SOAR Project Status

Jay Elias – September 6, 2018

1. Introduction

This document summarizes the status of SOAR projects as of the end of July, 2018. The list includes (a) projects approved by the Board and (b) project-like operational activities (e.g., aluminizing). The projects are listed below. Where CTIO has assigned a project number, that is listed also.

Table 1 – SOAR Projects

Project	ACTR ID	Brief Description	Completion
Aluminizing	494	Aluminize M1, M2, M3 in November	Dec. 2018
M1 Active Optics Speed-Up	493	Decrease response time of M1 aO	Dec. 2018
WFS Guider	496	Upgrade Nasmyth guiders to do auto-focus and more; both foci	Early 2019 (optical); late? 2019 (IR)
CWFS Upgrade	497	Upgrade calibration WFS to newer cameras	Nov. 2018
SOAR Seismic Upgrades	498	Anti-seismic safety measures	Encoder mounts done; remainder TBD
STELES Installation	502	Install and commission STELES	Feb 2019
SOAR Mount Upgrade	504	Overall project replaces mount control hardware/software	Phase 1, Dec. 2018; Phase 2, end 2019
SAM Reliability Upgrades	505	Replace older SAM components	2019
SAM Plus	--	Upgrade DM and WFS plus associated electronics/software	2020
SAMOS	--	RUI to provide a configurable MOS mode for SAM in campaign mode	2020
ARCOIRIS to SOAR	509	Modify ARCOIRIS for use at SOAR and install at SOAR	Sept 2018 plus commissioning; TBC
SOAR Automation	510	Automate manual functions on telescope and instruments to support queued observations	Late 2019 for Phase 1

This version is posted on the SOAR website to inform our users. It has been slightly edited from the version presented to the Board at its annual meeting in August.

2. Project Status

2.1. Aluminizing

The SOAR mirrors were last aluminized in late 2009. The coating of M2 and M3 was successful, but the coating of M1 produced a coating with low reflectivity in the blue. The reflectivity also does not show the typical dip in the far red that is characteristic of aluminum, leading to the conclusion that there was contamination.

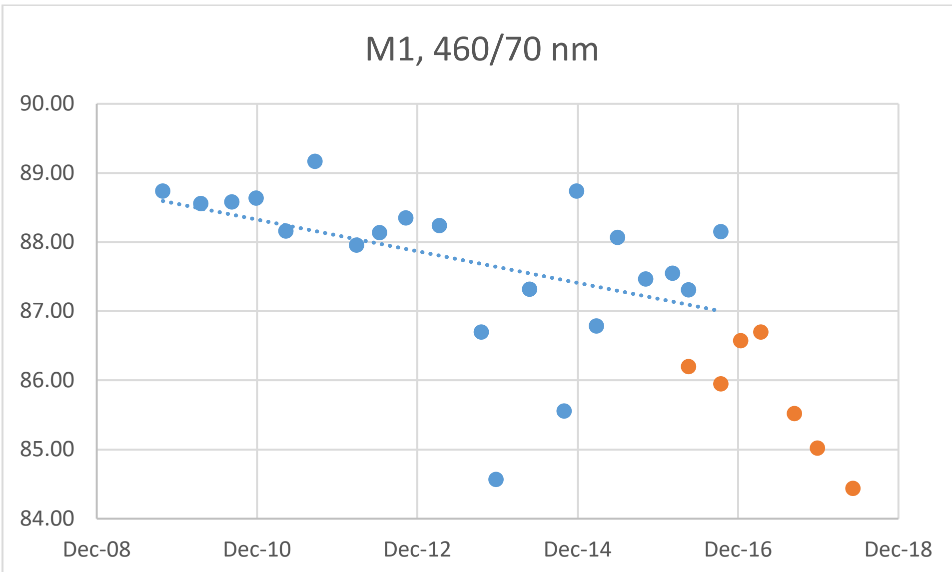

Figure 1 – M1 blue reflectivity. The blue points are at 470 nm, and the red points are at 460 nm, with a different reflectometer that replaces the instrument used through 2016. The trend line is a fit to the blue points only.

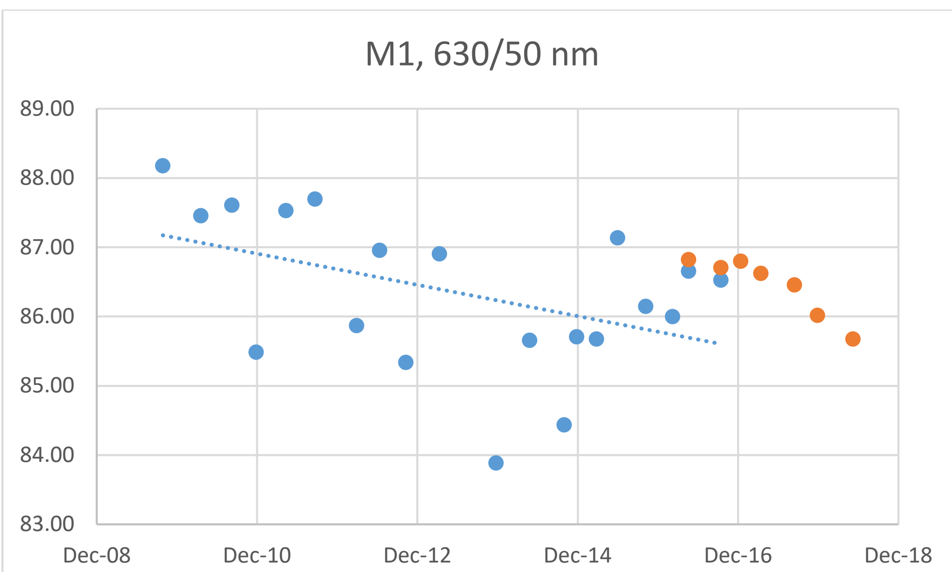

Figure 2 – M1 red reflectivity. The blue points are at 650 nm and the red points are at 630 nm. Trend line as in Figure 1.

Since then, the mirrors have been maintained by weekly CO_2 cleaning and quarterly washing. The reflectivity has stood up well over time, as shown by the figures above (M1) and below (M2/M3).

Note that the instrument used for measuring reflectivity was changed in 2016; there is some overlap between the two series of measurements, which indicates that offsets between the two are small. The newer instrument also measures shorter wavelengths; the data points for 365 nm indicate that reflectivity is current slightly under 84%.

Similar figures for M2 and M3 are shown below.

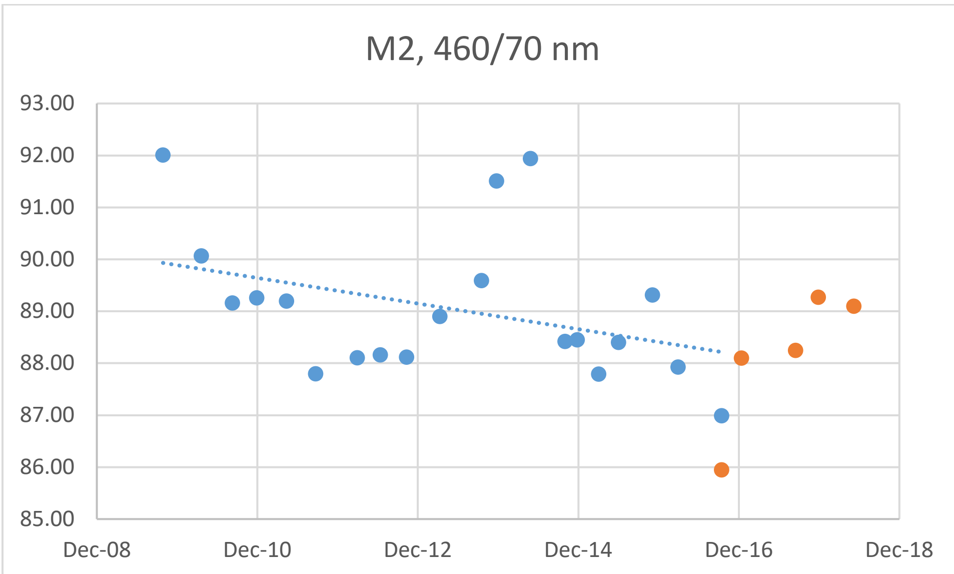

Figure 3 – M2 blue reflectivity, similar to Figure 1.

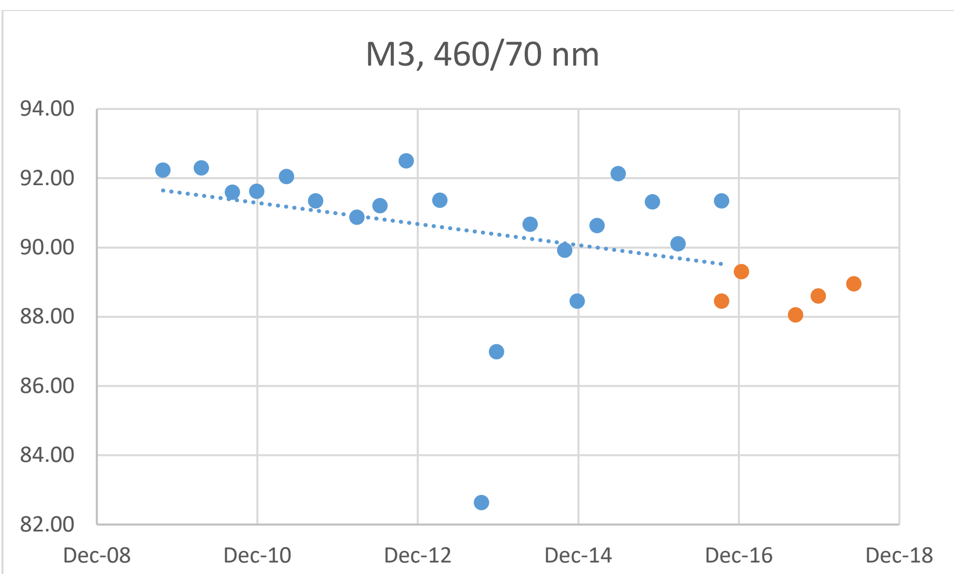

Figure 4 – M3 blue reflectivity, similar to Figure 1.

Measurement at 365 nm for M2 and M3 show both at around 88% reflectivity.

Looking at the plots, the decline in reflectivity is fairly slow, although there is some indication that the M1 blue reflectivity loss is now accelerating. Another mirror wash is due in August and this will indicate whether there is a real trend.

Overall, the losses in the blue over 9 years are approximately 4% for M1, 1.5% for M2 and 3% for M3, or a total of 8.5% for the three mirrors – close to 1% per year total.

However, if the re-coated mirrors had performance similar to that achieved for the Blanco Telescope primary in June, which was 91.6% at 365 nm, 91.0% at 460 nm, and 89.7% at 630 nm, the gains would be almost 15% at 365 nm, 10% at 460 nm and 6% at 630 nm.

A caveat with regard to all these numbers – they presume that the reflectivity measured by the reflectometers is true specular reflectivity. Small-angle scattering can be included in the measurements, in which case the loss of reflectivity is greater. Experience suggests that for the SOAR mirrors the effect is no more than a couple of percent overall.

Given the time out of service required for re-coating, we have decided not to start the coating until we are sure that a high quality coating can be deposited.

Recoating was originally planned for late 2016, but has been postponed twice as we could not guarantee a successful coating.

Originally, it was thought that the problem was entirely due to silver contamination of the Gemini coating plant, and that removing silver deposits from critical areas. Since then, we have discovered additional problems, requiring a general overhaul of the cooling water system due to internal mineral deposits, as well as replacement of the aluminum target. It is possible that the Gemini-S coating plant has *never* deposited a good aluminum coating, since the telescope switched early on to protected silver; no witness samples from early coating survive.

Testing of the plant will resume in August. If it is successful, then we can proceed with the planning coating starting in late October. If it not successful, it is not clear what the next steps should be. The two most plausible options are:

- Major overhaul of the Gemini plant, with dedicated magnetron system. This is likely to be expensive.
- Determine the feasibility of using the LSST coating plant instead. This is feasible in principle, but we have not had serious discussions with LSST on the topic. The plant is due to be delivered this year, but then needs to be commissioned; additional work by SOAR would be needed to allow our primary to be coated.

Both of these options would postpone the aluminization until 2020, possibly later. We would therefore plan to reduce the planned shutdown in November, but not eliminate it, and then retain the portion of the plan where we coat M2 and M3, where the options are to use the 1.5-m coating tank (known to work) or the Blanco coating tank (already thoroughly tested). This would recover about half of the reflectivity lost since 2009. The 1.5-m option is probably the preferred choice.

A go/no go decision should be made no later than early September.

Staff involved include NOAO and Gemini optics staff and members of the NOAO mechanical engineering group.

2.2. M1 Active Optics Speed-Up

The active optics system for the primary mirror (M1 aO) is slow, and cannot keep with the changes in support forces that occur during a large change in telescope elevation. As a result, for large slews, the telescope needs to stop before critical forces are exceeded, wait for the actuators to catch up, and then continue the slew. This can add minutes to the slew time.

A project was started approximately 2 years ago to address this issue, and has been proceeding at modest priority.

The overall speed gain required is a factor of 7-8; at this rate the actuators would keep up with the slew rate, although we would likely perform large slews in steps – the difference would then be that the steps would be continuous, without waiting periods.

After investigation, the engineers (Norman Diaz and Michael Warner) proposed to increase speed of response in two ways:

- Sufficient power to run all actuators in parallel. The existing power system can only run ¼ of the actuators (30 out of 120) simultaneously, so they are operating in sequential groups.
- Running the stepper motors faster. Although there isn't a hard limit to the possible increase, there is concern that too fast a speed will cause loss of steps and complicate closure of feedback loops. Tests indicate that the desired factor – approximately 1.8 – appears feasible; larger gains appear possible but provide no reductions in overheads.

In order to implement these changes the power distribution system needs to be replaced and the new power supply will be installed on the back of the mirror cell, with appropriate glycol cooling. The design and fabrication of the original power distribution box (PMAAT) is sub-standard; failure of the current unit would leave the telescope out of service until it was repaired.

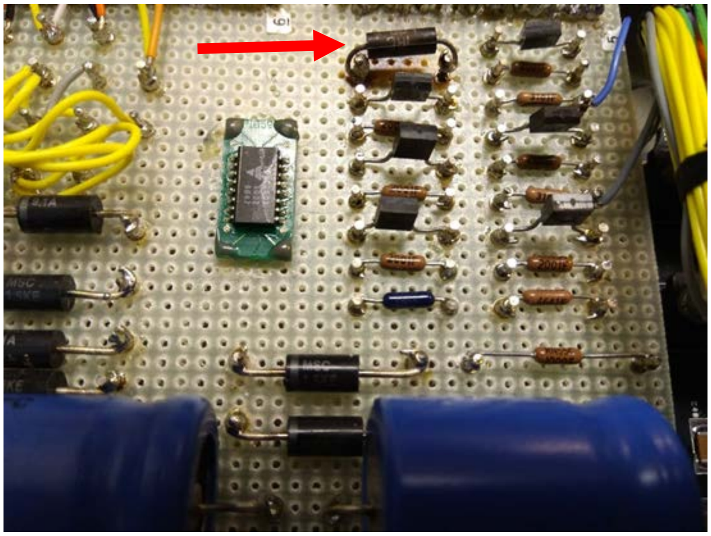

Figure 5 – PMAAT board. Note the "breadboard" technology. The resistor with the arrow shows signs of damage due to excess current.

In addition, additional daytime testing is desirable to confirm that the higher stepper motor rates are reliably providing the required steps.

Although there has been extensive testing as the project has proceeded, a changeover to the new system should be done during engineering time, with enough time to revert to the existing system if unexpected problems develop. In principle, the hardware should be ready at the beginning of September, which would allow for installation during engineering time in late September.

There are other possible uses for the September engineering time (see below), so we may have to consider which projects have highest priority, and postpone one or more of the others.

2.3. WFS Guider

This project has been on the Board's wish list for over a decade. It is finally making good progress. The final concept involves replacing the current guide optics and camera with new optics that include a 2x2 Shack-Hartmann sensor, and a new camera with better performance. Also, an additional motor to maintain focus across the curved focal plane is needed.

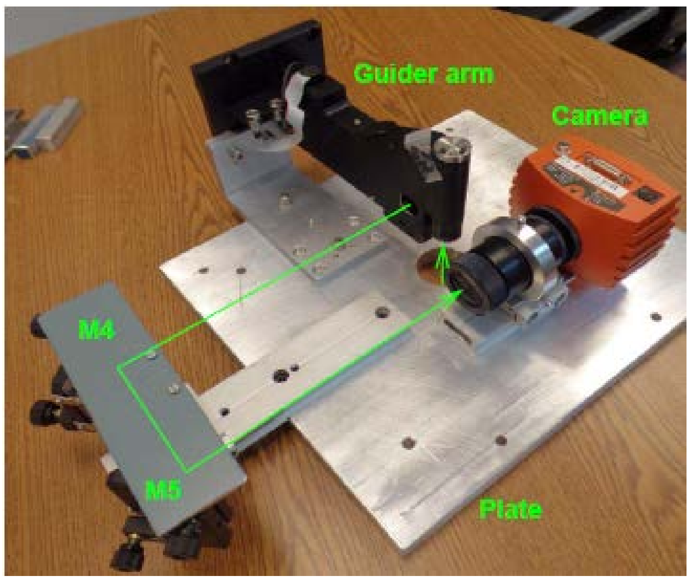

Figure 6 – Prototype layout for telescope testing. The focus mechanism is contained within the guider arm; it is needed to compensate for field curvature and instrument offsets. The Shack-Hartmann beam-splitter pyramid is near the guider arm.

By guiding on the combined 2x2 spot pattern, sensitivity is sufficient to cover >90% of the sky even under bright moon. Exposure times under these conditions are 50 ms; with brighter stars and/or darker sky exposure times only need to be 10 ms.

Averaging the spot pattern allows correction for focus and astigmatism, which are the dominant sources of loss of image quality on the telescope. Presently, focus must be done manually. Astigmatism is corrected using look-up tables; despite the active optics system there is residual hysteresis and other sources of error, which the new guider will correct.

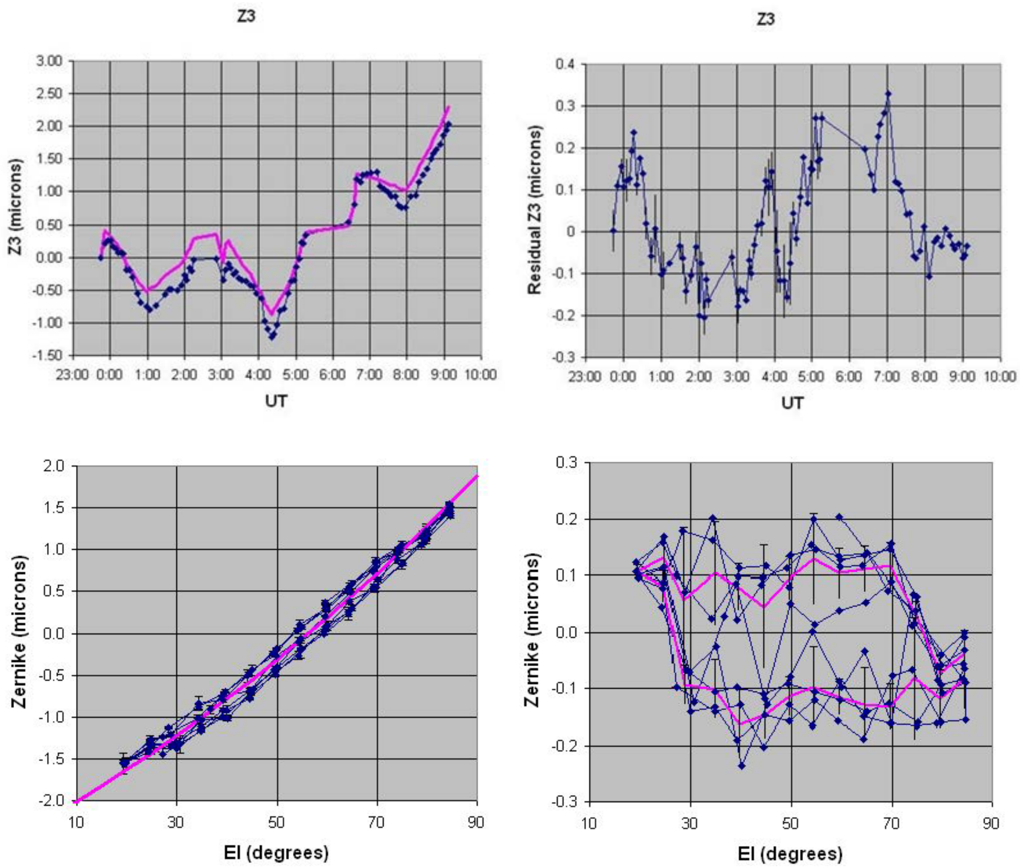

Figure 7 – Data from 2008 tests showing telescope performance during the night with periodic (manual) focus updates. The top left figure shows the nominal focus setting, while the top right shows the residual after correction. The bottom left figure shows the measured 0-degree astigmatism as the telescope is cycled from 10 to 85 degrees elevation and back, and the bottom right shows the deviation from the curve fitted through the data – note the hysteresis.

Tests using a prototype (final optics, but no guide probe XY motion; see Figure 6) have verified performance.

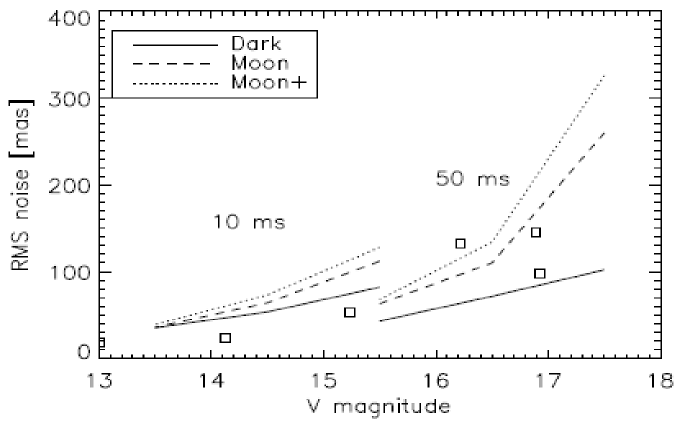

Figure 8 – Performance during engineering time. Expected performance with the Andor camera should be somewhat better (somewhat less than ½ magnitude).

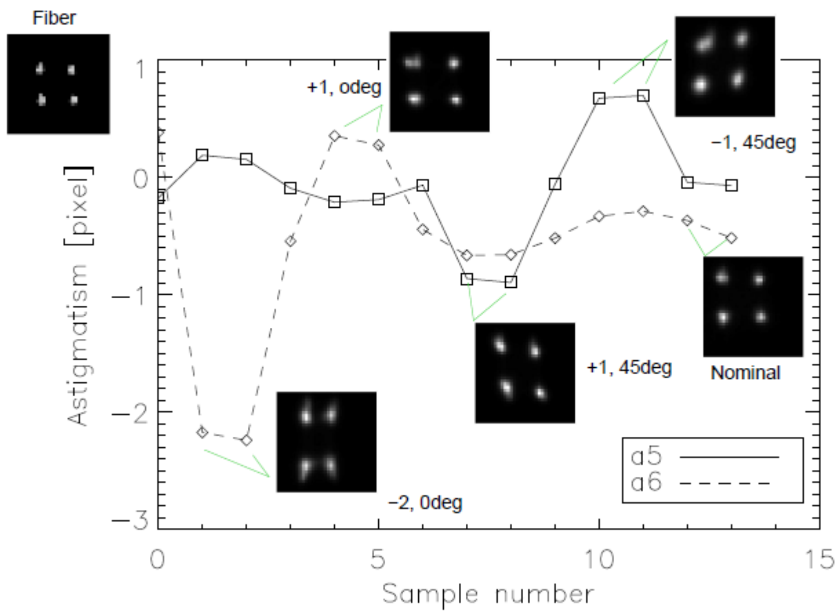

Figure 9 – Astigmatism correction. The measured correction and the spot images before and after correction are shown.

The mechanical engineering for the probe modifications is pending, and completion will not occur before the aluminizing shut-down. It is possible everything will be ready for installation at the optical Nasmyth in December, but a more plausible installation date is February 2019 (there is limited engineering time in January due to summer vacations).

A further reason to expect some delay is that the camera used in the prototype is no longer available. We have had to select a replacement camera, which will have somewhat better performance, but greater cost. It is compatible with the design but the software and hardware interfaces need modification.

In addition, the detailed design for the IR Nasmyth is slightly different; the time scale for this work is likely a few months additional if the mechanical engineer doesn't have higher-priority assignments.

When these two guider installations are complete, SOAR will have upgraded guiding capabilities for:

- Goodman
- SIFS
- TSpec 4.1
- Spartan

SAM already provides the required corrections. SOI and STELES will not have the improved capabilities. In principle, it could be implemented for SOI, also. STELES does not have an offset guider.

2.4. Calibration WFS

The calibration wavefront sensor (CWFS) is used to tune the optics (primary mirror) at the start of the night, or during the night if the need arises (i.e., image quality degrades). Once the optics are tuned, adjustment are made for different elevations using lookup tables.

The CWFS is therefore a critical sub-system – if it isn't working, the telescope image quality is terrible. The original system relied on Apogee ALTA cameras, one of which failed several years ago. The failed camera was replaced with an SBIG cameras "temporarily", and new Apogee cameras were purchased. The work then stalled for several years. The upgrade project completes the camera replacement. In order to simplify installation, the upgrade is planned as a full replacement, with duplicated optics and mechanical interfaces. This allows lab testing of the end-to-end system, and also permits the upgrade to be done without removing the telescope from service for an extended period of time (but some down time is required).

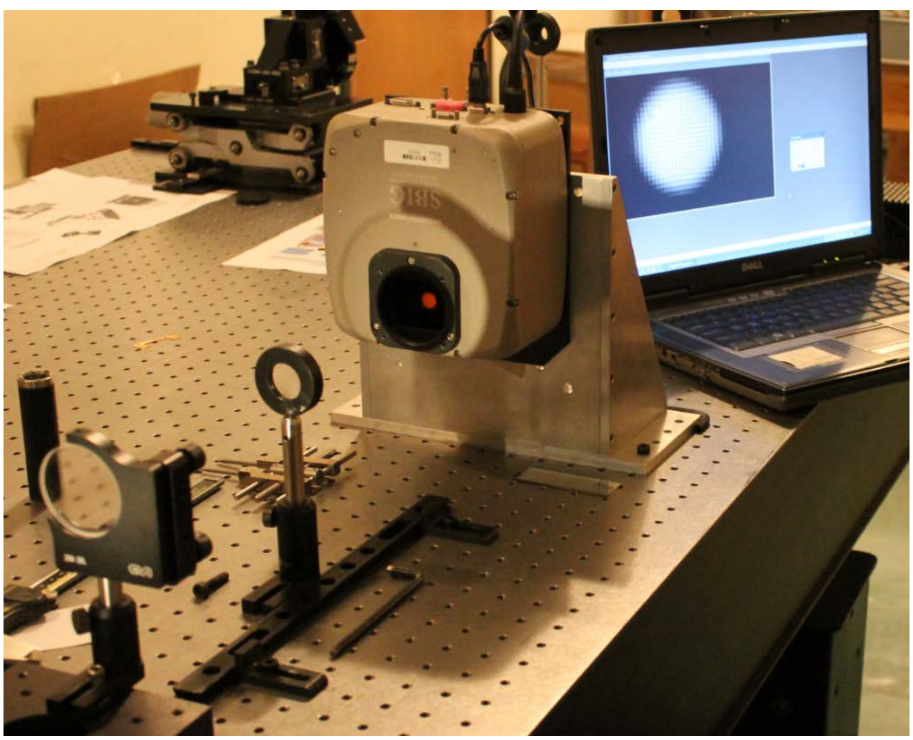

Figure 10 – Lab testing of new microlens array with an SBIG camera.

Our current plan is to complete fabrication of all mechanical parts in August, and to complete lab testing on the same time scale, so as to have everything ready prior to the aluminizing run in late October/November. The CWFS replacement would occur while the telescope is out of service, so in principle no additional down time is required.

If we end up doing only M2/M3 (see 2.1 above), we will still want to do the CWFS upgrade. In this case, some down time might need to be added to the schedule.

The project scientist is Cesar Briceno; key personnel are Roberto Tighe, Nicole David, Marco Bonati, and Jose Piraces.

2.5. SOAR Seismic Upgrades

This is really 3 separate projects:

- Upgraded mounts for the azimuth encoders.
- Triggered emergency stop
- Secondary mirror protection

The upgraded encoder mounts were design and installed in 2016; details are therefore not reported here.

SOAR purchased an appropriate commercial unit for the emergency stop system (there are many on the market). However, it became clear that finding a location and defining thresholds that would provide protection without frequent false alarms was not straightforward; the project is on hold for lack of resources. The lead engineer is Norman Diaz.

Protection of the secondary requires deciding on an approach – one option is to ensure that the secondary support system fails gracefully under high G-forces (“mechanical fuse”); the other is to attempt to damp the amplification of forces at the telescope top end.

Earthquakes with enough intensity to put the secondary at risk are not frequent – the two most recent were in 1997 and 2015. Events preceding those pre-date any of the local observatories.

Accordingly, the most critical project (encoder mounts) is complete; the other two are at low priority, though they may proceed slowly.

2.6. STELES Installation

Given the strong interest in completing STELES, the Board directed the observatory to use internal resources to assist LNA in completing the installation work. As a result, STELES installation should be considered as a project even through its costs are charged to operational support.

STELES was assembled at LNA, but had to rely on an SBIG camera for optical testing, because of the difficulties in shipping the detectors from Chile to Brazil. It was disassembled and shipped to Chile in August 2016, and re-assembled in the SOAR optics lab; the effort over the subsequent period has been devoted to optical alignment and correction of various issues identified while working with Andrei Tokovinin (SOAR instrument scientist for STELES) and other SOAR staff.

These tasks required additional design and fabrication effort, mostly at LNA, where the biggest efforts were:

- Upgrade of STELES computers
- Design and installation of internal calibration source
- Modified detector dewar interfaces

- In addition, it was determined that the blue camera detector was needed to be rotated to have the correct orientation; this work was done by NOAO-S ETS.

Work has proceeded intermittently since most of it has required the presence of LNA staff on the mountain.

At the same time, work on the telescope itself has been needed to support installation, including:

- Installation of pick-off prism inside ISB
- Provision for a counterweight assembly on the far side of the yoke
- Location and installation of attachment points that interface the instrument bench to the yoke
- Development of an installation plan, including any fixtures not provided by LNA
- Design and installation of an interlock system that protect the instrument periscope and the instrument support box from each other (the Nasmyth rotator must not rotate when the STELES periscope is deployed).

The status of the work is as follows:

STELES itself:

- Both channels are aligned reasonably well, although the red channel in particular could be further optimized. There is more trial-and-error to this process than might be desirable
- The slit mechanisms can cause the slit jaws to collide and break; a safer mechanism is preferred, and in the meantime the blue slit is damaged.
- Further alignment of the K-prism (de-rotator) is needed
- The calibration system has a variety of issues that need to be fixed; none are serious
- The red dewar developed a vacuum leak; this has been diagnosed as three weld leaks and these have been repaired. These developed over time and were not present 2 years ago.
- There are various software issues; these can be worked on remotely

Telescope:

- The parts for the prism installation inside the ISB have been fabricated, but the actual installation is pending
- Design on the interlock has been completed and parts have been purchased or are being fabricated
- Preparations for the attachment points are continuing; the parts supplied by LNA have been modified but drilling holes in the yoke is pending.
- The design of the counterweight is essentially done; a final stress analysis is pending (may needed a couple more points of attachment to the yoke)
- The handling fixtures all exist, and a detailed draft installation plan has been written. It has not been reviewed yet.

General:

- Acceptance plan documents exist in outline but approved final versions are needed
- The installation plan needs a full review (especially for safety)
- Pre-installation acceptance should occur
- Installation and readiness for night-time engineering
- On-sky tests; commissioning; science verification

There are two complications to the installation schedule. One is that there are enough pending details that it is difficult to commit to an installation date that might be too optimistic. The other is potential conflicts with other activities for the engineering time. Priorities are discussed in section 3, below.

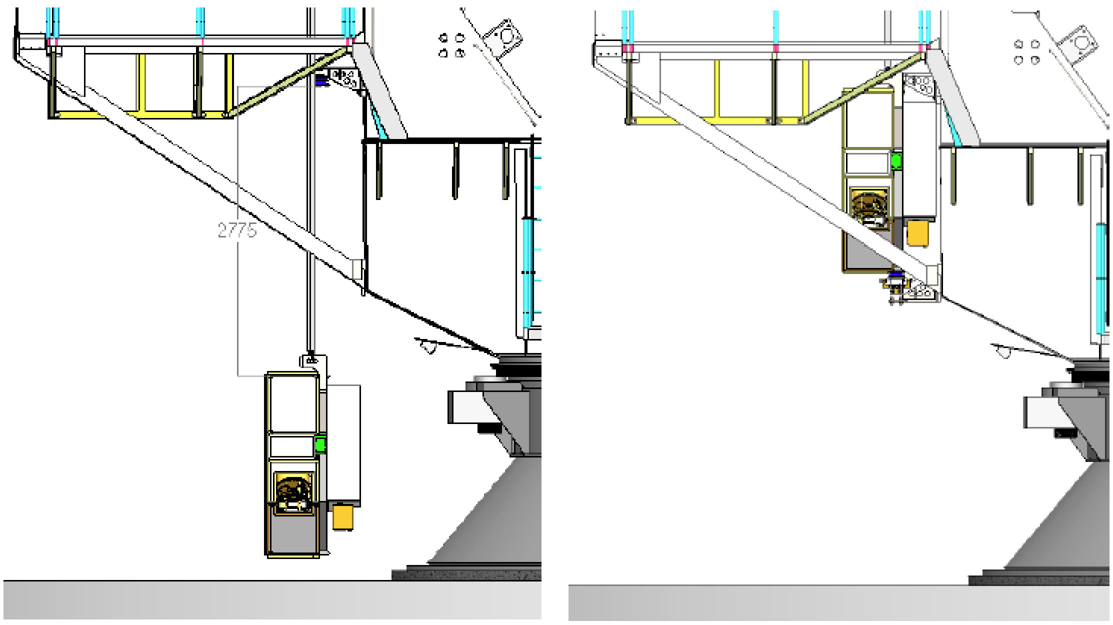

Figure 11 – Snapshot of STELES installation (from draft installation document).

2.7. SOAR Mount Control Upgrade

The SOAR mount upgrade project is intended to eventually replace all the obsolete portions of the SOAR mount control system. Whereas the upper level control system – the telescope control system – was recently upgraded (completed late 2016), the lower level system is "as delivered", based on technology that is in many cases close to 20 years old.

The first phase of the project consists of development and parallel installation of a telemetry system to monitor outputs from the critical components – primarily encoders and tachometers, but also interlocks and any other relevant sensors. The new system will be installed in parallel to the existing hardware, so we can build up telemetry information while the telescope continues routine operation. The total capacity required is ~96 channels of all types.

Once we have a better understanding of the telescope performance, we can then implement a control system that will use the new sensor data. At present, the scope of the project does not include replacement of encoders, tachometers, or similar items, but it is possible that some replacements will prove to be desirable.

The first phase is currently expected to complete this calendar year, with design and implementation of the control system to occur in 2019. In this regard, the basic control system architecture is defined already (it follows the Blanco and Mayall designs to the extent possible with an alt-az telescope); what remains is detailed implementation.

The current status of the project is that the sensor monitoring hardware has been designed and reviewed, and is now being fabricated. Because the installation is in parallel, it can be done as components are available, and does not require taking the telescope out of service. Once completed, we will want to dedicate some time to systematic measurements of telescope performance in addition to monitoring performance during normal operation.

The architecture is shown schematically below.

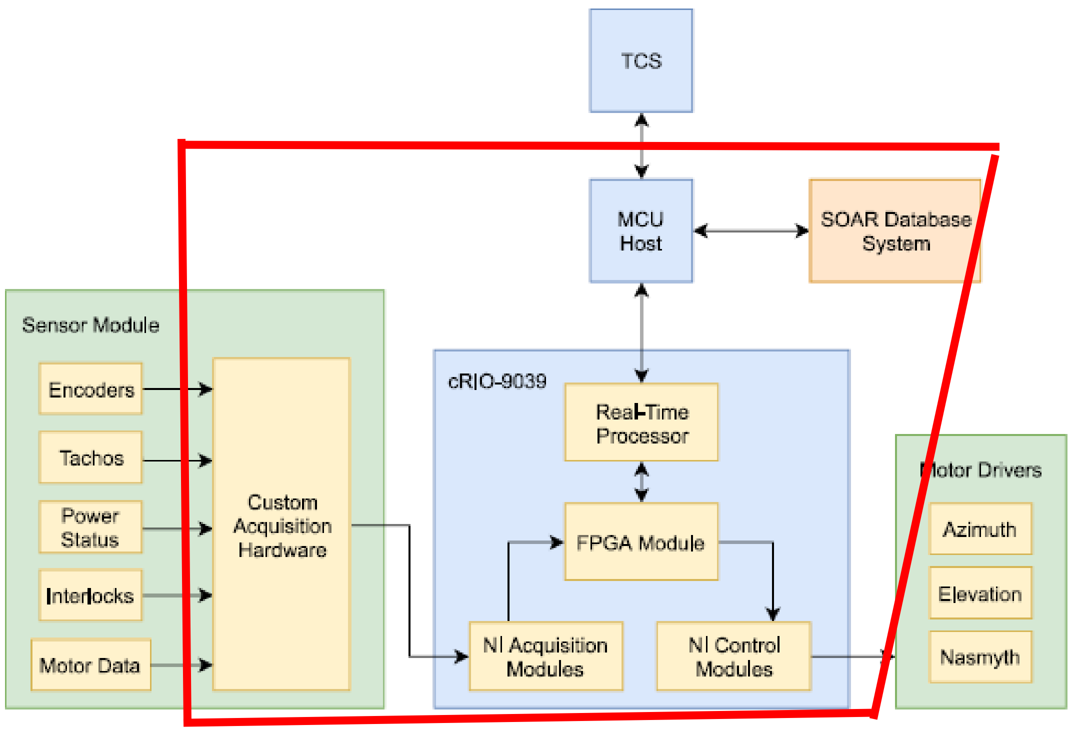

Figure 12 – MCU architecture. The scope of the upgraded system are the elements inside the red polygon.

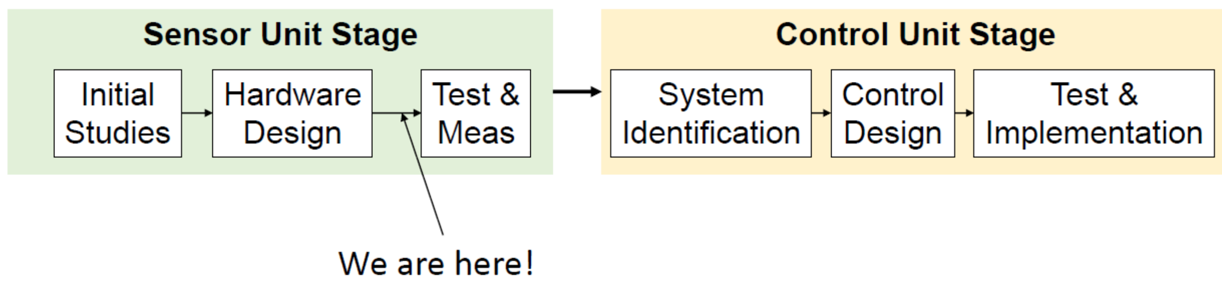

Figure 13 – Status of MCU upgrade project.

2.8. SAM Upgrades

There are three SAM projects listed in the introduction. They are discussed together as they are all related.

2.8.1. SAM Reliability Upgrades

This project is intended to replace obsolescent components of SAM. Originally, the scope potentially included the SAM computers, filter wheels, and critical AO components (deformable mirror and wavefront sensor). However, the AO components are now part of the SAM-plus project (below), as is the real-time computer for the AO system, so the upgrades are now reduced to the instrument computer and the detector computer, plus the filter wheel.

Both computers have been purchased, and the new instrument computer has been installed.

The schedule for the detector computer should be reviewed, but it is likely to be after the period of intensive SAM use in December/January, and then after summer vacations.

The SAM filter wheel (as well as the SOI filter wheels) rely on obsolete components, for which we have no spares; since the design is decades old, greater reliability would be obtained with more modern components. However, a design effort is required that will fit everything within the limited thickness of the filter wheel modules; no mechanical engineering resources have been available for this work.

If the SAM filter wheel is upgraded, fabrication of additional wheels for SOI is a modest addition, which we would likely do, unless we make a definite decision to decommission SOI in the very near future.

The time scale for freeing up a mechanical engineer is most likely once the design of the components for the WFS Guider on the IR Nasmyth is complete, probably mid-CY-2019. A decision on whether or not to fabricate wheels for SOI would be needed soon thereafter, although in principle SOI fabrication could be deferred.

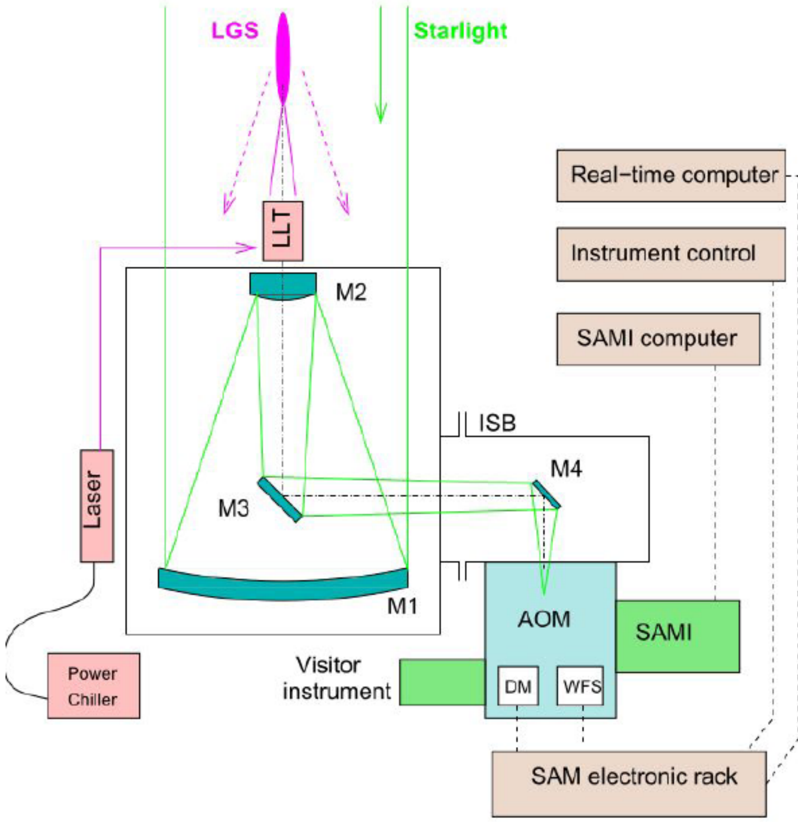

Figure 14 – SAM block diagram.

2.8.2. SAM Plus

The SAM-plus project is primarily a Brazilian project, supported by FAPESP (Sao Paulo Research Foundation) and based at IAG/USP and the Brazilian GMT Office. The project is intended to allow the Brazilian community to gain experience in AO development that could transfer to work on ELT projects; at the same time the project will provide greater reliability and modest increases to performance for SAM, which sees significant Brazilian use.

The work consists of replacing the deformable mirror and the wavefront sensor (camera and lenslet array) with more modern components. The deformable mirror would go from 60 actuators to either 241 or 441 (to be evaluated), though not all of the actuators in the new mirror would lie within the pupil. The wavefront sensing would go from 10x10 to either 17x17 or 20x20.

Expected gains in performance are shown below.

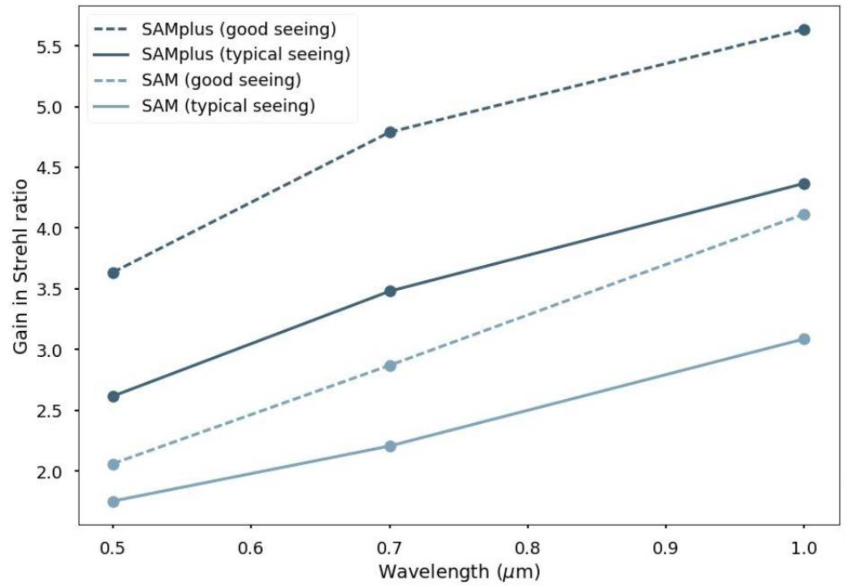

Figure 15 – Projected improvement in SAM Strehl ratio. The improvement in FWHM at 0.5 µm relative to SAM, is about 20% under all conditions.

There are multiple Brazilian institutions participating, with about half a dozen engineers and scientists. The project manager at IAG is Dr. Daniel Faes. SOAR is providing some technical support, mostly from Andrei Tokovinin but additionally from engineers familiar with SAM. At present the resource commitment is small, so that SAM-plus has not been assigned a project number.

The project was initiated, with approval from the SOAR Board, in November 2017. The next milestone is a conceptual design review, to be held the first week of October (TBC), in La Serena. The presentations should include the selection of key components, and the desired review outcome will be a recommendation to proceed with purchase of these components. The review will also cover mechanical layout, real-time computer specifications, and calibration sub-systems.

Delivery of components to IAG should take place in early 2019, and closure of the AO loop should occur late in the year. The project team would then hold a pre-ship readiness review in mid-2020, at IAG/USP, and complete commissioning by year-end.

2.8.3. SAMOS

SAMOS is another largely external project. It is conceived as a "restricted use instrument", which would replace the direct imaging mode of SAM with the low-to-moderate resolution configurable multi-object spectrograph.

Since it would do only MOS spectroscopy, it is assumed it would be scheduled for blocks of time and not continuously.

The instrument is primarily being developed at JHU Spaced Sciences (Robert Barkhouser and Stephen Smee) with some support from STScI. The sponsoring partner (and source of science support) is MSU.

SPIE papers describing the instrument concept and its current status are at:

- Proceedings of the SPIE, Volume 9908, id. 99088V (2016).

- Proceedings of the SPIE, Volume 10702, id. 107021O (2018).

Delivery to SOAR is on a similar time-scale to SAM-plus.

2.9. ARCOIRIS to SOAR

This project will modify ARCOIRIS, the fourth copy of the TripleSpec IR spectrograph concept, which is installed on the Blanco telescope, so that it can be used on SOAR. The instrument will then be transferred to SOAR and commissioned on the IR Nasmyth ISB.

The modifications will be performed by Cornell University (Terry Herter) under contract with SOAR.

The optical design was modified to provide enough back-focal distance to make use of the WFS guider. With some modifications to the dewar top cover and to the ISB support struts, the instrument will fit on the side port where OSIRIS is currently sleeping. This location has multiple advantages relative to the through port:

- Because it is fed by a dichroic, the guider (current or new) can guide on-axis if desired, and generally has a larger patrol field. This is particularly useful in bright time.
- The dichroic can be used to adjust the pupil alignment of the instrument, which simplifies the interface design
- The through port is left free for future instruments

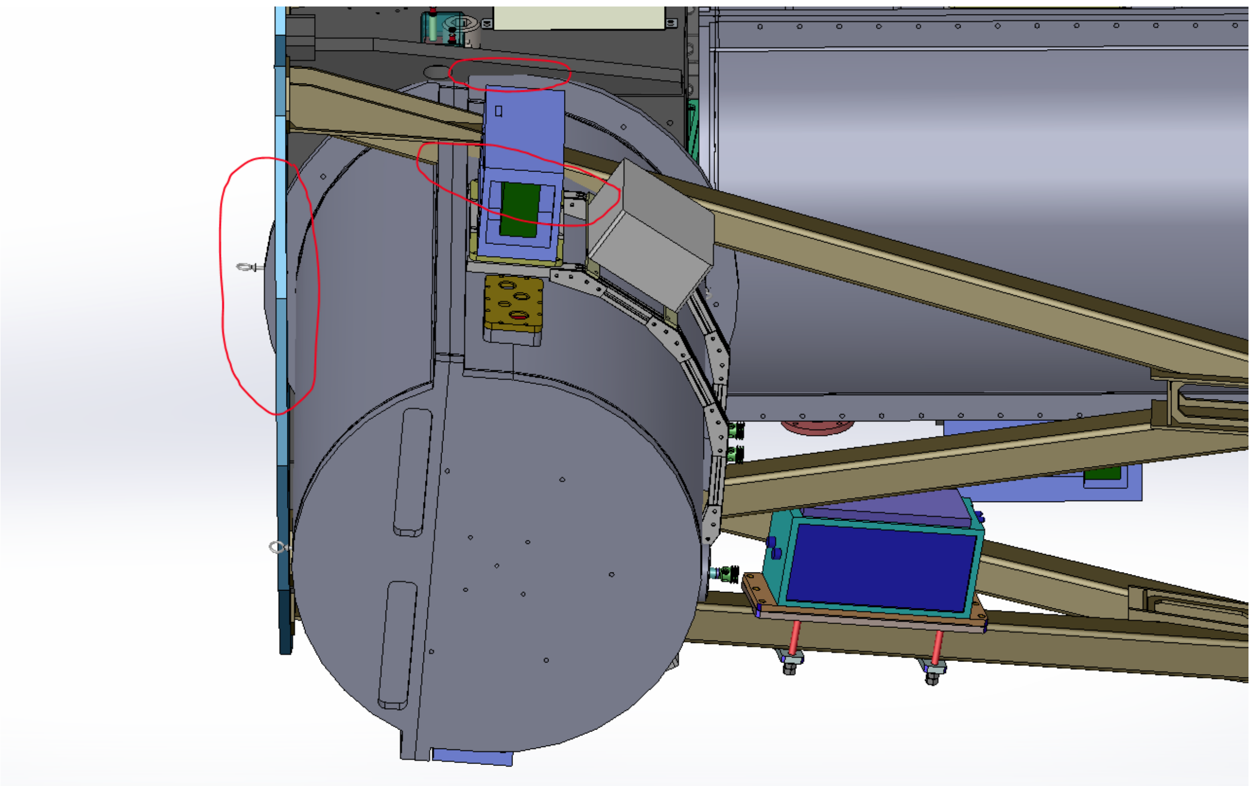

Figure 16 – TSPec 4.1 mounted on IR side port, showing interferences with dewar cover flange and with ISB trusswork (both circled in red). The dewar cover can be safely modified; the trusses will be modified (we had to do this for SAM also).

The modification work was originally supposed to be done during August, with installation on the telescope to occur at the end of the month, and time on sky the last week of August. This has clearly slipped, and the question now is whether the work on-site can occur in September in time for an engineering run at the end of the month. The schedule is complicated by the Chilean Independence Day holidays, which this year are likely to be the entire week of September 17. I am awaiting word from Cornell on their probable schedule.

If it is not feasible to get on sky in late September, the schedule then depends on whether or not M1 aluminization occurs (discussed above). Assuming that it does proceed, we could install the instrument in October but would not get on sky until December. The on-sky testing might not require Cornell staff to be on-site.

2.10. SOAR Automation

This project is somewhat of an umbrella, but the overall objectives can be summarized as follows:

- Goodman scripting (macro) project. The primary objective of this work, being done under contract at UNC, is to provide a scripting capability that can be used by conventional observers in order to gain efficiency at the telescope, and that can also be driven in queue mode without the need for extensive intervention by the telescope operator or local observer.
  The work at UNC is due to complete soon, one way or the other; any remaining effort will have to continue in Chile.
  Testing has been underway during engineering runs, including the one at the end of this month (July)
- A collaboration with Las Cumbres Observatory (must be abbreviated as LCOGT to avoid the ire of Las Campanas Observatory), which will provide the infrastructure to integrate SOAR as a node within the LCOGT network. This <u>does not require</u> SOAR to operate as such a node at all times. The project has 3 main milestones:
  - Description and documentation of relevant interfaces; due end of Q3 CY 2018
  - Phase A observing test, where the telescope is operated for one night using a schedule of scripted observations transmitted from LCOGT. It is possible that some operations will still require manual intervention (in particular, target acquisition). Nominal completion date is Q1 CY 2019
  - Ready for regular networked observing. Completion date Q3 CY 2019. The SOAR can be switched into automated scheduling mode for any allocated time, scripted observations executed and data products automatically delivered to the archive. Automated target slit acquisition and guide star acquisition are desirable but not a requirement.

  The initial operation will only be with a subset of Goodman configurations (probably red camera and one or two settings with the 400 l/mm grating and limited *griz* imaging).
  Resources for this work are distributed between Las Cumbres, NOAO-N and NOAO-S. Timely completion does rely on a new software hire in Chile; this is pending.
- Development of data reduction pipelines for SOAR instruments. We have focused on Goodman as this is what it most heavily used. Simon Torres, our data analyst, has been largely dedicated to this task. However, Bruno Quint has updated the SAM data pipeline, and the instruments we are expecting (TSpec 4.1 and STELES) should have pipelines as well.

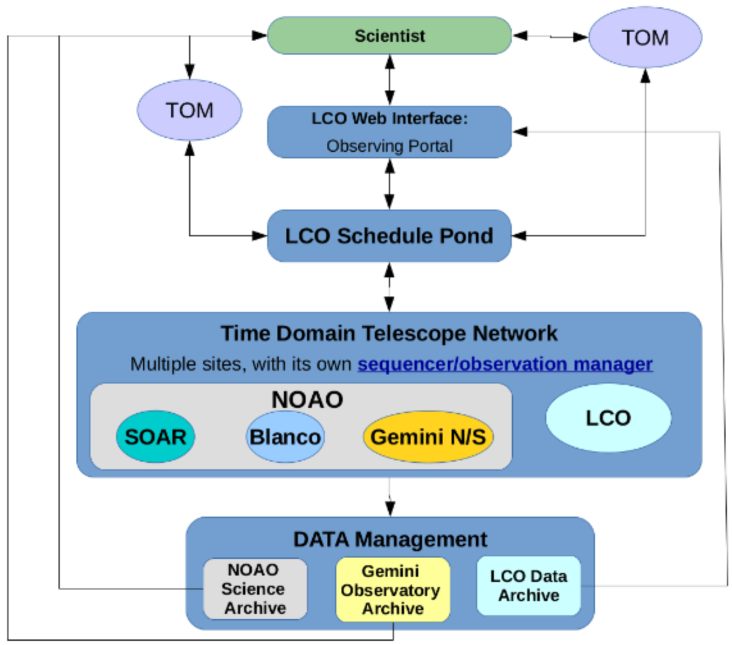

Figure 17 – System architecture for SOAR within LCOGT network.

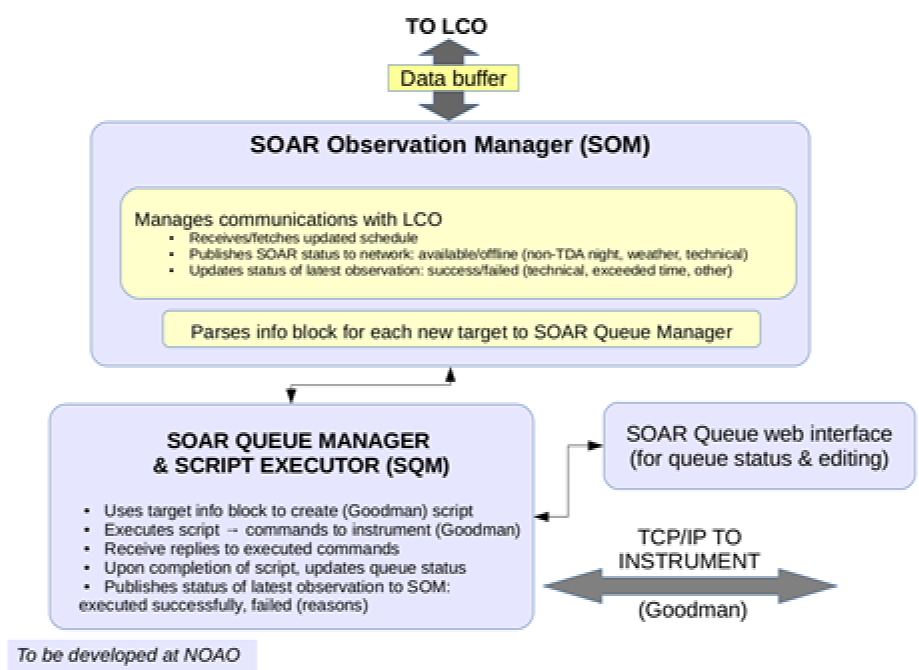

Figure 18 – Details of on-site system architecture

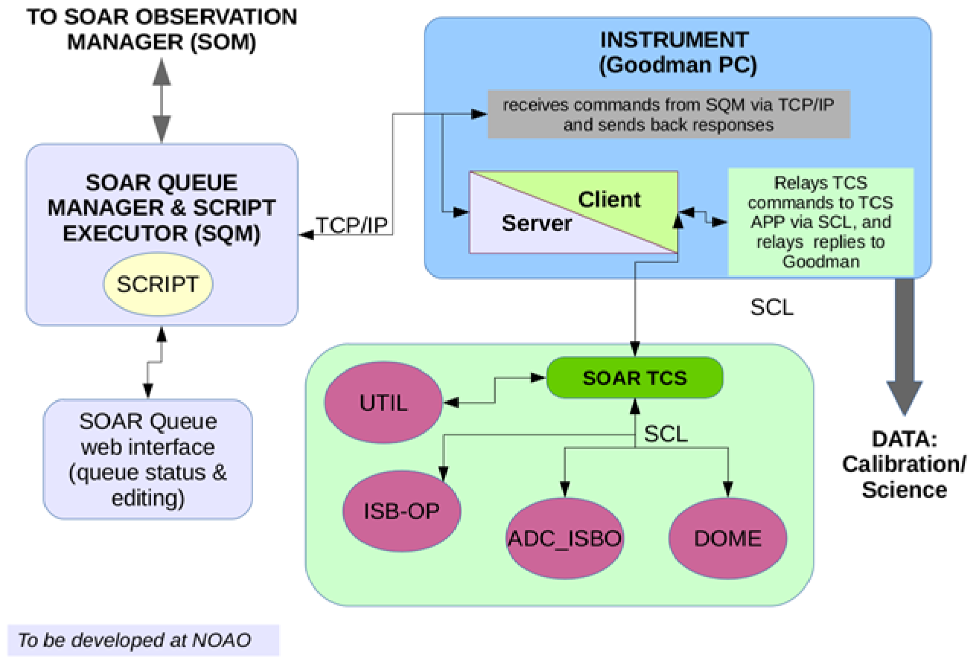

Figure 19 – Interactions between observation manager, telescope and instruments. The portion in the blue box (upper right) is largely covered by the UNC contract.

3. Schedules and Priorities

There are several projects listed above that are expected to complete before the end of the year, and phasing their installation and test on the telescope given the limitations in engineering time is a challenge. Overall, priorities and likely schedule are as follows:

- Aluminization, if it occurs, must happen during the scheduled shutdown beginning in late October. If we only do M2 and M3 we will shorten the shutdown period, and would be able to create another opening for instrumentation work.
- CWFS installation should occur in parallel with aluminization. A detailed installation plan is needed, especially for the case where only M2 and M3 are coated, in which case the work may not be entirely in parallel.
- The M1 aO speed-up is likely to be ready before the engineering time at the end of September, and could happen then unless TSpec 4.1 is also ready, in which case the latter would have priority. It is important to install and test this during engineering time since this allows time to revert to the current system.
- Both STELES and TSpec can be installed on the telescope when ready, but they can fully tested only during engineering time. There is enough engineering time in December to do limited testing on both, or extensive testing on one. Given that both instruments have a fixed configuration, we should be prepared to test both if they are ready. This would require that installation be completed and verified well before the engineering block, not at the last minute. Science verification would start in February.
- The upgraded SAM computer can be installed when ready.

- The MCU monitoring system can be installed as ready, since it operates in parallel and does not affect telescope operation with the existing system.
- It is expected that the optical WFS Guider will not be ready for installation in December; it is plausibly expected for February. Because it removes the optical Nasmyth from service during installation, an efficient installation plan is required.
- Data pipeline releases occur as they complete, similarly scripting capabilities can be released when ready.

For the remainder of the 2019 fiscal year, schedule and priorities are as follows:

- By the end of Q1 CY 2019 we should have installed:
  - STELES
  - TSpec
  - WFS Guider (optical side)
- First test of integration with LCOGT on the same time scale
- Work will continue on the MCU upgrade; the work on phase 2 will extend past the end of FY 2019
- Design and fabrication of the parts for the WFS Guider (IR side) will proceed, with expected completion by the end of the fiscal year.
- We may start work on the SAM filter wheel replacement

It is possible that some work will occur on the seismic upgrades, but they have lower priority.

We will be working with both the SAM-plus and SAMOS projects, but neither will arrive in FY 2019.

4. New Projects

As can be seen from the discussions above, available labor resources are generally committed for all of fiscal year 2019. (Budget, also). It may however be worth initiating planning for projects for FY 2020 and beyond. The SAC should be engaged for this process (and potential new SOAR partners as well).

It is worth identifying some possibilities now:

- *IGRINS*. This is a fixed-format high-resolution NIR (HK) spectrograph developed jointly by U Texas and KASI (S. Korea). It was successfully deployed as a visitor instrument at Gemini-S in 2018A, and is therefore generally compatible with SOAR. It would be operated at SOAR in a similar visitor mode. Some resources would be required to support it.
  The Gemini visitor-instrument pages for IGRINS are here:
  https://sites.google.com/site/igrinsatgemini/about
- *SOI Upgrade*. SOI is getting old, and we should make a decision either to retire it, or upgrade it.
  - The argument for retiring the instrument is that Goodman provides a roughly equivalent imaging capability. SOI can hold more filters, has somewhat faster read-out, but the Goodman red detector is a better detector.
  - The argument for keeping the instrument is that the detector could be upgraded, and that the instrument could be configured to support a standard filter set for time-domain observing, thus removing pressure from Goodman to make last-minute configuration adjustments. A stable configuration would also support performance monitoring. We might, however, then feel the need to also adapt the WFS guider concept to SOI.

- *Fixed-Format Spectrograph*. This concept has been discussed over the years, but the basic idea is a fixed format spectrograph that covers more or less from the atmospheric cut-off to the silicon cut-off, either cross-dispersed or with 2 arms. Slit-viewing would probably be included. The resolution would be moderate – around 1000-1300, with lower resolutions achieved by binning if desired.
  It would be installed on the IR Nasmyth through port.
  It would replace all (or nearly all) long-slit uses of Goodman with the lowest-resolution grating, and would generally act as the "go-to" instrument for time-domain observing. This would substantially reduce configuration conflicts with other Goodman uses. Based on current use, Goodman would likely still be the most popular instrument, but no longer more than 50% of the observing time.
  Within the current SOAR consortium, we have the expertise to build such an instrument, but not the funds to do so.
- *Other.* Various other instruments have been mentioned from time to time, but none are funded. The most serious are:
  - SORCERESS (exoplanet spectrograph)
  - SOAR Robo-AO (NGS AO for SOAR, similar to Palomar and KP installations)

  If either of these, or something else, was funded it would move into the same category as SAMOS.