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ABSTRACT

The Hobby-Eberly telescope (HET) is an innovative, low cost 9-meter class telescope that specializes in visible and near-infrared, queue observing mode spectroscopy. The operations costs for this telescope follow the capital cost model, being ~ 15 - 20% that of other 9-meter telescopes. In this contribution we describe the HET operations model and our early operations and scientific experience with this telescope, emphasizing those aspects that most directly impact the scientific productivity of the HET and describing the actions we have taken to optimize the telescope's scientific return.

Keywords: Hobby-Eberly Telescope, operations model, queue mode operations

1. INTRODUCTION

The Hobby-Eberly Telescope (HET) was designed and constructed on behalf of an international collaboration of five universities: The University of Texas at Austin, the Pennsylvania State University, Stanford University, Ludwig-Maximilians-Universität München, and Georg-August-Universität Göttingen. HET is located at the University of Texas at Austin McDonald Observatory (hereafter simply "McDonald Observatory") in the Davis Mountains of far West Texas. The HET facility sits atop Mount Fowlkes, at an elevation of 2008 meters. Mount Fowlkes is 1.5 kilometers from Mount Locke (2079 meters elevation), the site of the McDonald Observatory's 2.7m Harlan J. Smith Telescope, 2.1 Otto Struve Telescope, and 0.91m and 0.76 telescopes. The HET site's meteorological characteristics and 1.5 arcsecond median image quality are well-suited to HET's performance and scientific niches. Astronomers at Texas, Penn State, Stanford, München and Göttingen typically have access to HET night-time hours in the following percentages, respectively: 52%, 31%, 7%, 5% and 5%.

HET is a 9.2m aperture optical and near-infrared astronomical telescope that incorporates several features that are unique to the current generation of 8 - 10 meter class instruments, such as an Arecibo-like focal surface tracker. HET's primary mirror is also unique: 91 identical, 1-meter diameter, hexagonal Zerodur™ segments arranged in a close-packed 10-meter by 11-meter array. The primary mirror array is thus an unphased, spheroidal surface that requires correction by a 4-element Spherical Aberration Corrector (SAC) at the prime focus. Details of the HET design are discussed in several S.P.I.E. publications[1,2,3,4,5] The current status and operational capability of the HET is described by several papers at this conference.

HET ground-breaking occurred 25 March 1994. Construction was managed by the HET Project Team and Project Manager, Thomas Sebring. through June 1997. The first HET operations staff arrived on-site in early 1997. Commissioning officially began with the acquisition of the first HET spectrum, using the interim commissioning instrument, the Upgraded Fiber Optic Echelle (UFOE) spectrograph, on the night 5/6 September 1997. Commissioning continued through 30 September 1999, when the telescope's facilities and optical, mechanical and electrical systems had progressed through their integration, verification and test phases. The first Facility Instrument, the Low Resolution Spectrograph (LRS), was delivered and commissioned in Spring and early Fall 1999 [7,8,9]. On 1 October 1999, the Hobby-Eberly Telescope reached an important milestone: the transition from Commissioning to Early Science Operations. Since this transition date, at least two weeks of each month's night-time operations hours have been assigned to science operations.

In this contribution, we detail the operations model for the HET and describe our early operations experience with this telescope. After an overview of the science operations requirements (section 2), we discuss the HET operations organization in section 3, including how the HET day and night time operations personnel are integrated into the University of Texas - Austin McDonald organizational structure. In section 4, we describe HET Early Operations performance, including progress against our science, engineering and instrument commissioning missions. Section 5 describes the availability of national community access time on the HET, beginning in Summer 2000. An overview of the HET five year operations plan is in section 6.

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2. OPERATIONS REQUIREMENTS AND PHASES

To provide guidelines for the development of the operations staff and policies, HET Scientist Larry Ramsey coordinated drafting the Hobby-Eberly Telescope Operations Requirements document. The final version of this internal document, consistent with the consortium legal agreements and approved by the HET Board of Directors, was published on 27 November 1995.

This document defined the HET operations phases: Commissioning, Early Operations and Full Up Operations. It also described the required operational performance at each operations phase for telescope pointing, guiding; science instrumentation; hardware and software tools, user community services, queue-scheduled science, observing support data, science instrumentation, facility systems maintenance services, and telescope facility management.

To support the transition from Commissioning to Early Operations, the telescope systems and functionality had to be sufficiently robust to support 14 nights of science each month without incurring unacceptable levels of downtime. Time lost due to systems problems, during Early Operations science, were required to be less than ~ 10 % of the night-time hours. Additionally, the transition to Early Operations required that at least one of the HET Facility Instruments had undergone commissioning and was ready to function as a reliable science tool. By 1 October 1999, HET performance was such that these key requirements, and others, were expected to be met. The HET Board of Directors approved the transition to Early Operations at the early October 1999 meeting.

Among the key requirements on the future transition to Full Up Operations is that downtime must be within the final specification, i.e., no more than 2% of the night-time hours scheduled for science can be lost to operational problems. This requirement is consistent with McDonald Observatory operations policy and performance at the Mount Locke telescopes.
Also, transition from Early Operations to Full Up Operations requires delivery and commissioning of all HET Facility Instruments. The planned Full Up Operations science suite includes four instruments. The schedule for delivery of these instruments (see section 4 below) is consistent with transition from Early Operations to Full Up Operations in Summer 2001.

3. OPERATIONS ORGANIZATION

Ultimate authority for HET policy decisions and direction belongs to the Board of Directors, which meets semi-annually. This seven member Board consists of two representatives each from the University of Texas at Austin and the Pennsylvania State University. Stanford University, Ludwig-Maximilians-Universität München, and Georg-August-Universität Göttingen. each has one representative on the HET Board of Directors.

The HET Scientist is appointed by and reports to the Board of Directors. Larry Ramsey (Pennsylvania State University), as one of the originators of the HET concept, has served in this role for several years. The HET Scientist is an advocate for scientific excellence, with responsibility for scientific vision, including instrumentation development. The HET Scientist is also the Chair of the Users' Committee. As in many observatories, this committee serves a vital communication function between the community of astronomers using the HET, and the personnel responsible for the operations, maintenance and management of the facility. Since HET's initiation of Early Operations, the Users Committee has become increasingly involved in improving the details of the Phase I and Phase II proposal processes. The immediate Users Committee goals include the development of better communications channels for the dissemination of the latest HET performance data, the development of a uniformly applied and understood science target prioritization scheme, and a universal electronic finder chart format.

Since the HET is operated by the McDonald Observatory under contract to the consortium, day-to-day development and operations authority rests with Observatory's Director's Office. The Associate Director oversees all aspects of Observatory operations and development in Austin and in West Texas, including those related to HET. The high-level division of duties, within the Observatory, is that development is the primary responsibility of the Austin staff, while the West Texas staff concentrate on all aspects of operations and maintenance.

HET is integrated into the McDonald Observatory West Texas organizational structure as one of the six sub-units that reports directly to the Superintendent, who has technical and managerial oversight responsibility for all West Texas Observatory operations and maintenance. HET benefits by having first call on a wide range of Observatory technical resources and Physical Plant staff for tasks ranging from engineering systems design to preventive maintenance and custodial services. HET requires and has the budget to support a 2.0 person level-of-effort (LOE) from McDonald Physical Plant and 1.0 person LOE from McDonald Observing Support. The 10 person McDonald Observing Support group includes engineering and technician personnel who have responsibility for set-up, operations and maintenance of the Mount Locke astronomical facilities on Mount Locke. The 14.5 person McDonald Physical Plant team has responsibility for all grounds and building maintenance. Their domain includes the Observatory's 33 residences, the Transient's Quarters (visitor lodging and dining facilities), the W.L. Moody, Jr. Visitors' Center, all the research facilities, water and wastewater systems, fire protection and security.

The HET operations budget supports an on-site staff of twelve persons that naturally divides between the night-time operations personnel, and a group of engineers and technicians who support operations, maintenance and development, largely during the day-time hours. Each member of this on-site HET team is an employee of the McDonald Observatory. The HET team is led by the Facility Manager, an electrical engineer who is one of six West Texas personnel reporting directly to the Superintendent. In addition to the Facility Manager, the day-time operations staff includes a Mechanical Engineer, an Electro-Mechanical Technician, two Systems Analysts, an Optical Analyst and an Administrative Assistant. The first priority for these individuals is science operations support, followed by engineering and instrument commissioning support. Night-time operations positions include Telescope Operators and Resident Astronomers.

Safety considerations and the operations complexity of a 9.2m segmented primary telescope demand that all HET night-time operations be conducted by two persons. Since night-time operations naturally divides between telescope and science operations, the adopted HET model specifies that there is to be one Telescope Operator and one Resident Astronomer present at all times. To accommodate the operations requirement that 85% of the night-time hours be queue-scheduled, the HET staff includes multiple Telescope Operators and Resident Astronomers. During some engineering operations, the Resident Astronomer position is replaced or augmented by a member of the day-time engineering staff.

The HET Resident Astronomers provide the astronomical research, instrumentation and data analysis expertise required for effective HET science operations. The Resident Astronomers operate the science instruments and control software. They are responsible for scientific data quality. During queue-mode observing, they are the scientific representatives at the telescope for the astronomers whose science has been approved by each of the individual institutions' Telescope Allocation Committee (TACs). Two Resident Astronomers are sufficient to support Early Operations science. An additional Resident Astronomer will be hired prior to the initiation of Full Up Operations. This position will be shared between the Observatory's Mount Fowlkes and Mount Locke operations, providing Resident Astronomer support to HET and service observing capability at the Mount Locke telescopes. Each of the Resident Astronomers is a Ph.D. astronomer who is encouraged to maintain a vigorous program of personal research. All Resident Astronomers have access to all of the McDonald telescopes, including the HET, on the same competitive basis as the faculty and research astronomers at each of the five consortium institutions. During science operations, the Resident Astronomers usually work a schedule of seven nights on and seven nights off. They sometimes participate in engineering operations, and are available to assist instrument PIs with commissioning, depending on the expertise of the individual PIs.

The HET operations staffing model requires an allocation of 15% of the science nights to dedicated time observing. Dedicated time observing permits an institution or individual PI to conduct HET science operations in a classical observing mode, where the scientist is present at the telescope when his / her observations are conducted. In dedicated mode observing, no science targets are observed from the TAC-approved queue. An individual scientist from one of the consortium institutions replaces and functions as the Resident Astronomer at the telescope. Substantial training would be required for individual scientists to function efficiently as a Resident Astronomer. Thus, it is expected that dedicated time observing will not be made available by the HET Board of Directors until 2001. We anticipate that this dedicated time will be utilized by a small subset of observers from HET institutions, astronomers who are already familiar with HET instrumentation and the telescope itself.

The HET Telescope Operators are responsible for the safe and efficient night-time operation of the telescope. Per the usual astronomical operations model, the HET TOs prepare the telescope, dome and instruments for observations each night. They operate the telescope facilities while acquiring science, instrument commissioning or engineering data. They are responsible for maintaining the electronic and web-accessible TO Night Report, the archival record of that night's work. The TOs also operate the primary mirror alignment software and hardware systems, monitoring and adjusting the alignment of the primary mirror array. They also assist the engineering staff in resolving technical problems and performing routine maintenance.

The annual operations budget for HET for the University of Texas Fiscal Year 2000 (31 August 1999 - 1 September 2000) is $985,000 USD. This relatively low annual budget covers the salaries of all HET operations personnel, parts and supplies capital equipment, utilities and staff travel. The operations budget includes provision for Physical Plant expenditures (2.0 person LOE and a materials budget), and a 1.0 person LOE from Mount Locke Observing Support. The HET operations budget also includes a contingency line equal to 10% of the budget's non-salary portion. Large capital expenditures are handled as special assessments that require the approval of the Board of Directors and additional fund-raising. The HET Segment Alignment Maintenance System[16] is an example of such an expenditure. Special assessments will be required, for example, when the HET segments require re-coating, when the control room computer hardware requires upgrade, and when the HET dome requires re-painting.

4. EARLY OPERATIONS TASKS AND PERFORMANCE

Since the initiation of HET Early Operations, night-time hours have been divided between three principal task regimes: (a) science, (b) instrument commissioning and (c) engineering. Throughout Early Operations, science operations will consume a minimum of two weeks per month. The remaining monthly night-time hours are divided between instrument commissioning and engineering operations.

4.1 Early Operations Science and Performance

The HET legal agreements require "Early Operations" to include at least fourteen nights per month of science. Thus, since 1 October 1999, HET has scheduled at least this amount of science each month. Science commences on or near the Third Quarter Moon, continues through New Moon, and ends at approximately First Quarter Moon. This alignment of science with the Moon's phases is appropriate since the only Facility Instrument delivered to the telescope in 1999 was the Low Resolution Spectrograph [7,8,9]. The telescope also lacks the more sophisticated baffling systems that will accurately track the telescope's roving pupil and optimally minimize stray light. This "moving baffle" has been designed and is currently being built by Observatory engineers in Austin. It will be delivered, installed and integrated with the telescope during engineering time in August 2000.

During the first four months of Early Operations (October 1999 - January 2000), 60 nights of 100% queue-scheduled science operations were conducted. (It is expected that all HET Early Operations science will be queue-scheduled.) Only five of these nights were mostly cloudy or cloudy. The available science instrumentation during these initial Early Operations science nights included the medium resolution Upgraded Fiber Optic Echelle (UFOE) and the Low Resolution Spectrograph (LRS). The UFOE is a commissioning spectrograph loaned to the HET by Penn State and is not optimized for use on a 9m telescope. The maximum number of available night-time hours between evening and morning astronomical twilight was 634 hours. Of this time, 38 and 14 hours were re-scheduled, respectively, as engineering and instrument commissioning. An additional 68 hours were lost to weather, leaving 514 hours for science.

The Resident Astronomer on-duty carefully tracks the HET hours scheduled for science operations, characterizing each time interval as either: (a) primary mirror alignment, (b) move and set, (c) science exposure, (d) night-time science calibration, (e) time lost to problems, or (f) other. Primary mirror alignment time is defined as the interval that elapses between the completion of the last science exposure prior to alignment, and the time when the telescope begins to slew away to the next science target, after alignment is declared successful. Move and set time is the interval between the completion of a science observation, or primary mirror alignment, and the initiation of the next science target's integration. Science exposure time is the total CCD shutter open time plus any time that the Resident Astronomer needed to analyze the observation's output prior to a move to the next science target. Since some but not all programs require night-time calibrations, a separate accounting is kept of science calibration time. Time lost to problems includes all night-time operations hours that were lost to any problem that precluded continuing with the science program. "Other time" includes seeing measurements, and other night-time operations that do not fit into the categories of time accounting described above.

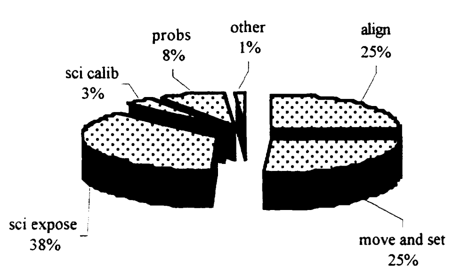

Figure-1: HET Early Ops night-time hours

Figure-1 illustrates the breakdown of the 514 hours of science operations for the period October 1999 - January 2000.Our motivation for aggressively moving forward with an Segment Alignment Maintenance System (SAMS) procurement is clear since 129 night-time operations hours (25.1% of the available hours) were expended for primary mirror alignment. Once SAMS is installed and operational, the night-time hours required for primary mirror alignment will be driven to zero, resulting a substantial gain in HET science productivity. In each of the four months in this period, the percentage of time required for primary mirror alignment varied from a low of 21.0% (January) to a high of 31.7% (December). The primary mirror alignment time is largely driven by the severity of the ambient temperature gradients.[18] Large temperature gradients drive alignment every 30 - 60 minutes; more rare static temperature gradients permit the primary mirror array to remain well-aligned for intervals in excess of 90 minutes. To guarantee the best image quality, HET operations policy generally requires the Telescope Operator to re-align the primary mirror prior to every science observation.

From October - January, move and set time totaled 131 night-time operations hours (25.5% of the available hours). The Telescope Operators, Resident Astronomers and HET PIs have worked to reduce this figure, and it has shown steady improvement. In the four months under discussion, the percentage time required for move and set operations steadily decreased . For the months of October through January, respectively, move and set time required 28.0%, 27.7%, 24.9% and 23.1% of the available night-time operations hours.

Over the four months of Early Operations, science exposure time amounted to 189 hours. Of this amount, 167 hours were CCD shutter open time accumulated on 725 different HET Principal Investigator science targets from 45 Telescope Allocation Committee approved science programs. Though the emphasis was on providing each TAC-approved PI with some HET data, several queue-scheduled programs were also completed. Science exposure time varied significantly from month-to-month, largely in response to how much science was requested of the two available spectrographs, LRS and UFOE. The UFOE is significantly easier to set-up and operate, compared to LRS. Thus, in December, when a large fraction of the science used LRS, the percentage of time expended for science exposure was just 27.4% of the available night-time hours. In January, when UFOE science dominated, the percentage of time expended for science exposure was much higher, 48.5% of the available night-time hours.

The night-time hours required for science calibrations (telluric line stars, radial velocity standards and spectrophotometric standards) is relatively small. Just 16 hours, or 3.1% of the available night-time operations hours, were used for this task.

Since HET has only recently been scheduled for substantial periods of continuous science, the fraction of night-time hours lost to problems is significantly greater than is expected in the long-term. Between October and January, 43 science hours were lost to problems, 8.4% of the available time. Note that, barring critical problems, the HET hardware and software configurations are invariant throughout a science operations run. As one might predict, the more complex HET systems, such as the tracker and the Telescope Control System software, accounted for a good fraction of these operational time losses. This number has varied considerably from month to month, from a low of 3.6% in January to a high of 13.9% in December.

The amount of "other" time has been minimal, just 6 hours over the four month period (1.2%).

Image quality from the 91 segment stack is routinely measured at the center of curvature faceplate, where the alignment sensor, a Roper Scientific Sensys CCD camera, views the individual segments spots produced by the laser projector. Image quality is also routinely measured on the sky immediately prior to each science exposure. During the October - January science operations, the 107 primary mirror alignment operations executed at the center of curvature faceplate by the night staff yielded a median diameter of 1.1 arcsec (EE50). The on-sky median image quality diameter was 2.5 arcsec (EE50). The greatest part of the current HET engineering effort is dedicated to image quality improvement. The October - January seeing (EE50) was measured as 1.7 arcsec. Adding this number in quadrature with the center of curvature EE50 spot size (1.1 arcsec), yields an approximate on-sky expected image quality of 2.0 arcsec. The difference between this approximate theoretical value of 2.0 arcsec and the observed 2.5 arcsec on-sky performance is a measure of the improvement we still need to seek in our mount modeling and optical alignment procedures. One of the challenges of the HET focal tracker design, for example, is that it introduces a large number of optical component and motion degrees of freedom.

The primary mirror alignment specification at the center of curvature faceplate is 0.6 arcseconds, in the absence of seeing. Our systems goal, on-sky, is to routinely produce seeing-limited image quality. At the McDonald Observatory site on Mount Fowlkes, in West Texas, being seeing-limited implies a median stellar EE50 diameter of 1.0 - 1.5 arcseconds, depending on the season (The best site seeing is always in the Summer since there are no cold fronts.)

4.2 Early Operations Engineering

Engineering operations are the joint responsibility of the West Texas HET operations staff and the Observatory's Austin engineering staff. Engineering tasks are defined by both teams, executed by the night-time operations staff, and jointly analyzed. Each engineering task has a Lead Engineer who is responsible for the task, procedure, execution and data analysis. Periodic engineering planning meetings and teleconferences assure coordination of the tasks between the multiple organizational units. The engineering tasks scheduled for January - February 2000, for example, include image quality improvement (especially tests and actions devoted to minimizing dome seeing) and CCAS integration, verification and testing.

A critical set of tasks scheduled for the Early Operations engineering time will support the Segment Alignment Maintenance System[16] development effort . The original concept for HET operations assumed a functional Center of Curvature Alignment System (CCAS) for fine primary mirror array alignment. Such alignment was required to consume no more than 10% of the available night time hours. Careful engineering testing by McDonald Observatory personnel during HET Commissioning[6] has demonstrated the inability of open-loop control to maintain the required segment alignment and enable the desired science. Thus, to provide closed-loop control of the primary mirror, the McDonald Observatory engineering personnel, led by John Booth, recommended that the HET Board of Directors approve the procurement of a Segment Alignment Maintenance System (SAMS). After extensive in-house discussions, specification development and consultation with the Board of Directors, a procurement package was let in Spring 1999. Several proposals were received and the contract was awarded to the team of NASA Marshall Space Flight Center (Huntsville, Alabama, USA) and Blue Line Engineering (Colorado Springs, Colorado, USA) in 1 November 1999. The NASA / Blue Line team SAMS system concept employs inductive edge sensor technology developed by Blue Line Engineering under NASA-sponsored research and development grants. This work also embodies an underlying control strategy based on the pioneering work of Nelson and Mast[17]. The specifications for this system are such that the HET segmented primary mirror array will require alignment only once every two weeks, reducing alignment night-time overhead to essentially zero. This system is expected to be routinely operational for HET science by late Spring 2001.

4.3 Early Operations Instrument Commissioning

Instrument commissioning is continuing throughout Early Operations. Instrument commissioning time is coordinated and scheduled with each of the Facility Instrument Principal Investigators (PIs) by the Observatory Superintendent, the HET Scientist and the HET Facility Manager. The LRS multi-object slit unit[10] is currently undergoing commissioning and will be in routine use by Summer 2000. A near-infrared, medium resolution spectrometer (JCAM) will be delivered and commissioned by Principal Investigator (PI) Larry Ramsey (Pennsylvania State University) and his collaborators in Spring 2000. The HET High Resolution Spectrograph (HRS)[13] will be delivered and commissioned by PI Robert Tull (University of Texas - Austin McDonald Observatory) in Spring 2000. A visible wavelength, medium resolution spectrometer (MRS)[12] will be delivered and commissioned by Larry Ramsey (Pennsylvania State University) in Spring 2001.

5. NATIONAL COMMUNITY ACCESS

Since some National Science Foundation funding was provided for the construction of the HET High Resolution Spectrograph and Medium Resolution Spectrograph, the HET consortium will provide the equivalent of 16 clear, queue-scheduled nights per year to the national community for six years. Thus, beginning in June 2000, the HET will be available to the U.S.A. astronomical community for queue-scheduled observing. Under an agreement with the National Science Foundation, administered through the National Optical Astronomical Observatory (NOAO), this community access time will be distributed over the phases of the moon and the seasons of the year in the same proportion as the scientific observations scheduled for the HET consortium members.

National Community Access will begin in Summer 2000, with proposals due at NOAO on 31 March 2000. Proposals must be submitted through NOAO using that organization's standard proposal form, available on the web at http://www.noao.edu/noaoprop/noaoprop.html. Though national funding only contributed to the MRS and HRS, national access time observers will also be welcome to use the LRS for their observing. Proposals will be reviewed by the NOAO TAC. Approved proposals will be forwarded to the HET for queue-scheduling. To assure a sufficiently deep queue, ~ 20% more proposals will be forwarded than can be scheduled.

HET is fully queue-scheduled for this national access time. PIs will not be permitted to request dedicated time observing. HET queue-scheduling is accomplished using a Phase I / Phase II proposal process similar to that used by the Hubble Space Telescope. Approved research programs resulting from Phase I proposals will be required to complete a Phase II proposal prior to the commencement of observations. These proposals are described at http://www.noao.edu/scope/het. HET's unique characteristics make it essential that potential users become thoroughly familiar with its capabilities. Data and calibrations acquired for a researcher are made available by ftp, with notification to the researcher on the day after the observation is made.

Investigators may request telescope time on multiple night-time facilities available through NOAO, including the HET, in a single proposal. HET time may also be requested as part of an NOAO Survey Proposal. NOAO Survey Proposals are only accepted during the March call for proposals. Because the HET is queue-scheduled, approved community access programs will be entered into the queue rapidly upon receipt from NOAO of the completed Phase II proposal.

6. FIVE YEAR OPERATIONS PLAN

Over the next few years, the fraction of time that HET spends on science operations will increase, while the fraction of time required for engineering and instrument commissioning will correspondingly decrease. Table-1 summarizes our current estimates for the relative proportions of science, instrument commissioning and engineering at HET over the next five years (2000 - 2004).

Table 1: Science, engineering and instrument commissioning allocations

year	science time fraction	instrument time fraction	engineering time fraction
2000	0.600	0.150	0.250
2001	0.700	0.100	0.200
2002	0.800	0.100	0.100
2003	0.900	0.050	0.050
2004	0.900	0.050	0.050

The year 2000 will see the commissioning of the LRS multi-object slit (MOS) unit and the commissioning of two new HET Facility Instruments (JCAM, HRS). The year 2001 will see commissioning of the MRS and the commissioning of a near-infrared augmentation of the LRS[11]. Looking further into the future, beyond 2001, we anticipate commissioning ~ 1 - 2 new science instruments each year at HET. Based on our experience with the first generation HET instruments, each of these new science instruments will require several three to six night observing runs to complete commissioning, characterize the instrument, train the operations staff and bring the instrument into routine science operations at the telescope. A long-term, steady state fractional allocation of ~ 5% of the night-time operations hours is estimated.

Requirements for engineering time will gradually decrease, too. We anticipate that ~ 25% of the night-time hours will be used for engineering work in 2000. Among the major demands on this engineering time allocation, at least through the Summer 2001, will be image quality improvement engineering and characterization. This will include completion of the integration, verification and testing of the Center of Curvature Alignment Sensor[6] and engineering tests required during the design phases for the Segment Alignment Maintenance System (SAMS)[16]. A portion of the engineering time allocation will be required for the installation, verification, test and acceptance of the delivered SAMS. Also, in Summer 2000, the McDonald Observatory will commission two Differential Image Motion Monitors, one of which will be dedicated to measurements of Mount Fowlkes site quality and HET image quality improvements. Overall engineering demands will decrease by ~ 5% per year to a steady-state level of ~ 5% of the annual night-time hours, beginning in 2003.

The net effect of the expected trends in instrument commissioning and engineering time demands is an increase in the night-time science operations hours. We expect to see the night-time science operations fraction increase by ~ 10% per year, from the current allocation of ~ 60% science to ~ 70% science in 2001, ~ 80% science in 2002, reaching a plateau at ~ 90% of the night-time operations hours in 2003 and succeeding years.

7. SUMMARY

The Hobby Eberly Telescope completed Commissioning and entered its Early Operations phase on 1 October 1999, initiating a scientifically productive operations cycle where two weeks of each month, approximately centered on New Moon, are devoted to science. One week each month is devoted to engineering, and the remaining week is dedicated to instrument commissioning.

The HET operations model implemented at the McDonald Observatory has been successful in Early Operations. The twelve HET day and night-time operations staff are well-integrated into the McDonald Observatory structure. Though HET operations are budgeted at < $1M USD per annum, the existing McDonald Observatory infrastructure and personnel allows HET to leverage this relatively lean budget for maximum effect. HET has, for example, high priority access to the West Texas engineering, technical and Physical Plant personnel whose primary function is support of the Observatory's 2.7m, 2.1m, 0.91m and 0.76m telescopes.

Early Operations science has proceeded well. As of February 2000, two science instruments (one Facility Instrument) are in routine operation. By Summer 2000, two additional instruments -- the medium resolution, near-infrared JCAM and the High Resolution Spectrograph -- will be commissioned and available to science programs. Additional science instrumentation is planned for the following years. The operations and development staff are making steady progress in improving the telescope's operability, functionality and output science quality . A variety of quality science has been accomplished in the first four months of HET Early Operations [14, 15]. This Early Operations phase is giving us important experience in handling a complex, multi-instrument queue, experience that we will use to efficiently manage the more complex science queue that will result as new HET science instruments come on-line in the coming months. Our goal is to initiate Full Operations at HET immediately after the SAMS installation is complete, in Spring 2001.

Though much remains to be accomplished, HET has proven its value and demonstrated its promise. The HET queue-observing mode implementation, for example, uniquely enables target-of-opportunity and synoptic observing programs in a manner not possible at any of the other 8 - 10 meter class astronomical telescopes. Queue-scheduled national community access to HET and its unique features will begin in Summer 2000.

By 1 January 2003, the fraction of science operations time at HET will climb from its present 50% to its planned plateau of 90%. At this level, the remaining 10% of the night-time operations hours will be divided approximately evenly between instrument commissioning and engineering. As the fraction of time scheduled for science increases, the productivity per unit hour will climb, too. Over the next six months, it is expected that intensive engineering efforts will drive the on-sky image quality to be seeing-limited. And a quantum leap in HET productivity will occur when the Segment Alignment Maintenance System (SAMS) comes on-line for science operations in Summer 2001. SAMS will drive the night-time operations hours required for HET primary mirror alignment to zero, netting an additional ~ 25% of the night-time hours for science.

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