S m i t h s o n i a n A s t r o p h y s i c a l O b s e r v a t o r y & S t e w a r d O b s e r v a t o r y , T h e U n i v e r s i t y o f A r i z o n a

Quarterly Summary

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**January - March 2017**

MMT Observatory Activities

Our Quarterly Summary Reports are organized using the same work breakdown structure (WBS) as used in the annual Program Plan. This WBS includes a major category with several subcategories listed under it. In general, many specific activities might fall a tier or two below that. The WBS will be modified as needed in future reports.

**Administrative**

**Program Management**

**Staffing**

**Scheduling**

**Quarterly Reports**

**Strategic Planning**

**Reports and Publications**

**Presentations and Conferences**

Safety

**Training**

**Safety Inspections**

**Procedures and Protocols**

**Personal Protective Equipment**

**Interlock System**

Primary Mirror

**Coating & Aluminization**

**Ventilation and Thermal Systems**

**Hardpoints**

**Actuators**

**Secondary Mirrors**

**f/9**

**f/5**

**f/15**

**Baffling**

**Hexapods**

**f/5 hexapod**

**f/9 and f/15 hexapod**

**Optics Support Structure**

**Truss**

**Secondary Hub**

**Spider Arms**

**Neutral Members**

**Pointing and Tracking**

**Azimuth**

**Elevation**

**Rotator**

**Science Instruments**

**f/9 Instrumentation**

**f/5 Instrumentation**

**f/15 Instrumentation**

**Instrument Handling**

**Topboxes and Wavefront Sensors (WFS)**

**WFS Software**

Portions of the wavefront software at the MMTO have been in use and largely unchanged for 10-15 years or even more. While it has worked well for the most part, it has become difficult to modify and significantly improve due to its lack of a cohesive design. Work has begun on a new, completely refactored wavefront sensor software system built from the ground up using entirely new code. Instead of the original mix of C and TCL, the core of the new system is based entirely on python. This provides the ability to use python’s very rich ecosystem of image analysis, visualization, and astronomy-specific tools such as Astropy. It also provides the ability to use the code testing and continuous integration utilities that that have also been developed by the Astropy community.

Some key features of the new software include:

* More robust pupil registration and aperture matching. Many of the problems encountered with the current system have a root cause related to errors in determining the pupil center or assigning measured spot positions to the wrong Shack-Hartmann aperture.
* The use of standard ordering for the Zernike polynomial terms. The old software used a custom set of terms with non-standard ordering which made comparison with results from other software such as Zemax problematic. The new software also uses recurrence relations to generate the Zernike polynomials and their derivatives which provides the ability to fit arbitrary numbers of terms.
* Improved analysis of wavefront sensor images via the Astropy-affiliated package, photutils. The two key capabilities that photutils provides are fast, accurate spot finding/centroiding and more sophisticated background modeling/subtraction. The spot finding/centroiding is performed using an updated and complete DAOfind implementation. It is faster and more accurate than the simplified implementation currently in use.

The new software is still being actively developed and validated against existing wavefront sensor data. We hope to deploy it along with the new F/9 wavefront sensor camera during the summer of 2017.

**f/5 WFS**

**f/9 Topbox**

**Natural Guide Star (NGS) Topbox**

**Laser Guide Star (LGS) Topbox**

**Facilities**

**Main Enclosure**

**Instrument Repair Facility (IRF)**

**Common Building**

**Bowl Dorm**

**General Infrastructure**

##### **Computers and Information Technology**

**Software Management**

The MMTO has had a Github organization set up at <https://github.com/MMTObservatory> for a while. However, it was only configured as a free, basic account so it did not support, for example, private repositories. If we wished to migrate the git repositories currently hosted on our local machines to Github, we would need private repository support. Some of our repositories contain sensitive information that wouldn’t necessarily be appropriate to share publicly. Fortunately, Github has a very generous program for providing free services to educational/academic institutions. We applied for this and have now been granted free, unlimited use of all Github capabilities, including an unlimited number of private repositories and unlimited storage/bandwidth for large files via Github LFS (Large File Support). Several projects have since been migrated to Github to take advantage of this and more will be migrated over time. Contact T. E. Pickering, D. Porter, or J. D. Gibson for details on how to get a Github account and have it linked to our organization.

**Computers and Storage**

**Network**

**Hardware/Software Interfaces**

The new CCD camera for the F/9 wavefront sensor, an SBIG STT-8300, required a new software interface for network-based camera control and image acquisition. This camera does have its own built-in Ethernet interface, however it communicates via a proprietary protocol, is prone to lock-up if the protocol is not followed exactly, and limits the camera’s readout speed compared to using the USB interface. An alternative solution was pursued based on the INDI (Instrument Neutral Distributed Interface) library: <http://indilib.org>. INDI provides a well-defined network interface and built-in support for many observatory-related devices, including SBIG cameras/peripherals. This solution consists of two components: a server running on a computer that is attached to the camera via USB and client software to communicate with the server while abstracting the gory details of the INDI protocol.

The server portion was solved by using inexpensive ARM-based single-board systems, specifically Raspberry Pi 3’s, as the host computers. The INDI software is pre-packaged for Debian-based systems, including those running on the ARM architecture, so installing it and its dependencies is very straightforward. There is very little configuration required of the server other than specifying the driver(s) to load and the network port to use. Commands to do this are added to the system initialization scripts so that the INDI server is started when the host computer boots up. The systems are run off micro-SD cards which makes it easy to archive/version system images as well as swap out cards or system boards if they fail.

There is a wide variety of INDI-compatible client software available. However, to more easily integrate INDI with our software we need a client library interface. INDI provides C/C++ libraries plus some shell utilities. The former would require extra effort on our part to integrate with other languages that we use while the latter are limited in what they can do (e.g. they cannot be used to perform CCD exposures). For easier integration with the wavefront sensor software, a pure-python INDI implementation was found and adapted. This software and its development is currently hosted at: <https://github.com/MMTObservatory/sbigclient>.

This software will also support a new camera system for the mount alignment telescope (MAT): an ST-402 with a B-V-R-clear filter wheel. This ST-402 system was actually procured in 2008 with the intention of installing it on the MAT, but those plans fell by the wayside in favor of a video-based StellaCam camera.

**Telemetry, Logging, and Database Management**

**Annunciator**

**Weather and Environmental Monitoring**

**Weather Stations**

**All Sky Camera and Web Cameras**

**Seeing**

**User Support**

**Web Pages**

**Remote Observing**

**Data Quality Assessment**

**Data Archive**

**Reduction Procedures**

Documentation

**Document Database**

**Procedures**

**Public Relations and Outreach**

**Visitors and Tours**

**Public Presentations**

#### MMTO in the Media

**Site Protection**

#### Appendix I - Publications

#### MMT Related Scientific Publications

*(An online publication list can be found in the MMTO ADS library at* [*http://www.mmto.org/node/244*](http://www.mmto.org/node/244)*)*

**MMT Technical Memoranda / Reports**

#### Non-MMT Related Staff Publications

**Appendix II - Service Request (SR) and Response Summary: January - March, 2017**

**Appendix III - Observing Statistics**

The MMTO maintains a database containing relevant information pertaining to the operation of the telescope, facility instruments, and the weather. Details are given in the June 1985 monthly summary. The data attached to the back of this report are taken from that database.