BIMONTHLY SUMMARY

May - June 2001

The f/5 secondary mirror cell under assembly in the MMTO Tucson shop.

Personnel

In June, MMTO opened a position for an Electronic Technician, Sr., to replace Karl Harrar. We expect to hire a candidate during the next reporting period.

Graduate Research Assistant Vijay Venkatraman left the MMTO in mid-May.

Contract technician Erica Enriquez worked at the MMTO for about six weeks during May and June.

Development

Red Channel

D. Smith modified the Red Channel handling cart to work with the new telescope. The process involved the removal of the lifting table from the cart and the welding of a new base.

The Red Channel of the MMT Spectrograph was subsequently mounted on the telescope for the first time. As you may recall, the 1200x800 CCD that is the Red Channel's detector failed for unknown reasons during the Conversion shutdown. A new chip was processed by Mike Lesser at the UA's Imaging Technology Laboratory and subsequently installed in the Red Channel dewar. The new detector has a slightly different package than the old, making it difficult to position the chip close to the dewar window. It was therefore not unexpected that, when C. Foltz and D. Smith mounted the dewar and took test images, they verified that the chip was not in the correct position. Furthermore, the camera was thermally unstable. The dewar was returned to the Imaging Technology Lab where it was verified that a problem existed in the temperature control system. Subsequent work showed that it was possible to move the dewar forward. Additional engineering time is scheduled during July.

Minicam

Ken Van Horn and Dennis Smith assisted Mark Ordway (SAO) and group with Minicam in June. Work was performed on the shutter drive, and both the encoder and drive motor were replaced. Use of the overhead crane was necessary, as the shutter assembly is large and heavy.

Aluminizing

During this time period, preparation for realuminizing the primary mirror continued. This required the updating and redrawing of all the aluminizing schematics. A modified aluminizing control board design was proposed by Dusty Clark as a result of the last aluminizing run – that is, changing from current feedback to a voltage feedback servo configuration. To accommodate the feedback change, changes to the original design were required: the addition of a differential amp INA105 (one each on the high side drive and low side drive channels), the reconfiguration of the intermediate gain stage adjustment, and the addition of an enable control and driver circuitry for the PWM command voltage using an Am26LS31 chip. To accommodate the addition of the Am26LS31, each channel required a 100 ohm terminating resistor at the input of the Am26LS32 receiver chip on the module driver card. The modifications were incorporated into the existing design, and a wirewrapped prototype control board was fabricated by contract technician Erica Enriquez. Along with these changes, an improved remote control with an LED display was fabricated with the assistance of Mike Orr (Steward). In addition, Acopian #21GT50D power supplies were tested for use with the control board. A test setup was built with the use of a spare driver module and two 12 volt batteries. The prototype control board was tested for functionality and found to operate effectively.

Mirror Support

We have decided to repair the primary mirror support actuators with a neoprene cement. Tests by Ron James show that our temperature dependent leaks are fixed by adhering the diaphragms directly to the end caps. Shawn Callahan proposed that we hire a few mechanical techs from the Mirror Lab to do this during summer shutdown when the actuators will be out of the telescope during aluminizing. He estimates that once the actuators are out it would take approximately 1-2 hours per actuator, and there are roughly 120 actuators including spares.

Thermal System

All of the components of the primary mirror ventilation system were tested in early June. The following graph illustrates the initial performance.

Initial performance of the primary mirror ventilation system. Ambient air temp is shown (yellow), lower plenum air temp (black), and average backplate, midplane, and frontplate temps (blue, red, green respectively). The system response shows all the ingredients for good thermal control: ~0.1C mirror isothermality, mirror easily driven to ambient, and fast response to ambient air changes.

Work continued on an integrated MMT thermal software system. A series of data visualization GUIs were developed that represent the 3-D distribution of temperatures across and within the mirror. Each visualization consists of a 12x12 array of colored fields, with each field representing a 0.5 m x 0.5 m square of the mirror surface. Colors range across the spectrum with warmer, reddish colors for high temperatures and cooler, bluish colors for lower temperatures. Colors adjust automatically for changing temperature conditions. Separate displays were developed from the frontplate, midplate, and backplate of the primary mirror. Displays were also developed to illustrate the temperature difference between frontplate and midplate, frontplate and backplate, and midplate to backplate. The user interface for control of the Neslab unit was modified to allow two automatic modes, where an offset can be applied to the current ambient or frontplate temperatures, or a manual mode where the user directly sets the Neslab internal setpoint temperature. Plotting capabilities were added to allow visualization of temperatures and user parameters for a 24-hour period. Further work was done to incorporate these various interfaces, as well as an overall summary interface, into a notebook-based GUI. Additional data logging capabilities were added to the code. Preliminary testing of both the GUI and overall properties of the thermal system was performed. The aim of this work is to have a single GUI for user interaction with the entire MMT thermal system.

Wavefront Sensing

The MMTO attended an active optics meeting with Magellan and the Steward Mirror Lab. We discussed results from the Magellan II laboratory figure correction, as well as active optics results and strategies for both Magellan I and the MMT.

The wavefront computer was upgraded to Red Hat 7.1. This broke the XPM display used by the wavefront analysis program. The error was tracked down to an incompatibility of the new version of Tcl/Tk with the Tix extension package. A stubs version of Tix was installed, which fixed the problem.

High Resolution Interferometric Device

MMTO Technical Report #37 is now published. It describes both the instrument and the first results for mirror figure and collimation corrections using wavefront sensor feedback.

Due to weather, only one of several attempts at wavefront sensing was successful during this reporting period. Fifth order coma and sixth order spherical aberrations were added to the analysis routines.

The last fraction of the nights of May 29-30 was used for wavefront sensing. Unfortunately, problems with both chillers precluded running the primary mirror thermal control system.

The starting diffraction image psf is shown on the left. This represents the image with no figure or collimation corrections and no thermal control of the primary mirror. The right image shows the resulting psf after two iterations of figure and collimation correction using feedback from the wavefront sensor. Each is shown in 0.75 arsec square box.

Here, the 16 modes (excluding tilt and defocus) are shown corresponding to the psf's shown above (uncorrected black and corrected grey). Mode 14, corresponding to 5th-order coma, doubled with each of the two corrections. The problem has since been attributed to a sign error in the correction for this mode.

Low Resolution Wavefront Sensors

There was little activity except for a refinement of observational needs of these systems. Currently, two f/9 Shack Hartmanns will be built. One will be used for instruments that use the 12-degree slit plate arrangement of the spectrographs. Pending a feasibility study, this unit will operate at the pupil of the Beseler lens in the top box. The second f/9 device will operate on a platform connected to the top of the rotator ring. It will be used for f/9 instruments that do not use the top box. The third Shack Hartmann unit will be for the f/5 instruments and will be placed on a platform attached to the rotator ring.

F/9 Hexapod

Logging of the hexapod motions has been ongoing for several months. A cursory look at the log files yields quite a bit of discrepancy between the incremental encoders and the lvdt's as shown in the following two figures. This must be investigated further during summer shutdown. We do know one source of non-repeatability is interference between a couple of the lvdt rods that span the actuator and the electronic boxes.

A plot of 1000 hexapod piston motions between April 24 and May 16, 2001. Plotted is the commanded piston motion (as resolved by the incremental encoders) vs. the achieved motion as reported by the strut lvdt's. Struts 3, 4, and 5 show a couple of anomolously large errors.

A zoom view of the above graph showing the region +/- 200 microns. Ideally for a given commanded z motion, all the actuators should be centered on a single point since piston motion requires all struts to change the same amount. Actuators 3, 4, and 5 again show the largest excursions.

F/5 Hexapod

The f/5 hexapod was delivered to the MMTO and determined to have arrived with no shipping damage.

The f/5 hexapod control system design was completed during the reporting period, and cables, connectors, and other hardware were ordered. The f/5 mirror cell microprocessor design was extended to add readout of the hexapod lvdt positions and to report this information, along with the mirror support force and thermopile data, via a serial link to the host computer.

M. Orr re-machined the ADS-supplied connector panels on the f/5 hexapod actuators to accept new MS-type connectors that will replace the original D-connector/Lemo connector arrangement. The new cable design significantly reduces the cable load, while adding the high performance of mil-spec bayonet-loc connectors.

The DAC and digital I/O controller was built, along with its chassis and power supply. This awaits population and checkout during the next few months. This controller will handle the actual DAC control and turn on/off the motor and brake enables on the f/5 hexapod. The amplifier chassis for the hexapod is mechanically complete and awaits completion of its chassis wiring.

Servos

Dan McKenna (LBT) and D. Clark tested the MMTO servos with the new LBT servo analysis computer/software to develop a system identification of the elevation and azimuth axes. Some useful data were collected. D. McKenna was able to off-line develop a system ID of the elevation axis and measure its performance characteristics; he predicts a bandwidth of 1.7 Hz with the current PID loops, and 12 Hz with a LQG loop (an advanced matrix-calculated predictive servo). More investigation remains in order to identify the source of the compliance seen on the elevation axis, especially in high-wind conditions. D. McKenna and D. Clark plan to repeat the tests with the help of the new tools and drive the elevation axis with the predicted LQG loop after aluminization to investigate its performance improvement.

F/5 Secondary Mirror Cell

Court Wainwright and Steve Bauman have finished the design of the ventilation nozzles and polycarbonate plates. These plates, now in fabrication at the UA instrument shop, support the many nozzles that inject air into each core in the back of the f/5 mirror.

S. Bauman has been detailing many components, including plates required for mounting the cell to the hexapod and plates to strengthen lift points. He also has finished the many interface plates that bolt together the heat exchanger, blower, and duct.

C. Wainwright, working with S. Callahan and J.T. Williams, has designed a dummy mirror that uses salvaged material from the basecamp yards. This 770 lb. steel mirror will have attachments for both the axial and lateral actuators. The center of gravity will be adjustable with a threaded screw, and there will be built-in lifting attachments. Court is now detailing fabrication drawings.

M. Orr has been working with us in laying out the pneumatic actuators and all of the plumbing hardware including gages, relief valves, pressure switches required by the servo system, and a few hundred brass fittings.

In preparation for mounting the hexapod and then the mirror cell on the fixed hub, a design modification to the original f/9 removable hub was finalized by J.T. Williams and S. Callahan. This design will allow rigid yet lightweight attachment of the hexapod to the fixed hub. At the end of July we should have the finished drawings package together for Larry Acedo (UA instrument shop) to plasma cut and weld the newly revised removable hub.

LVDTs have been ordered for the f/5 cell, and the axial mounts were fabricated and installed by M. Orr. The tangential lvdt mounts are still in design.

C. Wainwright, working with D. Clark, has designed and fabricated the electrical connector brackets. M. Orr or R. James will mount this bracket to the cell wall. This will allow D. Clark and others to begin wiring.

Nelson Caldwell, working with Brian McLeod, and S. Callahan have an initial design for the f/5 baffles. This "optical" design is ready to be turned into a structural design.

R. James has completed various fabrication details on the cell and has added many ideas on most areas of development discussed above. He also is responsible for the quality control of the fabrications. In addition, he is checking the designs of the engineers and students for feasibility of machining, and ensuring that the drawings are ready for the fabricators.

Brian Cuerden (Steward) and S. Callahan, with help from R. James and M. Orr, designed the procedure for attaching the lateral actuator pucks to the mirror. This included fabrication of glue jigs. John Ray and Dennis Casper (SOML) used these jigs to glue in all thirty pucks plus a witness sample.

Adaptive f/15

The MMTO met with CAAO twice during this reporting period. The first meeting was a discussion of mirror handling and safety. One interesting fact is that it may not be possible to move the telescope mount unless the AO shell support is active!

The second meeting was a first discussion of the software interface between the adaptive optics and the telescope control systems.

Computers and Software

Progress has been made on a number of ongoing projects that still await completion. Among these are backups of downtown computers, deployment of a GPS receiver as a time standard (providing, among other things, stratum 1 NTP service) on the summit, and security and software maintenance of the various Linux computers used at the telescope and in offices downtown.

The VME CPU that runs the mount servos was upgraded from a MC68030-based MV147 card with 4M of RAM to a MC68040-based MV167 card with 16M of RAM. Our benchmarks show that this processor runs our code 2.5 times faster than the older one.

Work on the mount control software is in a maintenance mode, with the only significant area of development being the instrument rotator control. A number of small bugs have been fixed, and the operator interface improved. In particular, the performance of the guide paddle was improved, and the first of several issues with the use of network communications was addressed. Drivers were developed for the LS7166 quadrature counting chip to be used to read the encoder tape. But as some limitations of the LS7166 became apparent, we set this driver aside and chose to use the quadrature input section of the LM628 chip (an old friend that we use to run the telescope servos) to read the Heidenhain encoder tape (this work is to be completed in the next report period). The LS7166 driver will be useful for applications less demanding than the Heidenhain tape.

Various software approaches were used to capture and process images from the DT3155 frame-grabber at a target rate of 10-30 frames per second. Included in this image processing is image stacking and image decay through a leaky memory approach. The majority of code being developed for the MMT is currently written in high-level, interpreted scripting languages such as Perl and Tcl. These high-level languages allow more software functionality to be written in a shorter time, but are computationally slower than compiled languages such as C. Programs written entirely in a scripting language would not be able to meet the performance goal of 10+ frames per second for image acquisition and processing.

Three different approaches were used to develop software capable of meeting the performance objectives: 1) modifications of existing code written in C by Don Fisher (CAAO), and using the Simple X windows library to run on more recent Linux kernels, 2) adaptation of guider software written by Gary Schmidt (Steward) in the Tcl scripting language, and 3) development of code using the Simple DirectMedia Layer (SDL) X windows library. Each had both advantages and disadvantages. Approach 1 and 3 used programming entirely in C and C-based libraries. Approach

2 used a hybrid of Tcl/Tk for the graphical interface and C for computationally intensive portions of the code. Time trials for image acquisition and processing were done for the three approaches. The results of the trials were that all three were comparable in speed. Most significantly, the hybrid C/Tcl/Tk approach performed as well as those using only C. This allows software to be written more efficiently in the higher level scripting languages with only critical portions written in C. It also allows use of the framegrabber with other astronomical software written in scripting languages, such as DS9, written in Tcl and developed by SAO.

Work continued on a GUI for critical telescope parameters for use by both observers and operators on a variety of platforms, including Linux and Sun/Solaris. Newly added features include: 1) addition of parameter sets for telescope offset and time, 2) the ability for users to view selected subsets of the various parameter sets, 3) the ability of the user to change from degrees, minutes, and seconds to decimal degrees, and 4) the ability of the user to change display characteristics such as font size and background highlighting. Minor changes were made to the code to work on Sun/Solaris machines. This software uses the SAO "msg" messaging protocol and can potentially be used on any system worldwide that supports the Tcl programming language, including Microsoft Windows, and that has internet access.

Optics

No activity to report.

General Facility

The buried cable to the RUPS room has been terminated at both ends and is complete between the drive room, RUPS room, and on to the blower building. Remote control of the blower is available from the control room. A large CPC connector has been mounted in the drive room to provide lightning disconnect for all the signals that run through this cable. Presently these signals are: RS-232 to the Neslab and a DAU to be installed in the RUPS room for temporarily handling temperature monitoring, blower control and power status, and an alarm signal to the control room when RUPS goes to DC power.

D. Clark provided K. Van Horn a first-cut purchase list to replace the DAU at the RUPS room with a stand-alone monitor and control system that can reside on the ethernet and be properly lightning protected. Ken needs to finish the design of this system and start procurement.

K. Van Horn began preliminary work to get the fiber optic system operational between the comm room and the drive room. It appears to be close to operational, but we will need to reconfigure the junction boxes for reliability.

Maintenance and Repair

A temporary worker was hired by FLWO to replace the temporary telephone wiring installed by K. Van Horn. He also reconnected the telephone set in the elevator. Instructed to install it on line one, he subsequently had to move it to line two. Line one is used by all the phones to correspond with each other, so cannot withstand any extra loading. The extra line length to the elevator was too much and caused the same problems as before.

We have received two quotes from Carrier to develop a serial interface on the chiller to control its set point. Carrier has been less than responsive in helping us. Duane Gibson has obtained some data reading the interface with a laptop. Given enough time, we should be able to reverse engineer what is needed. Since time is short, we will probably need to buy the module from Carrier.

RUPS has consumed much time, with three failed modules in the last month. One module, for which we had no spare and had to bypass until one was procured, has now been replaced. Another module was replaced by a spare, only to have the spare fail within 6 hours. These modules are no longer available. The units were analyzed and discovered to have damaged internal DC to DC converter power supplies that had been replaced by the factory under warranty. The power supplies were removed from one unit, and external AC input supplies were jury-rigged to operate the other module. We are developing a proper fix and repair for both modules.

K. Van Horn has developed an Excel wire list of RUPS that is proving to be very valuable in troubleshooting the system.

Visitors

No activity to report.

Publications

With the conversion of the MMT to a 6.5-m telescope, Conversion Technical Memoranda (CTM) and Conversion Internal Technical Memoranda (CITM) will no longer be issued. Technical Memoranda and Internal Technical Memoranda pick up where the CTM/CITMs leave off.

MMTO Internal Technical Memoranda

01-2 Secondary Mirrors Support: M2/F5 Hexapod Design Kinematics Algorithm
ADS International s.r.l.

MMTO Technical Memoranda

None

MMTO Technical Reports

TR #36 Secondary Mirrors Support: M2/F5 Hexapod Design Technical Report &
M2/F5 Hexapod Test Report
ADS International s.r.l.

TR #37 An Interferometric Hartmann Wavefront Analyzer for the 6.5m MMT, and the First Results for Collimation and Figure Correction
S. C. West, S. Callahan, D. Fisher

Scientific Publications

01-12 Emission-Line Properties of z > 4 Quasars
Constantin, A., Shields, J. C., Hamann, F., Foltz, C. B., Chaffee, F. H.
Submitted to *ApJ*

01-13 Emission Line Properties of the Large Bright Quasar Survey
Forster, K., Green, P. J., Aldcroft, T. L., Verstergaard, M., Foltz, C. B., Hewett, P. C.
ApJ Supp., **134**, 35

Observing Reports

Copies of these publications are available from the MMTO office. We remind MMT observers to submit observers' reports, as well as preprints of publications based on MMT research, to the MMTO office. Such publications should have the standard MMTO credit line: "Observations reported here were obtained at the MMT Observatory, a facility operated jointly by the Smithsonian Institution and the University of Arizona."
Submit publication preprints to *bruss@as.arizona.edu* or to the following address:

MMT Observatory
P.O. Box 210065
University of Arizona
Tucson, AZ 85721-0065

MMTO in the Media

No activity to report.

MMTO Home Page

The MMTO maintains a World Wide Web site (the MMT Home Page) which includes a diverse set of information about the MMT and its use. Documents that are linked include:

1. General information about the MMT and Mt. Hopkins.

2. Telescope schedule.

3. User documentation, including instrument manuals, detector specifications, and observer's almanac.

4. A photo gallery of the Conversion Project as well as specifications and mechanical drawings related to the Conversion.

5. Information for visiting astronomers, including maps to the site and observing time request forms.

6. The MMTO staff directory.

The page can be accessed in two ways. First, it can be loaded via URL *http:// sculptor.as.arizona.edu*. Second, it can be accessed via a link from the OIR's MMT page at URL *http://cfa-www/cfa/oir/MMT/mmt/foltz/mmt.html*. The former should be used by interested parties west of the Continental Divide; the latter is a copy, which is locally mirrored at SAO and is much faster for East Coast access.