A 3.5m Update

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I. Introduction

This report covers the period from June 1996 to June 1997. In June of 1996 a segment of the ARC community outlined problem areas with the 3.5m and its instruments, and called for a concerted effort to overcome the problems. In late 1996 the ARC board appropriated funds for this work. This report presents the progress that has been made to date.

Some documents that pertain to this effort are available from

`http://www.astro.washington.edu/deutsch/apoinfo.html`

As you probably know, we have been working on a number of fronts to improve the performance of the facility. This work has been carried out by the site staff, people at JHU and the University of Washington, and by Dr. Yorke Brown who is taking the lead on certain demanding technical tasks. The priority of the work is determined by consensus among those who are familiar with the telescope and the resources. It is important to bear in mind that this is a very lean operation. Given the fact that the site staff are split between SDSS and 3.5m tasks, the job of keeping the telescope running consumes essentially all of the resources on site that are available for the 3.5m. When we enter into an intense upgrade the site staff and the externally based crew are typically working 18 hour days over extended periods of time. Those who are not very close to the fray need to recognize that a great deal has been accomplished by a hardworking few. There is still much to be done, and we are continually trying to balance the engineering work against observing time. More on this later.

In prioritizing the tasks we have tried first 1) to fix glaring problems, and 2) to concentrate on image quality issues. As we progress we will address observing efficiency issues and performance enhancements.

II. Facing the Dragons: Enclosure Wheels, Throughput, and Drive Mechanics.

This past year there were two major problems that were dealt with. The enclosure that surrounds the telescope is supported by large metal wheels that run on a track much like a single rail of a railroad track. The wheels started to show severe cracks that required immediate attention. The problem was diagnosed, replacement wheels were procured and installed and appear to be sound. This was a major effort that bears little resemblance to changing the wheel on your car.

Another major success was the realuminization of the primary mirror in December of 1996, after which telescope throughput went up by a factor of almost 4 in the blue, a factor of 2 at 600 nm, and about 1.2 in the infrared. The throughput is now consistent with fluxes calculated from first principles. This is described in a nice document prepared by our NMSU colleagues M. Ledlow and A. Watson, available from the web site given above. Subsequent slitless spectroscopy of spectrophotometric standards indicates that the throughput has degraded by at most a few percent, if at all. This will be monitored on an ongoing basis.

The drive systems for the telescope have turned out to require more attention and care than was anticipated. The mechanical components have exhibited wear and tear that has required teardown and replacement which has consumed much effort on the site. A significant amount of engineering time has gone into maintenance and upkeep.

III. Progress in Improving Image Quality.

The report I prepared in June of 1996 has an image quality budget that we have used as a guide in prioritizing the upgrade tasks. Our emphasis has been on four fronts: 1) procuring a new secondary, as we have static optical figure errors that limit us to about 0.8 arcsec FWHM images when the site can deliver better, 2) reworking the primary mirror support mechanism so that the mirror is held in the right place without oscillation or untoward stress, 3) replacing the guide camera with a superior one, and 4) fully understanding the collimation of the telescope. Also, the mechanical stability of the secondary support structure was greatly improved with the addition of temporary cross-bracing, and this has greatly reduced susceptibility to the wind-driven oscillations that plagued us in the past.

New Secondary.

Hartmann tests of the optical train indicate a significant amount of small-scale optical figure error. This is consistent with profilometry tests of the existing secondary, done at Lick Observatory. This optical figure error appears to be the single largest term in our image degradation budget. The process of procuring a replacement secondary is well under way. A blank is on hand, and Ed Turner and Alan Uomoto are engaged in the selection of a vendor to figure and polish the new mirror. This selection process should be finished in the near future, after which work will begin on the mirror. As these optical jobs are always time-consuming, my personal guess is that delivery sometime between the fall of 1998 and the fall of 1999.

Primary Mirror Support Upgrade.

The primary mirror is supported by pneumatic pistons that are actively pressurized in response to error signals from a set of position sensors. The tolerances are very demanding if there is to be no image degradation as a function of zenith angle. The system was not stable over all zenith angles, and this was a significant contribution to the image quality budget at two airmasses. Dr. Yorke Brown investigated this problem in depth, and devised and implemented an upgrade to the mirror support system that overcame the limitations. Entirely new circuitry was designed, built and installed, as were new fast-acting valves that increase the bandwidth of the pneumatic system. This job is not quite finished, as we still need to replace a pumping station and tidy up a few loose ends, but from the user's standpoint it's fully functional. We are a few weeks away from being done with this job. It appears likely that this technology will be used in the SDSS

2.5m telescope.

New Guider.

The short-term tracking of the telescope is quite good, but long integrations (10 minutes or more) show image degradation unless closed loop guiding is turned on. The off-axis guider we have been using is a 512 x 512 pixel front illuminated chip. Pointing to an arbitrary place on the sky seldom yielded a useful star on the guider. This has meant that in order to guide the rotator has been used to position an appropriate star on the chip, by rotating about the science target. This sacrifices parallactic angle for spectroscopy, is inefficient, and generally leads to much confusion.

Jeff Morgan of the UW and the site staff are installing a new guide camera that quadruples the field of view (1024 x 1024 pixels) and has a thinned detector. This should provide nearly a factor of 8 improvement in coverage, and should allow us to pick up a guide star with a reasonable integration time at an arbitrary rotator angle.

The mechanical and electrical installation of the guider is essentially complete. The software has a few bugs that we need to iron out, but we do not anticipate that being a major job.

This upgrade will also provide more direct information to the remote astronomer- you will be able to ftp guider images and efficiently assess its performance.

Collimation.

The process of achieving optimal positioning and alignment of the mirrors on the telescope is clearly of prime importance in obtaining good images. Jeff Morgan has investigated the process of collimating the 3.5m and has produced a very comprehensive, readable and thorough analysis of how we should approach this problem. The use of the guider as a diagnostic tool is an important element in his approach, so we have deferred implementing a full-up collimation procedure until the new guider is installed, but it is high on our list of things to take up next.

The document on collimation is accessible from

`http://www.astro.washington.edu/morgan/collimation.html`

and demonstrates our understanding of the problem.

III. Instrument Developments

A new instrument was delivered to the site last fall, the Seaver Prototype Imaging camera, or SPIcam (pronounced spy-cam). A user's manual is now available off the Instruments link on the APO web page. At this point nearly all ARC institutions have an experienced SPIcam user, and reports are generally favorable. The instrument uses a thinned 2k x 2k detector and we have SDSS and UBVRI filter wheels. The instrument is not integrated into Remark, and there are no plans to do so.

A comprehensive User's Manual for GRIM was completed and is also accessible from the APO Instruments link. This is a very nice document and we all owe a hearty "thanks" to its authors: Alan Watson, Mark Herald and Bernie Rauscher.

Upgrades to DIS are under way. A fiber optic data link has been installed to reduce 60 Hz pickup, and new gratings are being ordered. Alan Uomoto is also planning to install metal air-gap slits. As a reminder, the slit viewing camera images can be placed in an ftp-accessible location by the Observing Specialists. There is a long-term plan to upgrade the detectors in DIS, but not this year.

IV. Near-term Plans

Our approach is to bring active tasks to full closure, meaning resolving the problem, verifying performance, and fully documenting the effort, before moving on to another task. We are nearing the end of the first wave of activity in improving the performance of the telescope, with demonstrable improvement in throughput and seeing at moderate zenith angles, and (soon!) guiding performance.

The next set of priority items in the 3 year plan include baffling the telescope, achieving repeatable proper collimation, installing monitoring instruments so we can keep an eye on system performance, and beginning to understand the thermal management problems and their impact on seeing.

On a somewhat longer timescale we will be addressing the rotation of the tertiary, closed loop focussing, etc.

V. Management

The upgrade effort is a significant undertaking that involves many people working on a variety of fronts at once. In my opinion the work reported above constitutes very significant progress, most of it achieved in the past 6-8 months. In the process we have learned some important lessons.

We do not have the resources to have "proper" project management of this effort, which would probably require something between a half to a full FTE. We just don't have the technical talent to spare. This means that despite our best effort to predict the optimal timing and duration of engineering shutdowns many months in advance, we have in all cases entered into a scheduled shutdown underprepared and the work has taken longer than predicted. I make no apology for this, and would welcome the active participation of anyone who could help us to do better. The scheduling of week-long engineering shutdowns many months in advance is counterproductive for both the science and the engineering effort.

In particular, we are imposing on the few who are actually trying to get all this done an unwelcome and avoidable burden that can be alleviated if we go to a preparation-driven approach to the engineering work. This is the motivation behind the recent e-mail from Ed Turner about revising the interplay between science observing and engineering.

The talented and dedicated technical staff who are working hard to get our telescope working need all the help we can give them.