Report of the SOAR External Review Committee

Submitted May 21, 2010

Committee Members

Charles Bailyn, Yale University

Chris Benn, Isaac Newton Group, La Palma

Horacio Dottori, Universidade Federal do Rio Grande do Sul

Deidre Hunter, Lowell Observatory

Mark M. Phillips (Chair), Carnegie Observatories

Table of Contents

I. Executive Summary

The first SOAR external review was convened in La Serena, Chile on April 26-27, 2010, in fulfillment of the requirement in the consortium agreement that the project be reviewed at least once every five years. The committee was charged with reviewing the status and development of the telescope and instrumentation, the effectiveness of operations, scientific productivity, and any additional topics thought to be appropriate. This report contains the findings and recommendations resulting from this review.

The SOAR telescope was designed to produce the best possible delivered image quality over a moderate sized field. Although the primary mirror support problems that delayed the commissioning of the telescope have been solved, a few key telescope and enclosure issues must be addressed in order to fully achieve this goal. The most critical of these are the real-time correction of residual low-order aberrations, the installation of the new tip-tilt servo controller, and implementation of a functional windscreen. In addition, fixing the tracking jitter and eliminating any contributions to the seeing from the dome and mirror could together yield additional improvement.

An impressive set of 1st generation instruments is in the process of being commissioned on SOAR, and three 2nd generation instruments are currently under fabrication. Nevertheless, the commissioning process has not always gone smoothly, particularly in the case of the Goodman spectrograph where delays have given rise to frustration and misunderstandings among users. It is critical that commissioning of all modes of the Goodman, which is expected to be one of SOAR's workhorse instruments, be completed by the end of Q4 2010, and that issues of the mechanical stability, documentation, and low UV throughput be rectified. To avoid such problems, the instrument acceptance plan provided by the SOAR Science Advisory Committee must be adhered to for all current and future instrumentation.

Although the instruments currently at SOAR or under construction will provide observers with an excellent range of capabilities, the current level of operations funding is unlikely to be sufficient to provide adequate support. A decision will need to be taken soon whether to restrict the number of instruments offered, or increase the level of operations funding. In this vein, it is important that all instruments be permanently mounted at dedicated ports, and that observing modes requiring major modifications to instruments be avoided.

The SOAR Adaptive optics Module (SAM) will provide a ground layer adaptive optics capability unique among southern hemisphere telescopes. Timely commissioning of this capability will require careful definition of schedule, strategy, and goals. SAM is intended to be user friendly and require modest technical support. Nevertheless, the consortium must be prepared for the possibility that additional support resources will be required to ensure that SAM achieves its scientific potential.

Future instruments at SOAR (e.g., a multi-object infrared spectrograph) are likely to be more expensive than can be provided by a single partner. Collaborations between the SOAR consortium members represents a sensible alternative to producing such instruments.

Although the SOAR partners have successfully implemented a variety of observing modes, queue scheduling is not supported at the consortium level due to budget constraints. Even so, the scientific potential of SAM would be considerably enhanced through flexible scheduling. It is strongly recommended that the SOAR Board explore ways of implementing at least a modest queue/service observing capability once SAM has been commissioned and accepted as a facility instrument.

SOAR is in an excellent position to carry out rapid follow up of variable objects discovered by the Dark Energy Survey and, eventually, by the Large Synoptic Survey Telescope. In preparation for this opportunity, the Board should consider ways to extend the current Target of Opportunity policy to better facilitate time domain observations.

SOAR scientific productivity as measured by refereed publications is presently low, and is a source of concern. Most likely the low publication rate is the result of the difficulties encountered in completing the telescope and initial instrument suite. The fact that SOAR is now capable of significant scientific output needs to be widely publicized to users. This can be done through increased presence at American and Brazilian Astronomical Society meetings, expanded information on the SOAR website, and the organization of a first SOAR Science Symposium. In addition, it is important to protect the science time of the scientific staff, especially postdocs and junior staff.

SOAR is fortunate to be able to call on the collective expertise of the NOAO staff. Nevertheless, it is important to maintain a core technical group who are at least 80% dedicated to SOAR operations. This team should include the Manager/Mechanical Engineer, an Electronics Engineer, at least one Mechanical Technician and one Electronics Technician, and a programmer. A senior scientist experienced in telescope and instrument operations is also critically needed. A high priority is to maintain the new postdoctoral position beyond the initial 3-year appointment.

Generally speaking, the SOAR management structure seems to work well. However, the Science Advisory Committee could play a more active role in surveying the user community as well as overseeing instrument commissioning and acceptance. An effective mechanism for users to provide feedback to SOAR management also needs to be developed.

Finally, unless the number of facility instruments is restricted, the SOAR budget will need to be increased to provide additional support resources for SAM and the complement of 1st and 2nd generation instruments once these are all commissioned. The recommended addition of a programmer and senior scientist to the core support team is likely to require an additional increase in the operations budget.

II. Introduction

The Southern Astrophysical Research (SOAR) Telescope is a 4.1 m telescope designed to work from the atmospheric cut-off in the blue to the near-infrared, to have excellent image quality (0.22 arcsec), and to have up to nine instruments mounted ready for use. It was funded by a partnership between the National Optical Astronomy Observatories (NOAO), the University of North Carolina at Chapel Hill (UNC), Michigan State University (MSU), and the Ministério da Ciência e Tecnologia of the Brazilian Federative Republic (Brazil). The original concept for the project was that NOAO would mostly provide operations funding, while the other three partners would primarily provide up-front construction funding. It was anticipated that there would be a construction phase, a fairly brief commissioning phase, and then an operations phase, which the partners felt strongly should have duration of no less than 20 years.

The SOAR consortium was formally established in 1999, and the telescope was dedicated in a first-light celebration in April 2004. However, early into the commissioning process, serious problems were discovered in the primary mirror lateral support system that prevented the telescope from being used scientifically until new lateral support links were installed and commissioned in mid-2006. Hence, science operations did not begin in earnest until the 2006B semester. The fraction of time used for science has gradually ramped up from 42% in 2006B to 80% in 2010A, and is expected to continue at this level. The remaining 20% of the time, mostly around bright of moon, is being used for instrument commissioning, as well as regular monitoring of telescope and instrument performance.

Four instruments are now in routine science use: the Soar Optical Imager (SOI), the Ohio State Infrared Imaging Spectrometer (OSIRIS), the Goodman Spectrograph, and the Spartan Infrared Camera. The SOAR Integral Field Spectrograph (SIFS) is currently in the process of being commissioned, and the Brazilian Tunable Filter Imager (BTFI) is expected to arrive at the telescope in mid-2010. Two additional instruments are presently under construction: the SOAR Adaptive optics Module (SAM) and laser guide star system and the SOAR Telescope Echelle Spectrograph (STELES).

The SOAR consortium agreement calls for the project to be reviewed at least once every five years by an ad hoc external review committee known as the "SOAR Review Committee". Issues for consideration in the review are to include the status and development of the telescope and instrumentation, the effectiveness of operations, scientific productivity, and any additional topics thought to be appropriate by the Committee.

This report contains the results of the first SOAR external review, which was carried out in La Serena, Chile on April 26-27, 2010. On the morning of April 26, the Committee was given presentations by the SOAR Director on the history and organization of the SOAR consortium, current status of the telescope and instruments, and details on operations, maintenance, and observing modes. That afternoon, the Committee traveled to Cerro Pachon to talk to members of the mountain day crew, and to observe the functioning of the telescope during the first hours of the night. In La Serena the next morning, presentations on partner aspirations, future planning, and scientific productivity were given by the Chair of the SOAR Board, Jay Elias. A one-hour telecon was also held with the SOAR Scientific Advisory Committee (SAC). During and after lunch, the Committee met with CTIO staff members Sean Points, who spends a significant fraction of his effort in support of SOAR, Tim Abbott, Head of CTIO Engineering and Technical Services, and Nicole van der Bliek, Project Manager for the SOAR Adaptive optics Module (SAM). Finally, the Committee was given a tour of SAM in the CTIO laboratories by the Project Scientist, Andrei Tokovinin.

In what follows, we present the detailed findings of this review, along with a number of recommendations. The latter have been divided into two levels:

- ***Critical recommendations*** are those that the Committee considers to be *crucial* to the full scientific exploitation
- ***High Priority recommendations*** are those that will significantly improve the operational efficiency and/or scientific productivity of the observatory

It should be said that the Committee came away from this review extremely impressed by the remarkable job that has been done with limited resources in addressing the serious problems and issues discovered during the telescope commissioning process. The SOAR staff is exceptionally dedicated, capable, enthusiastic, and hard working. Moreover, the consortium members clearly work well together towards common scientific goals, drawing on the strengths of each. SOAR is now delivering an image quality that is as good as any telescope operated by NOAO, and the level of technical downtime achieved is commendably low. Moreover, the consortium has delivered an impressive array of 1st generation instruments, and a 2nd generation is well on the way. These are all notable achievements. Nevertheless, there are still areas where improvements are needed to maximize the scientific productivity of the facility. It is the spirit of this report to call attention to these areas in a positive way, and to help focus attention on the efforts required to address them.

III. Telescope and Enclosure

1. Current Status

The observational niche that the SOAR telescope was built to fill is that of very high image quality. Remaining telescope and enclosure issues center around achieving the original design specs for delivered image quality (DIQ).

The original intention was that the SOAR Active Optics System (AOS) would run open loop in shaping the primary mirror, mainly using look-up tables with tweaks to the "zero-point" determined from the wavefront sensor (WFS) at most a few times during the night. Unfortunately, this did not work and the primary mirror did not retain required shape for long. Part of the problem was traced to the six-point passive lateral support system for the primary. Replacing the lateral supports with active force actuators operated in a three-point kinematic mode largely solved the problem. However, frequent reconfiguration during the night with the WFS is still necessary to attain good image quality, requiring that science observations stop for ~10 minutes every 1-2 hours and after large slews in order to re-determine the lower order aberrations of focus and astigmatism. Thus, good image quality can be achieved with the present system, but at the cost of valuable on-sky science time.

The SOAR staff understands what needs to be done to eliminate the need for frequent reconfiguration: use of on-the-fly wavefront sensing to run closed loop. Currently the staff is experimenting with a method (the "donut method" devised by Andre Tokovinin) that uses a slightly out of focus image. To date it works well on correcting the astigmatism but not focus. However, further work is needed to either make this method function or determine that it will not work for both lower-order aberrations. The solution, if the "donut method" does not work, is probably to convert the guiders to include a second probe for wavefront sensing, but that will be costly and mechanically challenging so it is worth first exploring alternatives.

The tip-tilt control of M3 has also not performed well. However, the staff expects that replacing this system with a digital controller will improve the performance as well as allow for easier tuning. The new system is expected to go to the telescope for first tests as this report is being written.

Another source of degradation in image quality comes from tracking jitter due to minor misalignments between the tape encoders and the read heads. The staff plans to replace the electronics that processes the encoder signals and use an algorithm that averages data from the read heads in combination with knowledge of the tape periodicity and track rate. This is based on hardware for the Blanco telescope that is being tested on that telescope now, and work on the SOAR system will begin once the Tip-Tilt servo upgrade has finished.

Observers have expressed concern over the lack of a windscreen to help reduce telescope motions due to buffeting by the wind. The original windscreen is not functional due to the windscreen track being welded rather than screwed into place and damage to the rail-guide and take-up spring mechanisms. The solution is to replace the rails and repair the damaged components. In addition, a drive mechanism needs to be installed so that the windscreen is not wedded to the shutter motion, as originally designed. The contract has been let for manufacturing and repair of the necessary parts.

The potential final source of image degradation comes from dome and mirror seeing effects. SOAR has air handlers for daytime cooling of the dome, exhaust fans for nighttime ventilation, a laminar flow system for the primary mirror (but the necessary compressor has not been purchased), and a suction fan for removing heat from the M3 turret. The SOAR staff recognizes the need to work on systematically identifying the effects of dome and mirror seeing and determining optimal methods of eliminating them.

2. Future Improvements

In the immediate future the SOAR staff needs to carry out and finish the projects that they have already identified for improving telescope stability and DIQ. So, no new exploratory work is currently needed, but they do need allocation of the time and resources to progress. When all of these activities are accomplished, an assessment of the DIQ compared to expectations will show whether the goal has been reached or further work is needed.

3. Recommendations

To fulfill its niche among the suite of 4-meter and larger telescopes, it is essential that SOAR achieve its design goal of exceptional DIQ. To reach that, it is critical that SOAR complete the path to telescope improvements that currently limit the DIQ. The most important of these are the correction of residual low-order aberrations, the installation of the new tip-tilt servo controller, and having a functional windscreen. In addition, fixing the tracking jitter and eliminating the many smaller contributions to seeing from the dome and mirror could together yield additional improvement. Furthermore, real-time correction of aberrations eliminates the need to spend considerable observing time solely on tweaking the mirror and is critical for highly efficient nighttime operations. Therefore, we have the following recommendations:

Critical

i. To obtain the maximum image quality and operational efficiency, it is imperative that real time correction of low-order aberrations be implemented. If the current donut method does not prove feasible, this will likely require significant modifications to the guiders.

ii. The new controller for tip tilt is very close to being ready for testing, and should be implemented as soon as possible.

iii. A functional windscreen is a basic necessity for SOAR that needs to be given sufficient priority to be finished.

High Priority

i. We applaud the desire to study and improve the mechanisms for dealing with dome and mirror seeing. This activity should be pursued with high priority.

ii. The fix for tracking jitter should be implemented as soon as tests of the fix are completed at the Blanco telescope.

IV. Instruments

1. Current Instruments

SOAR Optical Imager (SOI)

The SOAR optical imager (SOI) is a 4kx4k mini-mosaic of optical CCDs covering 5.5 arcmin on a side. The instrument was built by NOAO, and has been in regular operation since 2004. It is generally used in 2x2 binning mode, which generates a pixel size of 0.153". The readout time is 10 seconds – the relatively short latency is useful for time series observations, and results in very efficient calibration procedures and standard star observations. The instrument is well-documented, and by all accounts is mature, reliable, stable, and easy to support. A member of the committee (Bailyn) had an observing run (through NOAO) with this instrument immediately prior to our meeting, and the experience was generally a happy one.

It should be noted that SOI does not provide an exceptional capability compared to other optical imagers in regular use around the world. Its field of view is relatively small (necessarily true of all SOAR instruments). SOAR in its current state provides a modest advantage in image quality over most comparable instruments in the top 10% of seeing conditions, and it is possible that this might improve to the top quartile of conditions once all the currently planned telescope improvements are completed. Even so, the competitive advantage is relatively slight, in contrast to an imager fed by the Soar Adaptive Module (SAM), which would have dramatically better image quality than typical ground-based optical imagers. However, since the maintenance burden of SOI is small, the port is not required for other instruments, and there remains considerable demand across the consortium, we believe SOI should continue to be supported and offered to the SOAR community.

OSIRIS

OSIRIS is SOAR's workhorse near-IR (1.0-2.2 micron) imager and spectrograph. It was built by Ohio State University, and was formerly used on the CTIO telescopes. In spectrographic mode, OSIRIS can be used either with a long-slit, delivering a resolution of R = 1200 or 3000, or with a cross-disperser, delivering R = 1200, but all of J, H and K in one exposure. It is now complemented at these wavelengths by SOAR's newly-commissioned SPARTAN near-IR imager. With few exceptions, OSIRIS has been working reliably for several years, and is generating refereed science publications.

Goodman Spectrograph

The Goodman spectrograph is expected to be one of SOAR's workhorse instruments. It is an optical imaging spectrograph, with imaging, single-slit and multi-slit modes.
The Goodman is being constructed by a group at NCU led by Chris Clemens, and there is strong interest in the instrument throughout the consortium – in recent semesters one-third of NOAO's proposals and over half of Brazil's proposals have been for this instrument.

After considerable time and effort, early difficulties with the camera and CCD were resolved, and the instrument began to be scheduled for regular science observations in 2008. However commissioning[1] has never been completed, and the multi-slit mode is currently not available. Some users have reported difficulties in obtaining science-quality data with the Goodman, and there is considerable frustration with the delays and the remaining unresolved difficulties with this instrument. These problems include low throughput in the UV, mechanical flexure and jumps creating problems in wavelength calibrations, stray light (now resolved), insufficient and inefficient gratings, inefficient target acquisition, and severe fringing beyond H-alpha. The instrument team plans to resolve most of these issues and implement the multi-slit mode by the end of calendar year 2010.

The committee agrees with the assessment of the SOAR SAC that completing the commissioning of the Goodman spectrograph as a facility instrument should be SOAR's top short-term priority. We note that the required work goes well beyond commissioning the multi-slit capability. Observers outside North Carolina report difficulties in obtaining good data, particularly with regard to reliable wavelength calibration – by contrast UNC observers are more successful. Clearly the instrument cannot be considered commissioned until these difficulties have been thoroughly investigated, and a set of procedures that allows users from throughout the consortium to successfully use the instrument has been documented. The progress made by NOAO and UNC scientists to reduce the scattered light problem provides a recent success story that might be emulated.

The delays, many of them unavoidable, and the current lack of confidence in the Goodman spectrograph appear to the committee to be significant contributors to the difficulty SOAR has had in elevating its scientific productivity. The situation is causing tension and frustration across the consortium. It is essential that the instrument be fully commissioned in all modes, and the problems expressed by some users be explored and resolved as soon as possible – the timescale expressed by the instrument team that this should be accomplished in 2010 seems to us to be an appropriate goal. It will surely be useful, and perhaps necessary, for others in the consortium to work with the instrument team in identifying and resolving problems, and generating appropriate documentation of recommended observing procedures. The instrument team should work with SOAR management and consortium astronomers to generate and implement a detailed, specific plan and schedule for completing planned improvements, commissioning the multi-slit mode, and resolving user concerns as quickly as possible.

[1] The committee notes that in the material presented to us, the terms "commissioning" and "commissioned" are used to denote quite different situations. In some cases these terms refer to an observing mode that has been demonstrated to work on-sky by the instrument team. This is the current state of the Goodman multi-slit mode and the SAM natural guide star mode. In this document "commissioned" will be used in the more expansive sense, to refer to instruments and observing modes that have well-documented procedures that reliably generate science-quality data for users not associated with the instrument team. We believe this definition is more in keeping with the SAC's instrument acceptance document, and with the needs of a highly diverse user community like that of SOAR.

Spartan

Spartan is a new IR imager (1.0-2.2 microns), offering a 5 x 5 arcmin field at a scale of 0.07 arcsec/pixel. It has been designed to exploit the excellent image quality that should be delivered in the near-IR by a 4 m telescope equipped with a fast tip-tilt mirror.

Initial commissioning took place in early-2010, but the commissioning data have yet to be analyzed. Until commissioning is complete, Spartan will not be ready for significant use across the consortium.

SOAR Integral Field Spectrograph (SIFS)

SIFS is a fiber-fed integral field unit (IFU) spectrograph built by the LNA in Brazil. The IFU has 1300 fibers in a 50x26 rectangular aperture and sky fibers and feeds a bench spectrograph to be mounted on one of the platforms of the telescope. Field of view is 4 x 7.5 arcsec with 0.15 arcsec fibers, or double this field of view with 0.3 arcsec fibers. Resolving powers between R = 1000 and 30000 are foreseen for the VPH grating spectrograph. SIFS will be able to be used together with the SOAR Adaptive optics Module (see below). Commissioning of the instrument is currently in progress, with first light having been attained in late-April, a few days after this external review was carried out.

2. Future Instruments

SOAR Adaptive optics Module (SAM)

SOAR's AO module, SAM, will correct the incoming wavefront for the effects of ground-layer turbulence, using a UV Rayleigh laser guide star as the wavefront reference. SAM is expected to deliver images with FWHM <~ 0.2 arcsec in the optical. This will make SAM a unique facility in the southern hemisphere, and it is likely to be in particularly strong demand when HST is withdrawn from service.

Successful scientific exploitation of SAM requires: (1) delivery of good image quality by the telescope/enclosure; (2) satisfactory commissioning of SAM in NGS and then LGS modes (and with the instruments which it feeds, e.g. SIFS, BTFI); (3) characterization and documentation of the AO performance; (4) strong community interest in using the facility; (5) user-friendly interfaces, so that night-time support can be provided at reasonable cost; and (6) the operational flexibility to schedule AO observations to make the most of good seeing (queue observing). SAM is likely to be a scientific success only if all of the above requirements are satisfied.

Currently, the image quality delivered by the telescope is compromised by a number of problems (see Section III.1). In addition, the tip-tilt response of M3 is not as fast as originally planned, being able to reject only frequencies < 5 Hz.

We note that the commissioning of AO systems on other telescopes has typically been much more expensive than originally anticipated, particularly in terms of the staff effort required at all stages (off-sky tests, on-sky commissioning and training), and the telescope time required.

Even when using natural guide stars, AO systems are a lot more complex than most non-AO instruments, and this confers on them a high level of susceptibility to minor technical problems, user errors and environmental influences (e.g. electrical noise, humidity, vibrations). Their performance also depends strongly on parameters outside the user's control (seeing, vertical distribution of turbulence). These factors make it harder to predict the time required for each step of the commissioning, or even the order in which the steps are carried out.

It is, therefore, particularly important when commissioning AO systems that the commissioning goals are defined in detail, well in advance, and are understood and agreed to by all of the interested parties. For example, closing the loop and observing an improvement in FWHM or Strehl indicates that most of the system is working satisfactorily, but users will need to know a lot more than this. It's important to decide in advance e.g. how densely to sample the multi-dimensional performance-characterization space (wavelength, seeing conditions, NGS mag, loop gains etc.) in order to establish whether the on-sky performance matches that predicted by the model.

It is also important to recognize that when unexpected problems hold up commissioning of SAM, it may be necessary to re-deploy staff effort which is being channeled into other projects (e.g., NEWFIRM).

SOAR Telescope Echelle Spectrograph (STELES)

STELES is a Nasmyth-fed, two-channel, VPH cross-dispersed echelle spectrograph. Both channels will operate in quasi Littrow mode and in white pupil configuration. The object and sky spectrum will be recorded from 3000-9000 Å in one exposure with a resolving power of R = 50,000. The bench spectrograph will be permanently mounted on the telescope, for stability and easy access (below the Nasmyth platform), and fed by fore-optics installed in one of the SOAR ISB ports.

Although STELES had its Conceptual Design Review in November 2003, it is only now in construction phase. The optical and mechanical assembly is planned for December 2010. Full integration and tests are planned for the first trimester of 2011 and shipment for SOAR after the acceptance tests by mid 2011.

Brazilian Tunable Filter Imager (BTFI)

BTFI is a highly versatile, new technology, optical imager with a tunable filter to be used both in seeing-limited mode and at high spatial resolution with the SOAR Adaptive Optics Module (SAM). Plans call for the low-resolution mode of BTFI to be commissioned on SOAR in July 2010. The high-resolution mode will presumably be delivered in 2011.

BTFI is currently projected as a restricted-use instrument available only to the Brazilian community, but it may gain facility instrument status if there is sufficient partner interest. In either case, BTFI opens up important new science capabilities from studies of nearby galaxies and the interstellar medium to statistical cosmological investigations.

3. Commissioning

The commissioning of SOAR's first generation of instruments has already furnished SOAR users with an impressive array of facilities. The commissioning of OSIRIS (previously used on another telescope) and SOI (a fairly straightforward instrument) appears to have gone smoothly. That of the Goodman spectrograph (see above) has been slower than expected, giving rise to some frustration, and a few misunderstandings, within the SOAR user communities. This highlights the pitfalls of making available to users an instrument that is not yet fully commissioned. Such a situation can easily lead to users' initial high expectations being dashed, with consequent long-term loss of interest and reduced long-term scientific productivity.

In general, for a new instrument to realize its anticipated scientific potential, it is important that the objectives and strategy of the instrument commissioning be well-defined, and understood by all the interested parties, and that users are kept abreast of commissioning developments, in order to manage expectations. Otherwise, the perception can arise that an instrument has come into use with impaired or missing functionality or documentation.

These issues will be particularly acute for the commissioning of more challenging instruments, such as SAM, with its inherent complexity, and its dependence on suitable atmospheric conditions for commissioning and performance characterization.

The panel therefore welcomes the SAC's provision of an acceptance-requirements document for facility-class instruments on SOAR. This is a good starting point for defining, agreeing to, and publicizing commissioning goals and strategy.

4. Long-Term Planning

SOAR is being furnished with an impressive array of first-generation instruments, several of which will provide facilities that are unique on 4-m telescopes in the southern hemisphere.

To optimize its future scientific impact, SOAR will need to maintain this competitive edge by investing in future instrumentation that is well matched to the needs and interests of the communities it serves. These communities will in particular be interested in ensuring that new instrumentation (1) is geared to exploit upcoming scientific opportunities (e.g. follow-up of new surveys) and (2) complements existing and upcoming instrumentation on other 4-m and larger telescopes.

For maximum scientific impact, any new instruments should be perceived as being of high priority by all of the SOAR user communities. These communities are diverse, with different areas of scientific interest (as reflected dramatically in the SOAR publications list), different levels of instrument-building expertise (and of future interest in building instruments) and different resources.

It's therefore essential that there be planned and detailed cross-community discussions about what kind of instruments will be needed a few years downstream, and about how broad a range of instruments it is cost-effective to offer. These discussions will need to take into account the scientific opportunities afforded by other upcoming facilities (e.g. powerful new telescopes such as ALMA, ELTs, and large surveys such as that generated by LSST). They will also need to take into account the way in which any proposed new instrument (or major upgrade of an existing instrument e.g. OSIRIS) complements existing or upcoming instrumentation available elsewhere to the partner communities (although this will differ from one community to another). Current and ongoing community-wide reviews such as Astro2010 (U.S. decadal review), its Brazilian equivalent, and ASTRONET's recent reviews (of facilities required on European telescopes) provide useful context.

Ideally, SOAR's SAC should be both fomenting such discussions, and channeling the consensus community views to the SOAR Board. In the past, the SAC has not been very active (and rarely meets face-to-face), partly because the SOAR Board (which comprises mainly astronomers) has taken on much of the SAC role.

However, with decisions about future instrumentation becoming more urgent, the panel feels that the SAC should now take a more active role. In particular, it needs to be organizing meetings between the users and instrument-builders from all of the SOAR communities with the goal of converging on recommendations about what new instrumentation to build. (See Section VIII for further discussion of the role of the SAC).

Under the current agreements between the SOAR partners, each is committed to contributing, every few years, a new instrument costing ~2M US $. In practice, this significantly constrains what can be delivered, given the cost of building ambitious second-generation instruments, and the need for each partner to deploy the full range of design and engineering resources required. Some of the partners made it clear that they are keen to see a small number of highly competitive instruments on SOAR, rather than many less-competitive ones.

The panel therefore agrees that the SOAR board should encourage collaboration between the partners to pool resources to build more ambitious instruments than could be afforded by individual partners working alone, while accepting that collaborative efforts carry their own risks.

One of the strengths of SOAR is that several instruments can be mounted simultaneously, allowing access to more than one instrument during the night, and eliminating the need for instrument changes. The panel strongly endorses the SOAR Director's recommendation that this policy should continue to apply in the future. A corollary of this is that as new instruments are commissioned at SOAR, the available ports will be used up, and it will be necessary to retire old instruments.

On a related point, the panel notes that the current level of operational staffing appears only just sufficient to commission and support the existing suite of instruments, and will not suffice to commission and support additional new instruments already in the pipeline (e.g. SAM), let alone major new second-generation instruments. At some stage (the earlier the better), a decision will need to be made about whether to restrict the number of instruments offered, or increase the level of operational funding.

5. Recommendations

Critical

i. The top short-term priority for SOAR should be the completion and commissioning of all modes of the Goodman spectrograph by the end of Q4 2010, consistent with the stated goal of the instrument PI. Issues of particular concern are mechanical stability, documentation and low UV throughput.

ii. SAM will provide SOAR with a unique capability, hence commissioning needs to proceed in a timely fashion. The commissioning schedule, strategy, and goals need to be carefully defined and agreed upon by the various interested parties.

iii. We applaud the efforts of the SAM project team to produce a GLAO system that is user friendly and requires modest technical support. However, experience to date has shown that AO systems are expensive to commission and support. Therefore, the SOAR partners should be prepared to provide additional support resources as required to ensure that SAM meets its scientific potential.

iv. The instruments currently at SOAR, or being built, will provide an excellent range of capabilities and scientific opportunities. Nevertheless, we are concerned that the current level of operations funding is insufficient to provide basic support of the instruments, including user support.

v. The SAC has provided an excellent instrument acceptance plan. This needs to be carefully adhered to for all current and future instruments.

High-Priority

i. We encourage the SOAR board to pursue possibilities of collaboration between partners for future instrumentation for the purpose of producing instruments that are more expensive than can be provided by a single partner.

iii. The committee strongly agrees with the SOAR Director that current and future instrumentation plans should call for all instruments being permanently mounted at dedicated ports. Similarly, instruments modes that require major modifications to the instrument should be avoided.

V. Observing Modes

The SOAR partners use the telescope in a variety of observing modes. These different modes appear to be successful, and SOAR is to be commended for adapting well to the different needs of the partners in this regard. The current successful experiences provide a basis on which to explore new ways of exploiting the scientific opportunities offered by SOAR in the future.

1. Traditional

Traditional observing involves the allocation of a few contiguous nights to a particular PI and scientific project. The PI and/or collaborators travel to the telescope, and carry out their observations in the control room. This is the time-honored traditional means of carrying out ground-based observing. It provides maximally close contact between the visiting astronomer and the telescope, instrument, and observing support staff. It also fosters good ties between the observing community and the observatory, and generates enormous enthusiasm among students. The downside is the considerable effort and expense associated with travel to a remote site. In some cases, this can be a considerable disincentive to using the facility at all. Currently, virtually all NOAO and Chilean observers use SOAR in this mode.

2. Remote

Remote observing is similar to traditional observing, except that the observer works from a remote site, with the various computer displays, data, and other relevant information transmitted over the Internet. Communication with the on-site observing support staff is done by videoconferencing technology. This mode avoids the inconvenience presented by travel to the telescope. However, successful remote observing requires quite sophisticated communications software, and can be difficult to implement through the various firewalls at both ends of the link. Consequently, remote observing can be difficult to implement. Some specialized hardware is also useful, and a dedicated facility where the astronomer can work through the night is very important. Remote observing is also susceptible to Internet outages. The camaraderie and useful exchange of information between observatory staff may be somewhat less than in traditional observing.

Both MSU and UNC have constructed dedicated observing facilities on their campuses, and the vast majority of their SOAR observing is done remotely. Brazil also has facilities at several institutions. Those who use remote observing report great satisfaction. SOAR thus appears to have thoroughly resolved the technical problems associated with remote observing – the observatory staff and the university-based astronomers and technical support are to be commended for this success.

3. Service

Service observing refers to observing carried out by an observer on behalf of another astronomer or group. Often service observing is done by a dedicated individual on behalf of a number of other programs. This allows the observer to obtain experience and expertise in using the facility. Scientific productivity can be enhanced in this mode by matching the scientific programs carried out to the observing conditions best suited to them. Many programs involving time-variable objects are facilitated by service observing – it is very difficult to make brief observations on many nights with traditional observing blocks. When many programs are mixed and matched throughout the night, service observing is sometimes referred to as queue observing. The ability to carry out effective service observing is greatly enhanced by the ease with which SOAR can switch between different instruments – this flexibility is greater than at most other telescopes, and allows a variety of programs to be more effectively mixed and matched.

Brazil has implemented a program of service observing, sending post-docs to La Serena to carry out observations on behalf of the entire Brazilian community. These post-docs are also expected to contribute to the scientific support of SOAR. The post-docs involved have the opportunity to become expert in the use and support of SOAR and its instruments, which is hoped to enhance their scientific productivity and career track. Originally, the post-docs served only one year terms, which was problematic in that their terms ended shortly after they attained real expertise, at which point another post-doc arrived to start the process all over again. In the early days there were often two, or in some cases only one post-doc in residence at a time. This imposed a heavy burden on the individual(s) who had to carry out close to 1/3 of all observing on SOAR, leaving little time for their own science, or for other kinds of telescope or instrument support. Currently we understand that the terms of these post-docs have been extended to three years, and there are currently three in residence – this seems much more appropriate for the tasks they are being asked to carry out. The post-docs are contributing to the SIFS commissioning effort, which should not only help that effort along, but will make them more effective observers when the instrument is fully commissioned.

The Brazilian service observing program is greatly enhanced by remote observing carried out from La Serena, enabling the service observers to avoid the trip to the mountain – the committee was able to observe the start of a service night, and the process seemed very effective. The Brazilian community seems happy with the data the observers obtain. It is too early to tell whether the experience has the hoped-for positive effect on the careers and scientific output of the post-docs themselves; this needs to be monitored carefully.

4. Target of Opportunity

Target of Opportunity (ToO) observing is designed to facilitate observing transient celestial events. When a ToO event occurs, that program pre-empts the regularly schedule program so that time sensitive observations can be carried out. ToO interrupts are straight-forward to implement in a service observing queue, but can be problematic for traditional observers, whose observing time is effectively reduced in a way that is hard to compensate for. SOAR has implemented a ToO policy that has been used occasionally with considerable effect - one of the most celebrated SOAR science results, the high-redshift GRB (Haislip et al. 2006, Nature, 440, 181), was observed in this way. Once again, the ability of SOAR to easily switch between permanently mounted instruments makes it an unusually effective facility for ToO observations.

Thus the various SOAR institutions have arrived at observing modes that appear to serve their user communities well at the current time. However, the committee notes that there are scientific opportunities on the horizon that can only be effectively supported with an expanded set of observing modes.

First, the enormous scientific potential of the SAM instrument would be greatly enhanced by service/queue observing across the consortium. Supporting consortium users for SAM observations may require scientific and technical support beyond what is needed for other instruments – this support may not always be available, so it may be desirable to schedule SAM campaigns sporadically. More importantly, the really exciting applications of SAM are likely to occur only during naturally good conditions. Initial results from SAM in natural guide star mode suggest that optical image quality will be improved by about a factor of 2 in FWHM, whether the uncorrected seeing was good (~0.5") or poor (~1.2"). Correcting 1.2" seeing to 0.6" using laser guide stars is essentially an expensive way of improving the weather: similar results could be obtained at SOAR or elsewhere in better conditions. By contrast, correcting 0.6" seeing to 0.3" seeing would provide a capability far beyond that of any current ground-based imager – only in good conditions can SAM approach the stated goal of "HST-like" image quality. Therefore it makes sense to use SAM during good conditions only; this in turn requires queue/service observations so that other programs can be carried out if the conditions are not ideal. We note that this approach would *not* require a full-time service queue – there could be a much smaller operation, possibly generated by a modest expansion of the Brazilian service effort, that restricted SAM use across the consortium to a fraction of the available nights.

A second opportunity for greatly enhanced scientific productivity is provided by the imminent arrival of major astronomical surveys at Tololo and Pachon. The Dark Energy Survey will be initiated at the Blanco telescope on Tololo within the next few years, and the Large Synoptic Survey Telescope will be constructed on Pachon and begin operation toward the end of the decade. Both of these surveys will observe large areas of the sky, and identify interesting variable objects in real time. There will be a huge discovery space associated with rapid follow-up of these observations – it is likely that the scientific exploitation of many aspects of these surveys will have follow-up as a limiting factor. SOAR is ideally suited to this task. It is co-located with these survey telescopes, so similar observing and weather conditions will generally apply. Furthermore, the many simultaneously mounted instruments, and the ease in switching from one to another, make SOAR a perfect vehicle for this kind of work. We note that it is not just ToO observations that will be required – it is likely that other time-critical observing modes (e.g. repeated monitoring over many nights) will also be crucial.

5. Recommendations

High Priority

i. Currently SOAR does not support queue operations at the consortium level. However, GLAO will significantly benefit from flexible scheduling. We urge the Board to consider how this might be implemented following commissioning and acceptance of SAM as a facility instrument.

ii. The existing policy for ToO observations provides for infrequent, one-off interrupts. Given the imminence of the Dark Energy Survey (DES) and, subsequently, the Large Synoptic Survey (LSST) on site, and the excellent position that SOAR will be in to exploit these surveys, we recommend that the Board consider extending the present ToO policy to better facilitate time domain observations.

VI. Scientific Productivity

The productivity of an observatory can be measured in a variety of ways. For a consortium like SOAR, different metrics may be important for different partners. The aspirations of the SOAR partners, as expressed in the documents supplied to us and in conversation, do seem to vary somewhat. The universities place considerable emphasis on recruitment of good students and faculty, and on educational uses of the facility. Brazil hopes to develop a strong astronomical instrumentation program focused on SOAR. NOAO needs to ensure that SOAR provides a strong component of a balanced "system" that does not unnecessarily replicate other parts of the system. These goals are not contradictory, but they are not identical – thus there is no single metric that can represent "success" for all partners.

It is clear that SOAR is already fulfilling some partner aspirations. MSU reports that faculty and student recruitment has been considerably aided by the existence of SOAR, and both universities have a number of interesting student projects. Brazil's instrumentation capabilities are improving rapidly. SOAR is nicely complementary to the Blanco telescope for NOAO's southern hemisphere observing suite, since the Blanco is aimed at wide-field applications for which SOAR is unsuitable, and SOAR is working toward high spatial resolution applications.

That said, there is one metric that is common to all the SOAR partners that may be cause for concern. That is the production of refereed scientific publications. SOAR ranks considerably below comparable telescope facilities elsewhere in this crucial metric. SOAR is currently producing <10 papers/year, where other 4m-class telescopes generate 30-100 papers/year. Particularly notable is the almost complete lack of papers from the NOAO community – this is in contrast to the situation in the WIYN consortium, in which the educational aspirations and long term projects of the university partners have resulted in a lower ratio of papers/observing night for the universities than for the national community.

All telescopes experience a gradual rise from zero to a steady state number as the telescope is brought up to spec, and the initial instrument complement is commissioned. So one would certainly expect SOAR to be currently well below its ultimate productivity. The real worry is not the current number of papers being produced, but the fact that that number does not seem to have risen over the past few years. Most members of the SOAR consortium believe that the expected productivity gains have "stalled" at an early stage due to the difficulties encountered in completing the telescope and the initial instrumentation suite. The committee believes this is a plausible explanation. But the situation should be monitored carefully – if significant increases in publication rates are not seen in the next few years as new instruments are successfully commissioned, some deeper problem may exist.

The unusually long ramp-up to successful operations may create its own problems. In particular, there is a tendency in dispersed astronomical communities for observers to try out new facilities when they become available, but then give up if serious technical difficulties are encountered. Often, observers do not keep themselves abreast of progress made subsequent to an initially disappointing run – and they share their experiences with others. Thus technical problems early on can lead to a damaged reputation long after the problems have been resolved.

It is not clear that this problem is in fact happening in the case of SOAR – the oversubscription rates from the public communities are healthy, and news of progress is relatively easy to spread within the university communities. But it is a serious danger, and vigorous pro-active efforts to combat any lingering perception of technical problems should be undertaken. This will involve outreach to all potential users that goes well beyond simply announcing the current status of the telescope and instruments, although having up-to-date websites is certainly a necessary step. One venue for describing the current capabilities of SOAR is at astronomical society meetings. Both Brazil and the United States have regular meetings attended by a significant fraction of their communities. This is an ideal situation to counter any possible prior negative impressions, and to publicize exciting new capabilities.

It is also important for regular users of SOAR to meet one another to explore the scientific potential of SOAR, to promulgate best practices in getting the most out of the facility, and to think together about long term goals for the consortium. Such discussions present particular logistical difficulties for SOAR, since the observatory and its users are so widely dispersed geographically. Thus focused efforts will have to be made to get the user communities together. A SOAR symposium, including both recent science results and workshops and discussions on present and future capabilities, seems to the committee to be a useful and timely activity.

One specific impediment to scientific productivity that we became aware of during our visit involves the scientific staff associated with SOAR. The staff is deeply involved in resolving the technical issues of the observatory. But as such, they are the individuals best placed to make exciting use of the science opportunities. The rest of the community is anxious to collaborate with scientists who know all the ins and outs of the telescope and its instruments. Unfortunately, the technical burdens on the staff are such that they often do not have time to exploit the scientific potential of the facility they work daily to enhance. This applies at all levels: to the Director, to the NOAO scientific staff who work on SOAR, to the Brazilian post-docs, and most likely to the new SOAR post-doc. We believe that the on-site scientists associated with SOAR are generally devoting less time to science that their contracts allow. While their full efforts are currently required to address technical issues, this situation decreases the scientific productivity of SOAR. It also diminishes the career opportunities of junior scientists and post-docs associated with SOAR, as well as the ability of the observatory to recruit the finest scientists to its staff.

1. Recommendations

High Priority

i. The committee strongly believes that SOAR is now capable of significant scientific output. We recommend that the performance and capabilities of the telescope and instruments be widely disseminated to the user communities of the consortium members. This should take multiple forms including, for example, presence at Brazilian and American Astronomical Society meetings, expanded information on the SOAR website, etc.

ii. We urge the SOAR SAC to organize a first SOAR Science Symposium, highlighting SOAR science results and new capabilities. Such a meeting should provide a forum for discussing long-term goals.

iii. The agreed-upon science time of the scientific staff needs to be protected, especially for the postdocs and junior staff. This is important for both the staff and the scientific productivity of the observatory.

VII. Staffing

1. Operations and Maintenance Staff

Telescope Operators

Nighttime operation of the SOAR telescope is performed by two pairs of telescope operators working on a 7 days on, 7 days off shift. To comply with Chilean labor regulations, two operators are needed on each shift to allow operation of the telescope for the entire night.

The telescope operators not only operate the telescope, but also provide assistance to the astronomers. One of the two operators on each shift performs daytime instrument set-up and other support tasks during the afternoon, and then works through the first part of the night until midnight. The other overlaps with the first, operating the telescope for the remainder of the night until sunrise. This system appears to work well, and makes effective use of the requirement of having two operators on the mountain.

Mountain Day Crew

The day crew on Cerro Pachón consists of five full-time members: a mechanical engineer who serves as the Site Manager, an electronics engineer, an electronics technician, and two mechanical technicians. These personnel commute to and from the mountain each day. Their regular working hours are Mon–Fri 08:30-16:30, although in exceptional situations they may work beyond these hours, or on weekends to resolve critical problems. They are also "on call" to provide remote assistance with the resolution of problems that occur during the night and on weekends.

The Site Manager, Eduardo Serrano, is dedicated at the 80% effort level to SOAR operations, which the committee considers to be appropriate. Until a few months ago, the electronics engineer, Esteban Parkes, was also similarly dedicated to SOAR operations, but recently he was promoted to the position of Electronics Supervisor on the CTIO Telescope Operations staff. In the short term, the plan is to fill the SOAR electronics engineer position through a combination of part of Esteban's time, augmented by the effort of other CTIO electronics engineers. The committee understands that this is a transitory situation brought on by a retirement at CTIO, but is concerned that the SOAR electronics engineer return to being more of a dedicated position.

ETS Support

Additional engineering and technical support is obtained, as needed, from CTIO's Engineering and Technical Services (ETS) division. On rare occasions, the expertise of NOAO's Tucson-based engineering and technical group has also been called upon. SOAR receives support from ETS at a priority level comparable to that of the Blanco telescope. Problems that impact nighttime operation have overriding priority, and thus receive immediate attention from the appropriate engineering staff. Conflicts of priority between SOAR and Blanco are infrequent, and have apparently been easily resolved through discussion between the SOAR and CTIO Directors and the ETS manager.

SOAR does not currently have a dedicated software engineer. Instead, all software support is drawn from the CTIO ETS group. A number of ETS staff participated in the development and commissioning of the telescope and/or instruments, and are thus an important source of knowledge of the SOAR software. Nevertheless, these same personnel are significantly occupied in other large NOAO projects. Hence, while the committee applauds the concept of SOAR being able to call on the considerable experience of the CTIO ETS programming staff, this is an area where a dedicated position could actually prove more efficient.

Scientific Staff

In addition to the Director, the SOAR Memorandum of Understanding calls for the partners to make a "best effort" to provide scientists to support the telescope and instrumentation. The original intention was for NOAO and Brazil to provide one scientist each, and UNC and MSU to jointly provide a third scientist. These scientists were to spend one-third of their time on functional tasks related to the operation of the SOAR telescope and instruments. The remaining two-thirds of these scientists time was to be spent in ways determined by the sponsoring institution(s).

To date, NOAO has steadily provided one scientist fully identified with SOAR (initially Hugo Schwarz, and now Sean Points) plus considerable extra help from additional CTIO staff scientists as needed. Brazil has met its Scientist obligation using the postdoctoral fellows who also carry out queue observing for the Brazilian community. However, the contribution from UNC and MSU has lagged, with only infrequent short visits by graduate students plus occasional work done back at the home institutions. In an effort to improve the situation, Brazil, UNC and MSU recently agreed to pool their resources and jointly hire a postdoctoral fellow who will be dedicated to SOAR scientific staff work (plus time for their own research), on a three-year appointment.

The committee commends the consortium for addressing the need for scientific support of the SOAR operation. The new postdoctoral position is a positive step forward, and should be maintained beyond the first 3-year appointment. However, several members of the SOAR staff mentioned that they missed the experience in telescopes and instruments that Hugo Schwarz had contributed to the SOAR operation. Considering the heavy administration burden that the SOAR Director has necessarily had to take on, there is a clear need for a dedicated senior scientist to work with the technical staff in increasing the efficiency and scientific productivity of the SOAR telescope and instruments.

2. Recommendations

The core SOAR staff has done a remarkably good job with limited resources in understanding and solving the significant problems discovered in the commissioning process. The current SOAR technical and scientific staff is clearly highly dedicated, capable, enthusiastic, and hard working. The SOAR Director also appears to be doing an outstanding job, and is well respected by the staff. The consortium is fortunate to have such excellent personnel. Nevertheless, the panel feels that scientific productivity could be improved by augmenting the present staff in a few key areas. Our specific recommendations are:

Critical

i. A strength of the SOAR operation is the ability to call on the collective expertise of the NOAO technical staff when needed. Nevertheless, the committee recommends that there be a core technical team which includes the Site Manager/Mechanical Engineer, an Electronics Engineer, at least one Mechanical Technician, and an Electronics Technician who are at least 80% dedicated to SOAR.

ii. In addition to the above core staff, we recommend that the core SOAR technical team include a full FTE of dedicated software support.

iii. It is essential that the SOAR staff include a second senior scientist in addition to the Director. Specifically, a full-time, dedicated scientist with extensive experience in telescope and instrument operations is needed to ensure the successful implementation and optimal functioning of the SOAR telescope and instruments which is critical to increasing scientific productivity.

High-Priority

i. The new postdoctoral position represents an important increase in the SOAR scientific support effort. The committee recommends that this position be continued beyond the first 3-year appointment.

VIII. Management

1. Governance

In spite of their diversity, the SOAR partners have similar objectives for the observatory and the consortium works well together towards achieving their common goals. The partnership is able to draw on the strengths of each of its members, and each partner does what it can for the partnership when its circumstances allow. The committee commends the partners for the relatively smooth functioning of the partnership.

The SOAR corporation is governed by the SOAR Board of Directors, and the Scientific Advisory Committee (SAC) reports to the Board. Currently the SAC meets only when the SOAR Board needs it to address a particular issue, and then never face-to-face. However, the committee feels that a more active SAC is necessary to the vitality of the organization. For example, the SAC needs to represent the user community to the SOAR Board and management, particularly in the absence of a partner-wide users committee. In addition the SAC needs to more vigorously take on its role in the oversight and commissioning of instruments, as stated in the "Facility Class Instrument Acceptance Requirements" document. Regular face-to-face meetings would allow the SAC to be more pro-active.

2. Role of NOAO

NOAO and SOAR have a unique relationship; NOAO is a SOAR partner and is also responsible for a large fraction of the operation of SOAR. In addition SOAR is one of several telescopes on the mountain that NOAO operates. A major advantage of this arrangement is that SOAR has access to the larger pool of NOAO resources, including a wide array of technical expertise that would be impossible for SOAR to employ solely for itself. Furthermore, when circumstances require more than the core staff, such as during aluminization of the primary mirror, additional people can be added to the SOAR team on a temporary basis. This also means that SOAR can benefit from technological developments advanced for other telescopes under NOAO. An example is the upgrade to correct for tracking jitter that is building on an upgrade being done at the Blanco 4 meter telescope.

There are, however, potential weaknesses in this relationship. The pool of NOAO technical resources is limited, and when there are significant efforts taking place at other telescopes on CTIO, there can be more demand for resources than are available. For example, at this moment commissioning of NEWFIRM on the Blanco 4 meter is highest priority at NOAO and may have some impact on SAM, and in the near term commissioning of DECam on the Blanco will absorb considerable resources. To date, the relationship between SOAR and NOAO has worked well, but it requires some flexibility by both entities.

3. Communication

Board, SAC, and Users

The committee was generally concerned about the level and effectiveness of communication between all parties, but especially with the users. First, there needs to be more input and feedback from the users. Currently observers file end-of-night reports that keep the SOAR Director appraised of immediate equipment and software issues, NOAO users submit end-of-run evaluation forms, and Brazilian astronomers report on the quality of the data obtained for them through their own service observing. However, non-NOAO users do not report on how well their runs went and no one discusses issues that become apparent later during data reduction but that are important for understanding the capabilities, performance, and potential problems of individual instruments. Greater user feedback would bring problems to light that could then be addressed. One opportunity for canvassing the user community could be during SAC meetings held at partner institutions.

Second, it would be useful if observers exchanged information across partnerships on their experiences with different instruments, including data reduction tips and best practice observing methods. A wiki or blog would allow such an exchange. A current example of a situation that might benefit from such an interchange is use of the Goodman spectrograph and conflicting reports on its capabilities for radial velocity work and for time-series observations.

Third, detailed and up-to-date documentation for each instrument is essential to help the users prepare for observing runs and make the most of their telescope time. This documentation needs to include suggestions on how best to obtain high quality data with that instrument.

Within NOAO

The committee found that communications concerning SOAR within NOAO could be improved. For example, information about some technical issues was not reaching in a timely manner those responsible for allocating resources for fixing problems.

4. Synergies

As stated above, because of its location, SOAR is in a unique position to gain from activities and resources of the larger NOAO enterprise. SOAR is already gaining from the Blanco upgrade to the encoder processing electronics. After SAM is delivered, and even after commissioning, SOAR will also likely benefit from the resident expertise accrued in the process of building SAM. These sorts of benefits are likely to continue.

However, in addition SOAR may be in a unique position to take advantage of the output of big surveys such as DES and, later, LSST. SOAR could position itself to perform relatively fast follow-up to these surveys. This is especially so given the varied array of capabilities always ready to go on SOAR since instruments are permanently mounted on the telescope and kept in a “live” state. Thus, one can imagine a variety of science projects that could be undertaken based on these surveys, along with serendipitous science that depends on a quick response.

5. Safety

The committee saw a 2009 report from Mutual de Seguridad. The only issue brought to light in that report is the need to replace the current oil tank with a modern certified unit. On the mountain visit, the committee saw no safety issues other than the old oil tank. Furthermore, the committee was very impressed with the safety record of the mountain crew and commends the SOAR core staff for their strict adherence to safe work practices.

6. Recommendations

Generally, the SOAR management is working very well. However, the committee recommends a more active SAC and improvements in communications, especially from, to, and between users.

High Priority

i. The SOAR SAC needs to play a more active role in representing the user community to both the Board and the SOAR management. Specific recommendations include (1) holding regular meetings, including occasional face-to-face meetings, (2) more pro-active oversight of instrument commissioning and acceptance, and (3) periodic surveys of the user communities. The face-to-face meetings would benefit from being rotated among the partner institutions, using this as an opportunity to canvass users.

ii. The committee does not currently see an effective mechanism for users to provide feedback to SOAR management. We urge the SOAR Director to consider how this might best be accomplished.

IX. Budget

1. Current Status

When the SOAR consortium was formed, the original concept was that NOAO would provide most of the operations funding, while the other three partners would primarily provide the funding for construction. It was anticipated that there would be a construction phase, a fairly brief commissioning phase, and then an operations phase lasting no less than 20 years.

The annual operating budget was originally set at US$1.1M in year 2000 dollars, incrementing at 3% per year for inflation. However, as commissioning and early operation got underway, it became clear that the operations costs had been underestimated. An amendment ("Amendment 3") passed by the SOAR Board in November 2008 modified the operations budget upward and provided for regular operations contributions from all partners. Amendment 3 set the SOAR operations funding in 2009 at US$1.79M, and called for annual increases of 4.5% through the year 2013.

The funding of all of the international observatories operating in Chile is complicated by unpredictable yearly variations in inflation and the peso/dollar exchange rate. To deal with this uncertainty, Amendment 3 specified the annual SOAR operating budget in terms of a nominal exchange rate of 500 pesos/dollar, and included a clause designed to allow SOAR to accumulate money when the exchange rate is favorable and draw on the accumulated surplus when it is unfavorable. The panel concurs with this approach.

The nominal operations budget for SOAR in FY 2010 is US$1.87M. Of this amount, 62% corresponds to labor costs. This is a reasonably healthy fraction, and compares well with, for example, the Magellan Telescopes operations budget for FY 2010/2011 where labor costs are 68% of the total.

2. Recommendations

By any reasonable standards, the SOAR operations budget would be judged as admirably frugal. However, as discussed in section VII, the SOAR staff is too thin in a few key areas. Moreover, as new instruments and capabilities are added to the operation, we are concerned that some additional resources will be required to achieve optimal scientific productivity. Hence, we conclude that some further adjustments in the SOAR operations budgets are desirable (indeed, inevitable). Our specific recommendations are as follows:

Critical

> *i. Implementation of the full suite of 1st and 2nd generation instruments, including SAM, will almost certainly require additional support resources. This problem needs to be studied and a realistic budget developed, or else the number of instruments offered will need to be restricted.*

ii. The SOAR budget will likely need to be increased consistent with the recommendations in section VII to include in the staff a senior scientist and software FTE.