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Remote Observing on the Keck Telescopes

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Abstract. Remote observing has long been a part of the Keck Observatory operating plan. Remote observing from the Keck Headquarters, in Waimea, HI, has been operational since 1996, before the second Keck Telescope came on-line. Remote observing from the Keck HQ now encompasses over 95% of observing runs at the Keck Observatory.

Recently, additional efforts have been made to enable remote observing on the Keck Telescopes from the U.S. mainland. Driven primarily by financial motivations, and enabled by recent increases in the available bandwidth between the mainland and Hawaii, remote runs from the mainland are now provided to observers at UC Santa Cruz (UCSC) and Caltech. Additional locations are in preparation.

In this paper, we present a brief summary of the Keck remote observing efforts from the U.S. mainland, with an emphasis on the system at Caltech, which is the most recent to come on-line. We describe the history and motivation for remote observing with the Keck Telescopes, outline the remote observing system and hardware, and describe plans for the future implementation of remote observing on a broader scale.

1. Historical Background

Remote operation of the Keck Telescopes has always been part of the long-range plan for the observatory. Remote operations of Keck I from the Keck headquarters in Waimea began before the Keck II telescope opened for observations. See Table 1 for a summary of the history of observing modes at Keck.

The last few years have seen the emergence of remote observing with Keck from the U.S. mainland. This effort had been spearheaded by a group of us from UCO/Lick Observatory. An essentially identical observing system has been installed at Caltech; it is now operational and used in a testing mode approximately two nights per month. Additional remote observing stations, following the same system parameters, are being established at other sites, including UC San Diego and UC Berkeley.

1993	Keck I science first light
1995	remote control rooms installed at Keck HQ
1996	videoconferencing between summit and HQ
	Keck I HQ remote observing first light
	Keck II science first light
1997	$>$ 50% of Keck I operation is remote from HQ
1998	HQ-summit bandwidth upgraded to 45 Mbit/sec
	mainland (UCSC) remote observing first light
1999	$>$ 90% of Keck I/II operation is remote from HQ
2000	HQ remote operation is default mode
2001	mainland (Caltech) remote observing first light

Table 1. Keck Observatory remote observing timeline

2. Motivation for Mainland Observing

When the Keck Telescopes began to be used remotely from the Keck HQ in Waimea, HI, the motivations were twofold: First, to increase service for the observers by providing a direct link between HQ observatory staff and the observers at the telescope. Second, remote observing at Keck HQ provides a much less demanding observing environment, due to its altitude of a mere 2,500 feet above sea level. In extreme cases, Keck HQ provides a safe alternative to those unable to ascend the mountain (e.g., those with heart conditions). In the average case, Keck HQ simply provides a much more comfortable environment, with 60% more oxygen than the summit of Mauna Kea.

In recent years, additional factors have arisen which have motivated remote observing from the U.S. mainland, even from the home institutions of the observers. The primary impetus here has been financial: Some hundreds of thousands of dollars are spent each year on observing travel alone. In more than half of cases, these costs are for runs of one night or less. The cost is increased if one includes lost time for travel (usually 2 days). Finally, remote observing from the mainland provides a way for increased involvement by large groups, students, and collaborators.

3. Remote Observing System

The remote observing system has been designed for a high level of redundancy, to ensure minimal loss of observing time in case of failure. It is functionally equivalent to the systems at the Keck HQ and the Keck summit control rooms:

- Sun Ultra 10 instrument computer with 3 LCD monitors
- Sun Ultra 10 backup instrument computer with 1 LCD monitor
- Redundant graphics and SCSI cards
- Exabyte Eliant 820 tape drive for data backup
- Polycom 512MP videoconferencing station
- Cisco 2600 router with 4-port ISDN card

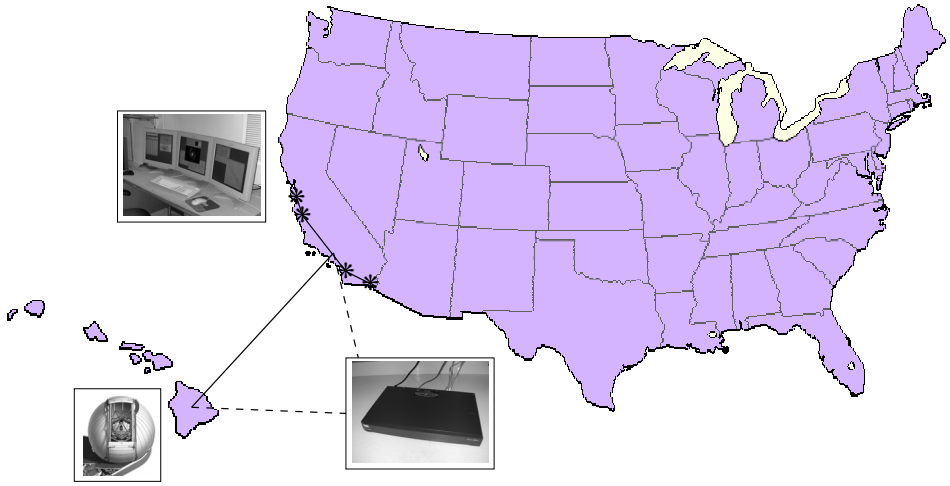

Figure 1. Schematic representation of the Keck remote observing network. The asterisks denote the four remote observing stations currently operational or under development. The dotted line denotes the backup network link via a group of ISDN lines.

The videoconferencing unit is a critical component of the remote observing system. Remote operations typically involve three sites: observers at the remote mainland location, observers at Keck HQ, and the telescope operators on the summit of Mauna Kea. The videoconferencing system provides a crucial link between these parties, allowing for much better communication than a simple voice line. When problems arise, the videoconferencing system can be used to share paper documents, audible noises, and computer output screens (thus the use of LCD panel displays on the computers).

To ensure complete redundancy of the remote observing system, a Cisco 2600 router with a 4-port ISDN card has been installed. During normal operation, the router is configured to pass all traffic over the standard Internet. (As of the year 2000, the Internet-2 project has enabled a peak bandwidth of approximately 35 Mbit/sec between the mainland and the summit of Mauna Kea.) If the router senses at any time that the Internet connection to Keck has failed, this route is disabled and a set of ISDN lines to the summit are activated. Although the ISDN lines provide much lower bandwidth (128 Kbit/sec per line), it is sufficient to ensure that critical traffic is passed. In particular, the observing software contains a number of timeouts that are triggered after inactivity for ~ 90 seconds. Given that network traffic between the mainland and Mauna Kea must traverse some dozen different networks, approximately one third of the remote runs from Caltech (thus far) experience a network dropout. These dropouts typically last 2-3 minutes, but are easily handled by the ISDN failover system.

4. Summary and Future Work

Remote observing with the Keck Telescopes is expected to slowly expand, to encompass additional remote sites and more flexible observing modes:

- Reliable remote observing with the Keck Telescopes is now possible from the U.S. mainland. Observing sites include UCSC and Caltech, with UCSD and UC Berkeley coming soon. Current redundancy requirements effectively prohibit remote observing from arbitrary home institutions, and there are no plans in this direction.
- Observatory policy currently requires at least one observer to be on-site at Keck HQ, to ensure that telescope time is not lost in case of remote system failure. As reliability is increased and experience gained, this restriction may be relaxed.
- Hardware for remote observing is easily affordable, especially when the cost savings are included (i.e., from travel). The available network resources are currently sufficient for observing with first-generation instruments on Keck. It remains to be seen how well advances in networking will keep pace with the next generation of larger detectors and more complicated instruments.
- The social implications of remote observing are complex and not yet fully understood. On the negative side, one must appreciate the impact of further distancing the observer from the telescope and observatory staff. On the positive side, the possibilities for group collaboration and education are clearly vast. Understanding the importance of such issues may be the key to a successful remote observing system.