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Night-time operations diagnostics at the Hobby-Eberly Telescope

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ABSTRACT

The Hobby-Eberly Telescope (HET) is an innovative, low cost 9-meter class telescope that specializes in queue mode spectroscopy. To observe astronomical targets, the HET uses a unique focal tracker system that employs complex robotic mechanisms to accurately point and track. In this contribution, we describe the electro-mechanical subsystems that have been designed and installed to monitor and diagnose this unique telescope's operations modes. These subsystsems are designed to maximize the fraction of night-time hours that are devoted to science operations, optimizing the telescope's scientific output by quickly detecting problems and minimizing engineering overhead.

Keywords: Hobby-Eberly Telescope, large telescopes, commissioning, audio, video

1. INTRODUCTION

The HET is unique among 9-meter class telescopes in featuring an Arecibo-like design with a focal surface tracker.[1] This tracker is the *only* moving mass of the telescope during an observation. The focal surface tracker is a sophisticated 13-axis electromechanical system which contains the majority of the HET's technical complexity. In addition, the tracker is the platform within which the Low Resolution Spectrograph[2], Fiber Instrument Feed[3], and other devices are riding. HET is unique in that, during an observation, the HET prime focus operation is where *all* active telescope operations are occurring.

Access to the HET tracker is very limited. The tracker is located 70-feet (21-meters) above the dome floor. The only means to the tracker is by riding a manlift up to prime focus. To get to the dome floor from the control room, an operator must pass through two doors over a distance of 40-feet (12-meters). The tracker is not visible from the HET control room, nor can the tracker be heard from the control room.

Tracker access difficulties impact operations on two fronts: First, because personnel are not in and around the tracker on a regular basis, problems are less likely to be detected before they degenerate into something more serious. Secondly, time can be lost investigating things that are not true problems. Early in the commissioning of HET it became obvious that the telescope operators (TO's) needed better information about the health and welfare of the tracker.

The project team subsequently devised three systems, audio, video and tracker diagnostics, that have distinctly helped the commissioning of the telescope. By enabling the TO's to identify and resolve problems in their early stages, these systems have benefited the ongoing night-time science, engineering, and instrument commissioning operations.

2. TRACKER AUDIO SYSTEM

The HET team has found audio to be an invaluable tool in the commissioning and operation of the telescope. An obvious advantage to audio is that telescope operators (TO's) quickly become accustomed to the sounds of the tracker in normal, safe operation. The TO's can hear shutter clicks from the guide and acquisition cameras, deployment of the calibration screen, operation of the Low Resolution Spectrograph, and such. TO's have detected subtle sound changes that were then traced to significant mechanical faults. By way of example, a bearing failure in one of the hexapod legs was detected as a subtle rattling sound which would have gone undetected until more serious damage resulted. There are also workplace safety benefits to having such an audio system, aside from the astronomical and engineering benefits. Workers on the tracker use the audio system to communicate with personnel in the control room in a "hands-free" mode, in lieu of having to press a button on a radio microphone. Because the tracker is suspended 70-feet (21-meters) above the ground, workers are required to wear safety harnesses and keep their hands free as much as possible. When a worker is using a tool to work at prime

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focus, communication with the ground is not possible by radio because there is no practical way to hold a radio and a tool at the same time; this "hands-free" system is invaluable.

2.1. Audio System Description

The sound is detected by any of six high fidelity microphones, each having an audio response from 60Hz to 20KHz. Three of the microphones are omnidirectional (Crown GLM-100), and are located in the prime focus payload area. These microphones detect sounds from the tracker hexapod, acquisition and guide cameras, PFIP optical bench slide, and the Low Resolution Spectrograph. The other three microphones (Crown GLM-200) are unidirectional. They are located to detect sounds from along the mechanical drives at Upper X axis, Lower X axis, and Y axis. Owing to the miniature size of the microphones (Fig. 1), they are simple to mount within preexisting equipment.

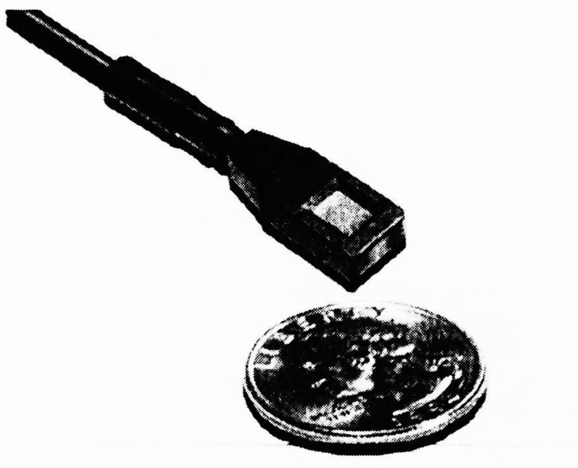

Fig 1. Microphone

The signal from each microphone passes through a pre-amplifier unit manufactured by Radio Design Labs. The outputs from the pre-amplifiers are fed into a fiber optic stereo transmitter, manufactured by FiberOptions. This allows the audio signals to be transmitted to the control room via fiber optic cabling for noise immunity and grounding reasons. In the control room the signals are converted from fiber into electrical signals.

The six audio signals are processed differently into two audio channels, Left and Right, typical of a stereo system. The Left audio channel is a simple mixing of all audio signals, allowing the operator to hear the audio from all microphones at once from a single speaker. The Right channel is any one of the six signals, user selectable by use of the routing switcher (Leitch Xpress 12x1). TO's routinely use the Right channel based upon the operations occurring at the time. By pressing a button, the operator can select which of the signals is playing on the Right channel.

Figure 2 is a block diagram of the audio system showing the interconnection of components and the signal flow. Figure 3 is a photograph of the audio system main control panel which is mounted in the control room 19" rack, immediately adjacent to the TO workstation.

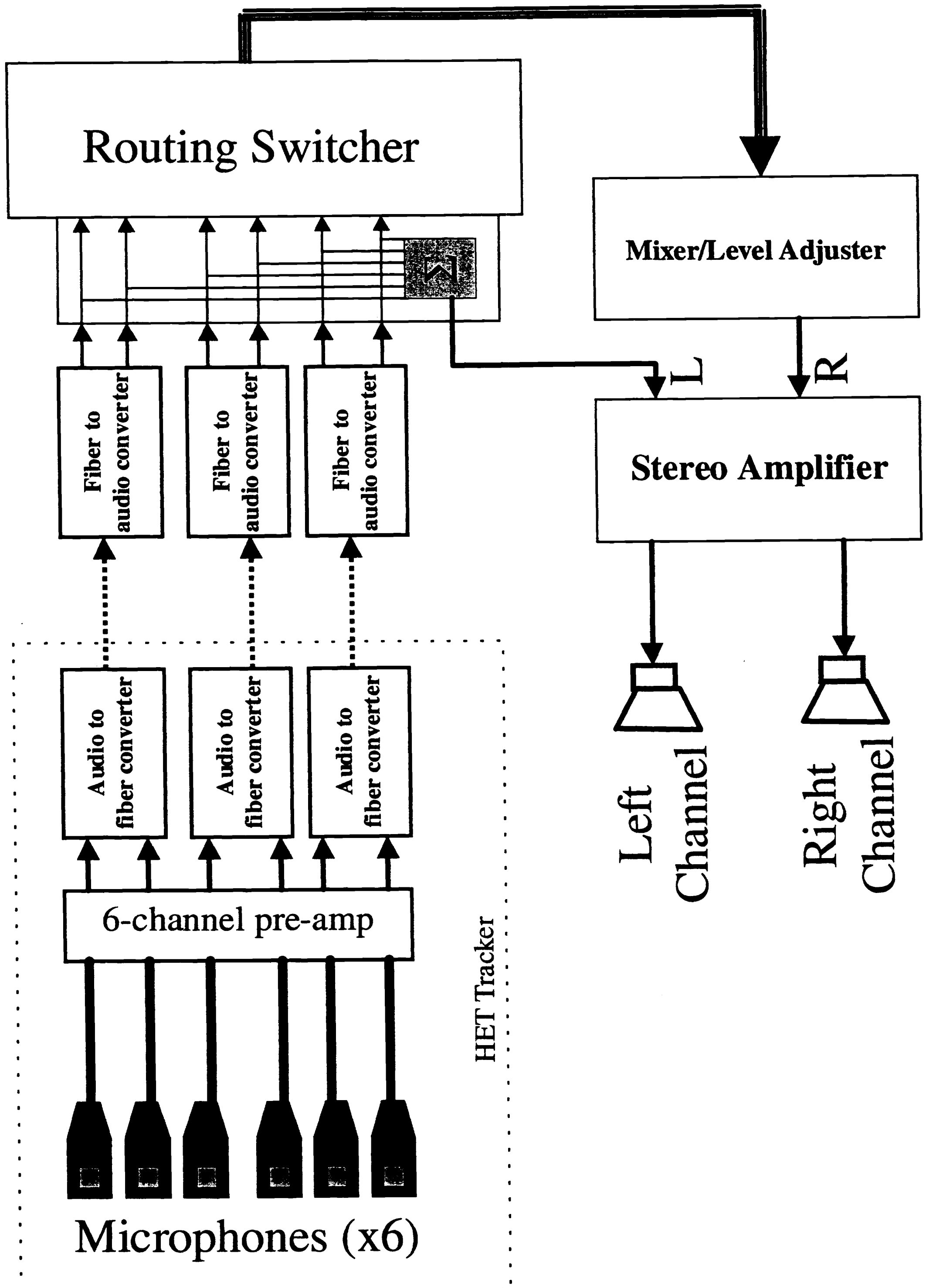

Fig 2 Audio System Block Diagram

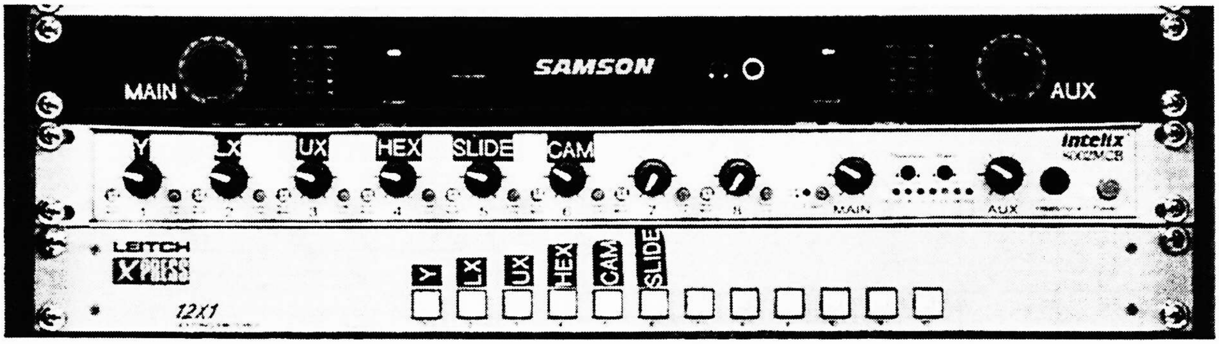

Fig 3. Audio Equipment in Control Room

2.2 Audio System Device Manufacturers

Below is a list of manufacturers of the various components which were built into the HET tracker audio system:

Microphones	Crown International, Inc., P.O. Box 1000, Elkhart, IN 46515, Model GLM-100 and GLM-200
Pre-Amps	Radio Design Labs, 1-800-933-1780 (USA), www.rdlnet.com; Model RU-MP2
Fiber Modems	FiberOptions, 80 Orville Dr., Suite 102, Bohemia, NY 11716-2533; Series 312B
Switcher/Router	Leitch, Inc., 920 Corporate Lane, Chesapeake, VA 23320; Leitch Xpress 12x1 Routing Switcher
Mixer/Leveler	Intelix, 8001 Terrace Ave., Middletown, WI 53562; Intellix MC-Series microphone/level mixer
Stereo Amplifier	Samson Technologies Corp., 575 Underhill Blvd., Syosset, NY 11791; Servo 120 Stereo Amplifier
Speakers	JBL Inc., 8500 Balboa Blvd., Northrige, CA 91329; Model Monitor 4208

2.2. Future Plans

The HET has found the audio system so beneficial that plans are to expanded it to monitor other aspects of the HET operations. Locations slated for future monitoring include the dome rotation mechanics, dome shutter mechanics, mechanical rooms, and the spectrograph rooms. This would cue the telescope operator to problems in those areas as well. The system is readily expandable to add additional channels as the need arises.

3. TRACKER VIDEO CAMERAS

Access to the tracker is severely limited due to its location. Because if this, the use of video as part of monitoring telescope tracker performance, especially as part of engineering, has proven exceptionally useful. At the present time, the HET makes use of two video cameras, each of which can be moved and pointed as needed. One camera provides a wide-field view of the tracker, while the other is used for close up views of tracker mechanics. Because of the difficulty in using video in low light, it is helpful as a diagnostic in concert with the audio system. If an unusual sound is heard via the audio system, lights can be turned on and the video used as a first reconnaissance to identifying a problem without leaving the control room.

3.1. Description of Cameras

For wide-field reconnaissance, the HET uses a SunVideo camera which was acquired as part of a new SPARCstation for the HET control room. The camera is mounted on the HET dome interior catwalk pointed at the HET tracker servicing position. The image is viewed by starting the SunVideo software in the control room. A captured image from this system is shown as Fig 4. This camera also provides the operator images of the dome rotation, structure rotation, and shutter operation, depending upon azimuth. The camera can be manually adjusted as the need arises.

For close up views, a Pulnix TM-7CN CCD video camera is mounted in the prime focus area. It is mounted on a manually adjustable mount and is often pointed at locations of interest. The video from the camera is fed into a fiber optic modem which converts the video signal for fiber optic transmission. Fiber optic cabling carries the signal to the control room where it is converted from fiber and fed into a video monitor. The image is displayed on the video monitor as part of the telescope operator workstation. The captured image below (Fig. 5) is an image of the cryogenic cooling lines for SF1, the LRS CCD system. Recently this video view prevented damage to these lines when an operator observed that they had fallen off of their supports, something that was undetectable from the ground.

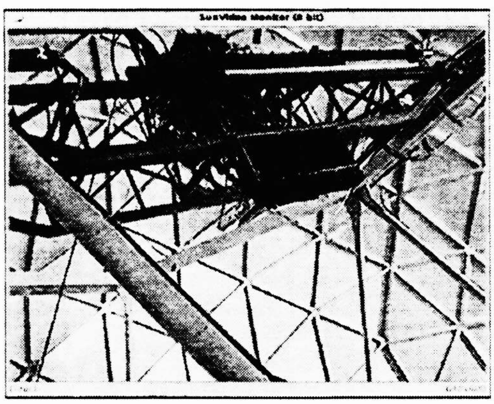

Fig 4. SunVideo image of tracker

Fig 5. Pulnix image of cryogenic lines at prime focus

3.2. Future Plans

Given the benefits of this initial system of cameras, HET plans to install a more complete video monitoring system in the near future. Of particular interest are low-light CCD cameras used in the surveillance industry, and cameras that are completely controllable from the control room (zoom, pan, and focus).

4. TRACKER DIAGNOSTICS SYSTEM

The HET project team designed, constructed, and installed a real-time electronics system to sense tracker I/O commands at the component level, and to monitor fault conditions. This system provides a means to monitor the tracker independent of the software interface. It has proven useful in cases when the software is not performing as intended.

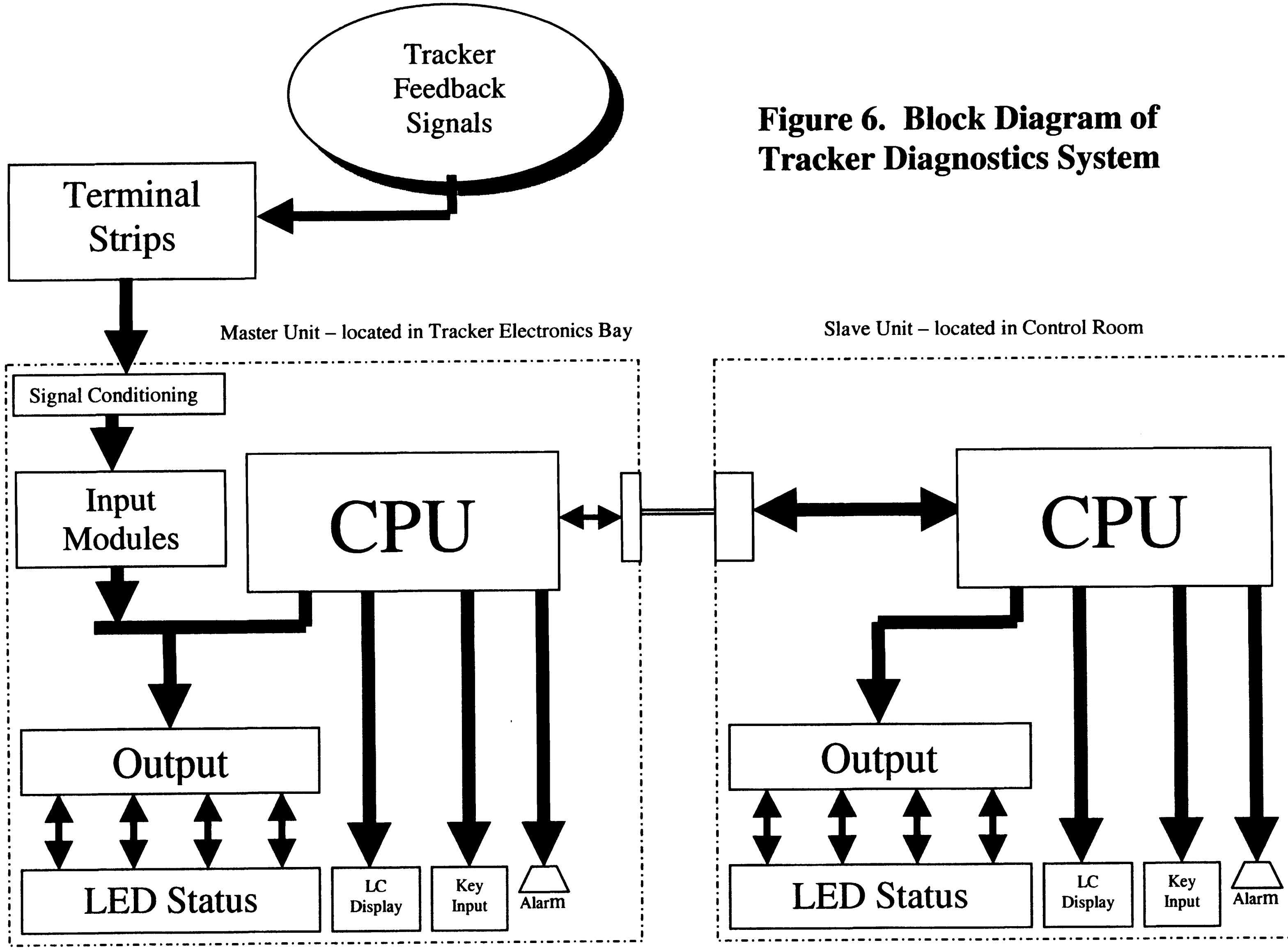

Figure 6. Block Diagram of Tracker Diagnostics System

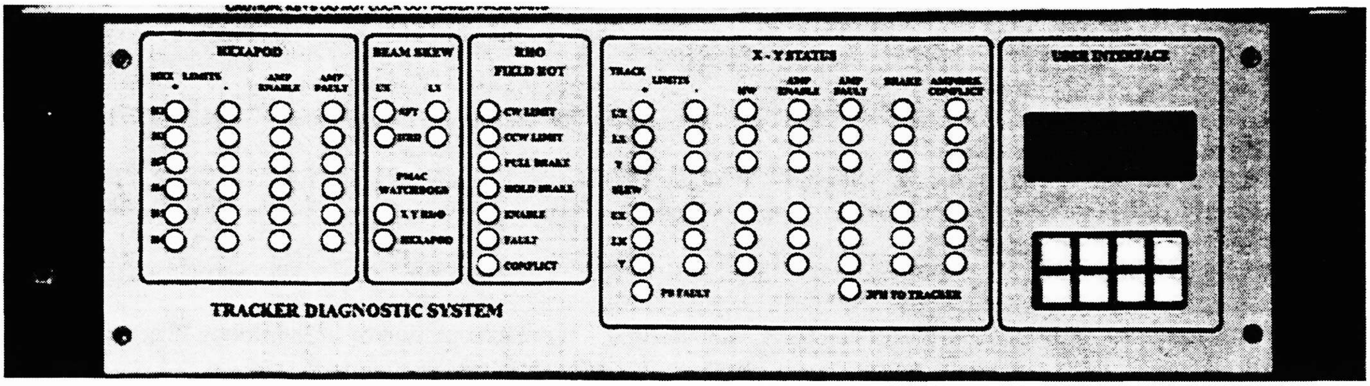

Fig 7. Photograph of the Tracker Diagnostics System display

4.1. Description of the Tracker Diagnostics System

As shown in the block diagram (Fig. 6), there are two diagnostics boxes. One, the master, is located in the tracker electronics bay[4]. It directly monitors various tracker signals using pre-existing terminal strips. These signals are conditioned and processed to generate a real-time display. This information is fed over RS-232 to the control room. There is a cosmetically identical panel, called the slave, which mirrors the display that the master is generating. By having two boxes, one is available to the operators in the control room, while a second is available in the tracker electronics rack, eminently useful during troubleshooting.

The TDS employs tri-state LED's which can display either green, orange, or red; dead states (i.e., non-illuminated states) are not permitted. When designing the TDS, red was reserved for unambiguous fault conditions, such as an amplifier fault. Green was reserved for the state of the tracker during an observation. For example, during an observation all brakes are released and amplifiers enabled. These statuses are green if true. Orange was reserved for states, such as brakes locked down, which are not faults, but do not occur during an observation. The result is that an operator should, if everything is operating nominally, see only green illumination from the LED's. If a fault were to occur, the appropriate LED will turn red. In addition, it is configured to emit an audible alarm when certain fault conditions are present. If the tracker is in a standby mode, there will be a mixture of green and orange colors, which the operator can easily interpret. This device has allowed the staff to detect fault conditions of importance, such as amplifiers being enabled without the corresponding brake being released.

Given the value of this system, plans are to continue use throughout the life of the telescope.

5. SUMMARY

The Hobby-Eberly Telescope operations staff has found that the audio, video, and tracker diagnostic systems provide a level of user interaction with the telescope that has enhanced the operability of the HET. These systems have alerted the staff to many conditions in their early stages that, if gone undetected, could have been costly. The HET staff considers the minimal resources expended in the development of these systems worthwhile, and recommends these in similar applications.

6. ACKNOWLEDGEMENT

The authors wish to thank Mark Blackley, McDonald Observatory Electronics Technician, for his role in the development of the audio and diagnostics systems. Mark took the basic concepts outlined in this paper and single-handedly tuned them into hardware. He worked with high-end audio equipment manufacturers and suppliers, explaining the HET's unique audio needs, and developed the hardware configuration that has worked so well. Mark was solely responsible for *all* of the

hardware and firmware development of the Tracker Diagnostics System. His critical role in the production of these two systems has greatly benefited the HET.

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