of the reference design process, Ralf Flicker did a complete simulation of the KPAO system. The simulation was done with the YAO (public domain software for AO simulation, written by Francois Rigaut of GEMINI). The trial KPAO was dimensioned using simple AO scaling laws. Using these rules of thumb, the system was estimated to have 150 nm of wavefront error. This wavefront error was chosen as compromise between run time of the simulation and the desire to model the lowest wavefront error possible. The predicted level of wavefront error was verified. This was a very complete simulation that included sensor noise, servo lag, elongation of the laser spots and geometrical optics propagation through random realizations of atmospheric turbulence.

Our KPAO modeling effort is exploring possible collaborations with two groups. One is collaboration with Francois Rigaut of the GEMINI observatory on his AO simulation code (YAO). Neyman and Flicker traveled to Hilo to discuss possible collaborations on future releases of the YAO code. One outcome of the meeting was the availability to Keck of YAO test versions that include useful features not found in the public domain YAO code. For example one such feature is the ability to add as-built optical prescriptions to the AO model.

Another area of possible collaboration on AO modeling is with TMT. These efforts would be focused on building a more useable interface to the sparse matrix wavefront reconstruction tool (COW). Ralf Flicker has experience in sparse matrix wavefront reconstruction and will be working with the TMT, so this area appears to be a very fruitful for future work. Flicker and Neyman met with Aron Ahmadia (Illinois Institute Technology) the developer of COW when he was in Hawaii in March. During the meeting Flicker and Ahmadia were able to install the COW package on Flicker's computer and started to outline possible interfaces for other AO simulations to the COW

reconstructor tool box. At present the COW code is only interfaced to Brent Ellerbroek's MATLAB code (LAOS).

2. Accomplishments of the Past Months

A working draft of the KPAO science case document was completed. A simulation of the KPAO reference design with 150 nm RMS wavefront error was completed. The group determined that the KPAO wavefront error from multiple laser guide stars is limited by measurement of focus modes.

3. Problems

The ability to model KPAO with large numbers of subapertures was limited by the availability of a suitable computer. This limitation will be eliminated when the KPAO workstation arrives.

C. Schedule and Budget Status

1. Overall Assessment of Progress and Expenditures

Although the project is behind Neyman's original milestones for March, these milestones will be passed in the first weeks of April. The expenditures are on track for the project.

2. Problems

The original plan for KPAO made in summer of 2004 didn't include any system administration support for the project. At present we anticipate some system administration support for disk backups and account maintenance on the new KPAO Linux workstation. Neyman and Flicker will do most of the software instillation, so a minimal number of hours will be needed from the software group.

D. Proposed Actions Regarding Problem Areas

1. Scientific or Technical

No problems in the scientific and technical areas.

2. Schedule

No changes anticipated for the Schedule.

3. Budget

No changes anticipated for the budget. A small increase in the KPAO budget may be needed to account for some system administration costs (see section C.2).

E. Anticipated Accomplishments in the Next Two Months

Install adaptive optics simulation tools on new KPAO workstation. Finalize "straw man design" in early April. Include effects from segmented mirror telescopes in the KPAO simulations. Simulate a KPAO system with 120 nm of wavefront error. Include facility vibration effects in the KPAO system simulation. Draft requirements for AO system and possible instruments.

F. Other Issues and Information Deemed Essential to Include

II. Schedule

A. Current Schedule

1. Schedule for the next phase of the project

See Figure 1 at the end of the documents.

2. Overall Project Schedule

See Figure 1 at the end of the documents

B. Graph of Earned Value

We have decided not to track earned value for this small a project.

C. Analysis and Discussion of Project Performance

The project is headed in the right direction. It would be advisable to start the design phase of the project as soon as the details of the system architecture are known. The present plan requires the system performance phase and the requirements documents to be completely finished before the design phase begins. See Figure 1.

III. Confirmation or Amendment of Project Schedule and Milestones

No amendments for the reporting period.

IV. Confirmation or Amendment of Project Budget

No amendments for the reporting period.

V. Project Financial Summary

Project is under budget at this time

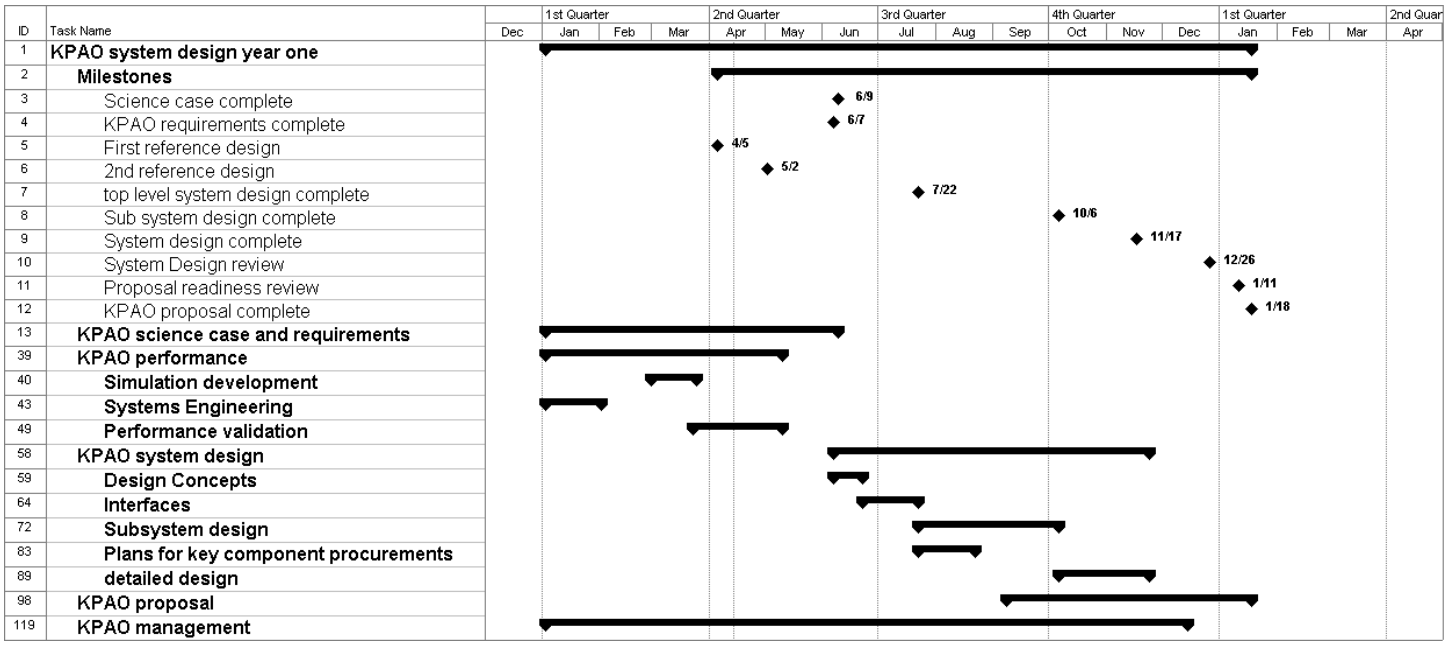

Figure 1 the top level tasks in the KPAO project plan for calendar year 2005.