Keck Adaptive Optics Note 302
Thirty LGS AO Science Nights in 05B

P. Wizinowich for Keck AO team
February 8, 2005

Table of Contents:
1. Introduction
2. Number of scheduled K2 AO nights
3. 05B scheduling
4. LGS AO development
5. LGS AO operations
6. Preliminary recommendations

1. Introduction

The purpose of this note is to respond to the request by the SSC that CARA be prepared to support 30 LGS AO science nights in 05B.

The following issues need to be addressed in the determination of if and how we can support this many science nights:

- Number of scheduled K2 AO nights.
- 05B scheduling.
- LGS AO development in 05A and 05B.
- LGS AO operations in 05A and 05B.
- OSIRIS in 05A and 05B.
- LGS AO observing support calculations.
- AO and laser configuration control, maintenance and fault recovery.
- Backup programs.

The current state of the LGS AO system is described in KAONs 300 and 296.

DISCLAIMER: This document is a first iteration on the implications of 30 LGS science nights in 05B. As such there are likely topics/issues/ideas that have not yet been raised, and there has not been sufficient iteration yet with the AO and operations team to generate reliable effort estimates.

2. Number of scheduled K2 AO nights

These are the number of nights the AO system is used. In a few cases these are ½-nights. The 05B numbers are guesses.

<table>
<thead>
<tr>
<th>Semester</th>
<th>04B</th>
<th>05A</th>
<th>05B</th>
</tr>
</thead>
<tbody>
<tr>
<td>LGS eng w/NIRC2</td>
<td>8</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>LGS sci w/NIRC2</td>
<td>5</td>
<td>14</td>
<td>30</td>
</tr>
<tr>
<td>LGS eng w/OSIRIS</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
The distribution of nights is another important factor. In 05A the longest gap between runs is 18 days, while the average dark time gap between runs is 13 days.

The above assumes that OSIRIS will be fully commissioned with NGS AO by the end of 05A and that it has not been fully commissioned with LGS AO.

We could consider recommending no NIRSPAO nights in 05B, and/or a reduced number of NGS AO nights, to relieve some of the pressure.

3. 05B Scheduling

We need to determine what run length we are willing and able to support. The total number of LGS nights in this proposed plan is 39. If we determined that the maximum number of sequential nights is five then we would require seven 5-night runs and one 4-night run, requiring two runs in two of the months. If the maximum is 6 then we could consider six 6-night runs and one 3-night run, requiring two runs in only one month. If the maximum is four then we would need nine 4-night runs and one 3-night run, or two runs in 4 months.

Six night runs are only feasible if we have two operations teams. Five night runs are probably feasible for crews at headquarters, but they are likely not supportable with a single summit crew (this deserves further discussion since it would reduce the setup time and number of runs). Four night runs, on the other hand, could potentially be possible for a single operations team. Please see the spreadsheet “30 nights in 05B.xls” for a potential calendar of the 4 and 5 night scenarios.

The four night scenario is the recommendation made in this document. This requires LGS runs on either side of the full moon in 4 of the 6 months. Each of the 10 runs, except for the last run, is preceded by an engineering night. Since LGS observations are sensitive to the full moon an additional recommendation is that no LGS science nights fall within 5 nights of the full moon.

We also need to carefully think about the scheduling of the NGS AO nights in order to try and maximize development, maintenance and repair access to the system.

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>7</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGS eng w/OSIRIS</td>
<td>0</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>NGS sci w/OSIRIS</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>NGS eng w/OSIRIS</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>NGS sci w/NIRC2</td>
<td>18</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td>NGS sci w/NIRSPEC</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Interferometer – eng</td>
<td>13</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Interferometer – sci</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total =</strong></td>
<td>52</td>
<td>68</td>
<td>76</td>
</tr>
<tr>
<td><strong>% of total nights =</strong></td>
<td>28%</td>
<td>37%</td>
<td>42%</td>
</tr>
</tbody>
</table>
Chaffee suggested that we not have any LGS runs in Dec. or Jan. since we are likely to lose more time to weather during those months. It might be possible, in the 4-night run scenario, to move the two January runs into Aug. and Nov., respectively, and to shorten one of the Dec. runs to 3 nights (it could be worth checking historical weather records to determine the best times to avoid). No runs in Jan. could also allow for a hardware development activity, however this would be too late of 06A.

4. LGS AO Development

We will need to emphasize completing those LGS AO and laser system development activities that maximize the preparedness of the system for operations in 05B. We have already had a preliminary discussion on this subject with the AOWG. The general view is that the categories that need to be emphasized include reliability and automation, especially to minimize the number of required support personnel, observing efficiency, and completing the optimal basic set of science capabilities.

We plan to complete our current milestone 5 success criteria, and to review our milestone 6 criteria, in collaboration with the AOWG, to ensure that these best position us for 05B operations. All of these success criteria will need to be completed prior to 05B.

Some items to consider include:

- **OSIRIS.** How much effort will be required to make this instrument operational with the NGS and LGS AO systems? Note that LGS engineering with OSIRIS is scheduled to begin in March. The AOWG has recommended that no proposals be accepted for OSIRIS in 05B, but that people be allowed to use OSIRIS if it is available and better suits their science needs (which it will often do).
- **Spotters.** We should consider accelerating our efforts to get the Gemini all sky camera in place (Gemini has recently begun to make progress again), and to get FAA approval for a less personnel intensive aircraft safety system. This won’t be in place for 05B and getting FAA approval could be a challenge. Mosaic radar may also be required to get FAA approval.
- Development of a maintenance plan for both the LGS AO and laser systems.
- **Response to problems.** Identification and procurement of spares, failure analysis and plans, risk analysis and mitigation plans, contingency plans, etc.
- **Implementation of a more robust configuration management system for changes to the operational LGS AO system (including software and hardware changes).**
- More LGS engineering time in 05A. A good part of why we are behind schedule on milestone 5 is the fact that we lost 3 of our 9 LGS nights to weather and 1 to laser burns. We certainly need more clear sky time.

Personnel from outside the AO group could certainly help in getting the LGS and laser systems to a higher operational standard prior to 05B (or free up AO personnel to do this work). We should look at this possibility in more detail.

One possibility would be to have no development in 05B. We do not recommend this approach since we will need to continually improve the system in order to stay
competitive. We should definitely make sure that OSIRIS is available for NGS and LGS science in 06A (this requires an adequate demonstration of these capabilities by the end of August). ESO has already closed their STRAP system on 20th magnitude stars, presumably because their system has better throughput. We will have to make sure that our system has the capability to do great science on 18-20th magnitude targets by the start of 06A. We should also be proceeding on a general performance optimization effort similar to the very successful effort on the NGS AO system.

5. LGS AO Operations

The LGS AO ops personnel are summarized on sheet “05B ops personnel” of the spreadsheet “30 nights in 05B.xls”. The proposed development personnel are also shown in this spreadsheet for a more complete picture. These are all rough estimates based on the observing model and plans that we have right now. The observing model will be further developed by the LGS Operations Team (LOT) during 05A and better effort estimates will come as we gain more experience with the system and continue to improve it.

Note that the following estimates assume that we only carryout a single PI’s observations on any given night. Presumably the overall scientific output of the system would be improved by various levels of queue scheduling. Even simple approaches such as distributing observations over a run, instead of a single night, to observe the targets when they are highest in the sky, would help. The benefit and cost of various queue scheduling approaches are worth considering.

Tasks associated with each night of LGS AO operation:

- Prepare laser for night and monitor early evening performance, including LTCS. 1 technician on swing shift (2-10pm) at summit.
- Monitor laser performance and LTCS, and shutdown system. 1 technician on night-shift (10pm-dawn) at summit or potentially HQ.
- Aircraft spotters. 4 spotter on night-shift (7pm-dawn).
- Calibrate and operate LGS AO system. 1 operator on night-shift at HQ (14hr shift implies ~60hrs/run).
- Astronomer support, NIRC2 support and AO high-level performance monitoring and optimization. 1 support astronomer on night-shift at HQ (14hr shift)
- Night-time on-call support. LGS AO specialist, LGS AO software engineer & laser engineer (4 hrs per night).
- Check system, follow-up on night-time problems, make recommendations. AO specialist (4 hrs per night).
- Total people working each night ~ 9.
- The spreadsheet also assumes that the equivalent of 3 of the 9 engineering nights is devoted to operational checkout.
- The total from the spreadsheet is 4.5 ftes (2.1 ftes excluding the spotters).

Additional tasks associated with each LGS AO run:

- Laser alignment/checkout/optimization. 1 laser eng + 1 laser tech for 1 day
- LGS AO checkout. 1 AO specialist + 1 AO software eng for 1/2-day
• Administrative support. Assist the LGS AO expert in scheduling pre-run meetings, documenting meetings, following up with observers on target lists and other logistics, reviewing and checking target lists, communicating with Space Command and the FAA and other Observatories, coordinating post-observing run responses, tracking responses to faults, reviewing proposals, scheduling spotters, etc. 3-4 days per run.
• The total from the spreadsheet is 0.8 ftes.

Additional operation costs:
• Laser maintenance. 3 days of laser technician + 2 days of laser eng per month
• Laser safety system maintenance. 1 day/month
• LGS AO software maintenance. It is important to have at least two software engineers well informed about the system. 3 days per month.
• LGS AO bench maintenance. 1 day per month * 2 people.
• LGS AO electronics maintenance. 1 day per month * 2 people.
• LGS AO operations tools maintenance. 1 day per month.
• Troubleshooting. 4 work-days/month.
• The total from the spreadsheet is 1.2 fte.

The above costs assume that NIRC2 is used for LGS AO science. At this point it is difficult to determine how the costs might be different if we were to use OSIRIS instead. OSIRIS usage could potentially conflict with Interferometer usage in terms of access to the AO enclosure.

Response to breakdowns:
• It is important that we have a reliable and well maintained system so that breakdowns are infrequent.
• We need to review the status of spares for the AO and laser system, and ensure that a reasonable level of spares is on hand.
• In the event of a significant breakdown it would be nice to have the flexibility to move an LGS run. Otherwise a run may need to be cancelled.

6. Preliminary recommendations

• Scheduling:
  ○ Determine the optimal scheduling. Current recommendation is to split the LGS AO runs into a total of nine 4-night runs and one 3-night run. Each run, except for the last, starts with 1 engineering night. Total of 30 science nights and 9 engineering nights.
  ○ Schedule the AO nights overall to allow the largest possible gaps between AO runs in order to permit development and/or fixes.
  ○ No NIRSPAO nights in 05B.
  ○ All Observers must have a backup program per the LGS backup program policy. This will impact which instruments need to be ready for each night.
Proceed with advertising the LGS AO system for unlimited number of nights with NIRC2, but have the option to reduce the number of LGS and NGS AO nights if necessary.

The support personnel scheduled to be on-call for a night should be LGS AO experts. In particular the software on-call person should be an LGS AO expert.

- Operations Personnel:
  - Hire and train a full-time LGS AO operator so that they are able to fully operate the system at the start of 05B. This should be done as soon as possible to ensure a trained operator is in place by August. There would be benefits to moving an existing OA into this role.
  - Train the laser operators (Melcher and Mouser) so that they are able to fully operate the laser and LTCS at the start of 05B.
  - Make Melcher a part-time, instead of a temporary, CARA employee at the 50 to 60% level to support night-time observing.
  - This LGS plan has Mouser at 2/3rds of his time instead of the previously planned ½ time. His other ½ time was intended to be on telescope optics. In order to maintain the ½ time on optics we would either have to get more ET support for starting up the laser or more mechanical or facility technician support for the optics tasks.
  - Have the Support Astronomers (SA) assume the LGS AO expert role starting in 05B. This includes coordinating with the astronomer to prepare the observing plan (including the target lists to be sent to Space Command), coordinating the readiness of the LGS AO system and backup instruments for each observing run, supporting the astronomer in the operation of the science instrument for LGS AO observations, and supporting the LGS AO operator in the optimization, monitoring and troubleshooting of the LGS AO system. The SA also needs to review the next semester’s proposal.
  - Since more than one SA will be needed to support the above role it will be important to train a 2nd SA in the LGS AO expert role, and to complete Campbell’s training.
  - In order to provide adequate operations software support we believe that we need at least 0.25 ftes of an additional instrument software engineer such as Conrad or Chock.
  - Train and schedule Melcher or an admin assistant to support the LGS AO expert/SA in the administrative part of supporting LGS AO runs.
  - Determine if we should hire more spotters as CARA temporary employees, to ensure reliability.
  - Ensure through training that we do not have any single points of failure for maintaining or operating the laser and LGS AO systems.
  - Ensure that this plan fits into the Observatory’s FY06 plans.

- Development:
  - Re-evaluate the success criteria for milestone 6 and develop a plan to achieve these criteria by the start of 05B.
  - Include maintenance and configuration control as part of the operations development effort. For example, implement a maintenance program for the
AO and laser systems. Roger Sumner is a good person to lead this effort (as our new AO system engineer), but could use help from the facilities, electronics and mechanical groups.

- Evaluate how personnel from outside the AO team could help in getting the LGS AO system to a higher operational standard prior to 05B. For example, Al Conrad’s involvement could significantly help with the development of the LGS AO operational tools, Liz Chock is very helpful with releasing tools and version control, and electronics, mechanical and facilities support could help make the laser and AO bench more reliable.

- Evaluate whether we can get and use any more LGS engineering nights in 05A.