ReSTAR Reprise

August 2, 2010

Introduction

The original ReSTAR committee issued its report and recommendations in January 2008. Afterwards, NOAO began a program to address community needs identified in that report. First described in a white paper that was widely distributed for public comment and input, the ReSTAR program was envisioned to comprise three phases over a period of ten years. Each phase would undertake some projects aimed at modernizing facilities, some projects that would produce new capabilities, some that would increase telescope access, and some that would lay groundwork for future development.

The first phase of this program (hereafter "Phase I") was initiated as an unsolicited proposal to NSF/AST starting in FY 2009. The Phase I proposal was positively received and resulted in significant funding. Public access to the Hale 5-m telescope at Palomar is now available through a 3-year partnership with Caltech for 23 nights per year, and a copy of the MDM OSMOS optical spectrograph for the Kitt Peak Mayall telescope is being built in partnership with the Ohio State University. In addition, critical detector and controller upgrades for Hydra at CTIO and for the 4-m CCD mosaic imager at Kitt Peak are underway. In the second year of Phase I, funding is likely to be available to build a second copy of OSMOS and a copy of the "TripleSpec" IR spectrometer, in partnership with Cornell University. Both instruments would be destined for the Blanco 4-m telescope at Cerro Tololo.

Other Phase I activities, not yet funded through the ReSTAR proposal, remain high priorities. The provision of time-domain facilities and operating modes that support time domain observations require detailed study - this aspect of Phase I should receive high priority. The option of adding adaptive optics capability to existing telescopes should be explored in more detail, and options to provide public access to optical interferometry through partnership with existing interferometers should be explored.

A second "ReSTAR Phase II" proposal is planned for submission to NSF/AST early in FY2012. Because of the long lead time to identify partners and the need to guide the detailed content of future phases by what has already been accomplished, NOAO reconvened the ReSTAR committee to update its vision of the state of the 2-5 meter part of the U.S. OIR System, and to make recommendations about how to proceed in assembling the Phase II proposal. The committee was specifically charged with:

- Reviewing the details of the original ReSTAR report, the implementation white paper, and the Phase I proposal.
- Examining the status and outlook of the work underway in Phase I.
- Examining the status and outlook of any facilities or projects (NOAO and external) that may be relevant for understanding the current needs and condition of the 2-5m part of the U.S. OIR System.
- Developing a prioritized list of activities for Phase II.
- Developing recommendations concerning the process of producing a proposal for Phase II, particularly the solicitation and selection of partners.

The Committee met on July 15-16, 2010, in Arlington, VA. Attending members included

Deidre Hunter (Lowell Observatory)
Jennifer Johnson (Ohio State University)
Robert Joseph (University of Hawaii)
Steven Kawaler (Iowa State University)
Lucas Macri (Texas A&M University)
Catherine Pilachowski, Chair (Indiana University)
John Salzer (Indiana University)
David Trilling (Northern Arizona University)

Charles Bailyn (Yale University), Tom Barnes (University of Texas at Austin), and Michele Thornley (Bucknell University) were unable to attend.

At this meeting, the ReSTAR committee addressed issues associated with the health of the 2-5 meter system of telescopes, both federal and non-federal, with the understanding that long-term goals include strengthening the infrastructure for all US research telescopes within the ReSTAR aperture range. Discussions included the balance of available instrumentation and the need for new or enhanced capabilities as well as the need to respond to the evolution of the US observing system.

The recommendations for ReSTAR Phase II are described in the sections below. We stress that the recommendations and priorities found in the original ReSTAR report remain valid and strongly supported by the ReSTAR committee; among these is the recommendation to increase the number of research facilities in the 2-5 meter aperture regime. Building new instruments addresses a crucial need to increase scientific capabilities. However, the committee recognizes that hand-in-hand with modern, competitive new instrumentation must come an increase in telescope access in order make maximum use of those instruments. This need will become particularly critical regarding 4-m class telescopes in the southern hemisphere over the next several years. Therefore, we recommend that NOAO pursue additional access to 2-4-m class telescopes that could host new instruments coming on line, particularly in the southern hemisphere.

Instrument Capabilities

The committee emphasizes the goal of improving observing capabilities on all telescopes within the ReSTAR system, including non-federal facilities as well as NOAO facilities. Initial investments in Phase I were allocated to provide new, state-of-the-art instrumentation on the Blanco and Mayall 4-m telescopes, and our top priority is the completion of those new instruments. Future investments in instrumentation should be considered not only on NOAO facilities, but on non-federal telescopes as well. The recommendations below for augmentations to ReSTAR instrumentation are presented in priority order.

Two new wide-field imagers were underway at the time of the original ReSTAR report: the Dark Energy Camera (DECam) destined for the Blanco 4-m at Cerro Tololo and the One Degree Imager (ODI) destined for the WIYN 3.5-m telescope at Kitt Peak. The ReSTAR committee reiterates the importance of completing these instruments. Wide field optical imaging is a critical and much-needed capability in the ReSTAR system.

Plans to offer increased access to low resolution optical and IR spectroscopy, in some cases with multi-object capability for modest-sized fields, will help to address community needs. These include access to TripleSpec at Palomar, new OSMOS spectrographs at Kitt Peak and Cerro

Tololo, a new TripleSpec at CTIO, and the Goodman Spectrograph at SOAR, all of which are valuable additions for low and moderate resolution spectroscopy. The Committee is concerned that insufficient spectroscopic time will be available at Cerro Tololo over the next five years, since the OSMOS copy at CTIO will compete with DECam during dark time and NEWFIRM will compete with TripleSpec during bright time. A similar problem could occur in the north, but could be alleviated by providing public access to more non-federal telescopes supporting new instrumentation. Public access time at Palomar provides access to TripleSpec on the Hale telescope and is an important contribution to the ReSTAR system in the northern hemisphere.

Additional access to high-resolution optical spectroscopy remains a high priority within the scope of ReSTAR. Such access could be provided through partnerships with non-federal facilities equipped with echelle spectrographs, rather than on NOAO facilities. Specific needs (for resolution, wavelength coverage, long-slit vs. single object) vary widely and access to more than one spectrograph would be beneficial to meet the wide range of scientific capabilities needed. We recommend specifically that NOAO pursue options for access at multiple facilities offering high-resolution spectroscopy, with resolving powers from 30-60K, to address the range of needs.

Wide field IR imaging capability remains important, as evidenced by the heavy oversubscription for NEWFIRM on both the Mayall and the Blanco. Community access to WFCAM on UKIRT or WIRCAM on CFHT may be a good avenue to sustain wide field IR imaging in the northern hemisphere, permitting NEWFIRM to remain at Cerro Tololo. Availability of narrow band filters is important for many scientific programs in the IR. Hence, instruments compatible with narrow-band imaging are preferred, and support for filter acquisitions should be considered where appropriate.

Access to wide field (FOV of one degree or more), multi-object spectroscopic capability is also important. Hydra at WIYN is aging and may need an upgrade, including new motors and fiber cables. Hydra at CTIO is being upgraded with a new detector that will permit better sky subtraction through a nod-and-shuffle approach.

Capability for high-resolution IR spectroscopy is very limited in both hemispheres. Available IR high-resolution spectrographs (including Phoenix, for which a new home is needed, and CSHELL on the IRTF) offer limited wavelength coverage. The planned ISHELL instrument on the IRTF (scheduled for completion in 2014) will be a useful addition, but additional access to IR spectroscopy with more complete simultaneous wavelength coverage remains a priority, perhaps for telescopes with larger aperture.

Recent AO systems for mid-sized telescopes are more user-friendly, are more reliable than first generation systems and may be deployed at lower cost. Low order systems might effectively improve efficiency of almost all capabilities by significantly improving image quality. A feasibility study for the development of a low-cost, versatile system that could effectively feed existing instruments on existing telescopes at both NOAO and elsewhere as part of the ReSTAR system should be undertaken. Such an evaluation should include a complete study of life cycle costs, quantify benefits to science productivity, and estimate the cost/benefit ratio.

The committee recognizes that NSF/AST manages several programs that support development and deployment of instruments. Of these, only the Telescope System Instrumentation Program (TSIP) requires that the proposing institution provide community access to non-federal facilities and/or data in partial return for funding. The committee observes that such access is valuable and believes that offers of access as part of proposals for other programs should be welcomed and should count positively in their review.

Operations and Infrastructure

Major surveys either underway or starting soon will substantially increase the need for new observing modes for time domain science and time-constrained follow-up observations of transient events. A study should be undertaken to understand how the operation of public access facilities can be fine-tuned to address these needs, including formal mechanisms to support significant numbers of targets of opportunity and synoptic observations. The study is particularly critical in advance of LSST operations. Developments at the Las Cumbres Observatory may be particularly helpful for understanding issues involved in support of time-domain science observing needs.

The scientific potential in following up large surveys (Kepler planet-hosts, for example), is enormous, especially if follow up is approached in an organized way rather than through piecemeal projects by a variety of PIs working independently. We encourage NOAO to develop a strategy to facilitate formation of collaborative teams to maximize the scientific return from public access facilities for follow up of major survey data. This contributes as well to preparation for the LSST era.

The Blanco 4-m will soon receive DECam and host the Dark Energy Survey, which will receive 100 nights of observing time per year for 5 years. Proposals for a similar arrangement at the Mayall 4-m have recently been solicited. Such initiatives should be considered on major public access facilities only if they provide outstanding new instruments that meet high-demand needs of the user community and/or provide significant data products of wide scientific interest to the community. The consequences of such major commitments of observing nights should be considered in detail, and consistent policies developed to continue to support a range of programs, including traditional PI observations, surveys, coordinated followup programs for large surveys, time domain science, etc.

Remote observing has become common at many observatories, such as APO, IRTF, Keck, SARA, WIYN, and SOAR (only for university partners in the case of the latter two). NOAO should review the approaches in use at these facilities and encourage common standards and usage for remote observing, with the goal of implementing remote observing at NOAO facilities as feasible. As a first step, remote observing should be implemented for experienced NOAO users at WIYN and SOAR. Following its implementation at WIYN and SOAR, an extension of remote observing to the Kitt Peak and Cerro Tololo 4-m telescopes should proceed.

The CHARA initiative to provide public access for interferometry and the proposed Magdalena Ridge Observatory workshop and conference on *Science with Optical Interferometry* are good first steps toward broadening community interest and expertise in interferometry. NOAO support of these and similar initiatives is encouraged. Such support might include, for example, assistance with community outreach and peer review for community access.

The use of archival data is increasingly part of many science programs. Mechanisms to improve the utility of ground-based OIR data for archiving purposes, accessible through the Virtual Astronomy Observatory (VAO), include the following:

- Documenting standard, good-practice observing procedures and calibration guidelines for instruments used for public access, and providing this information to observers.

- Assuring that new instruments on NOAO facilities and/or funded by the NSF produce VAO-compliant data.
- Encouraging authors of AAS journal papers to provide reduced data to a repository, where appropriate, for archiving purposes.

Partnerships for Phase II

NOAO should pursue opportunities for increasing access to instrumentation and to observing nights at non-federal observatories in both hemispheres. Such opportunities may take the form of new consortia in which NOAO would have a "seat at the table" in discussions about new instrumentation, operations, and future directions, or may simply involve the purchase of observing nights at a facility. Arrangements may involve capital contributions, contributions of new instruments, or even trading nights to obtain access to capabilities not available on NOAO telescopes. Several criteria are important in considering arrangements for providing public access nights on non-federal facilities:

- Public access should be provided for a minimum of 3 years, with longer arrangements preferred, to allow the user community to make effective scientific use of the instrumentation.
- The arrangement should provide enough public access nights per year to generate community interest.
- The capabilities provided should be important and desired additions to the observing system, and could provide access to specific instrumentation, access to capabilities heavily over-subscribed on NOAO facilities, or access to operations modes not available on NOAO facilities.
- The original ReSTAR report identified a clear need to set standards for the ReSTAR system for efficiency, reliability, performance, documentation, usability, and data quality. Decisions on new partnerships to provide public-access nights should include a review of the maturity and completeness of instrument documentation, the availability of data reduction tools or documentation on data reduction, and the availability of technical support to assure that public-access users can make effective use of the facility. An important goal of ReSTAR is to strengthen the system by improving infrastructure system wide. Proposals for participation in the ReSTAR system should address infrastructure improvements at non-federal facilities (if needed) as well as instrumentation and public access.
- In addition, participants in the ReSTAR system are expected to provide data in a format that can be transported readily to common reduction software packages, and image headers that allow users to reduce their data using those packages. We reaffirm the critical importance of these requirements to the success of the system in serving the astronomical community.
- Non-sidereal tracking is highly desirable for solar system science, and should be considered as an important operations mode within the system.

The next step in planning for ReSTAR Phase II is the selection of non-federal facilities interested in partnering with NOAO to develop new capabilities or increased public access within the system. The selection process should be open and transparent, and provide a level playing field for all potential partners, while also providing sufficient guidance on options for participation, potential returns to non-federal partners, priorities for instrumental and operational capabilities needed in the ReSTAR system, and requirements for support of public users. The ReSTAR committee considered a variety of approaches, and recommends the following process.

- Draft a preliminary solicitation for proposals
- Hold a workshop, inviting all potential participants, to present guidelines for proposals for participation in the ReSTAR system, to discuss the process for selection, and to receive comments on the preliminary solicitation.
- Finalize and distribute the final solicitation to potential partners.
- Receive proposals.
- Review of proposals for technical content by NOAO staff.
- Conduct a review and selection process by a committee including external members (including some ReSTAR members) and some NOAO staff. Access to instrumental capabilities highlighted above should be a key criterion for the selection of new partners.
- Negotiate final terms with selected partners.
- Complete and submit NSF proposal for ReSTAR Phase II.

The final form of the proposal will depend on the partner(s) selected. The proposal could be submitted by AURA only, or as a collaborative proposal from multiple institutions.

International Partnerships

NOAO (and NSF) may wish to consider mechanisms for the participation of international partners in the ReSTAR system. Additional telescope access, especially in the southern hemisphere, is a high priority and international options may provide opportunities for increased access.

It may be appropriate to invite potential international partners to attend the Phase II workshop, as well as potential domestic partners. In addition, parameters for an expansion of the ReSTAR system with non-US facilities should be explored. What advantages might accrue to international partners through participation in ReSTAR, and what options are appropriate for their participation? From the US perspective, international partners can expand public access, contribute instrumentation or unique capabilities not available from US telescopes, and incorporate new communities and ideas into the ReSTAR system.

One potential international partnership to increase observing nights available to the US community could involve the UK Infrared Telescope (UKIRT) on Mauna Kea. UKIRT is a 3.8 m telescope providing excellent image quality (median seeing ~ 0.5 arcsec at K). Its complement of state-of-the-art instruments includes WFCAM, a wide-field, 1-2.4 μm imager with a field of view of 0.2 deg^2, and three additional (currently inactive) Cassegrain instruments. Access to WFCAM on UKIRT could alleviate the need to transport NEWFIRM between the north and south. UKIRT could be incorporated into the US system by: a) buying observing time, which would be exclusively for use of WFCAM; or b) for a larger sum, NOAO could become a full partner.

Likewise, an international partnership with CFHT on Mauna Kea would bring strength to the US system, including expanded access to optical wide field imaging in the northern hemisphere and also possible access to a high resolution spectrograph. Other potential international partnerships should also be explored, particularly in the southern hemisphere, where options for partnership with other US facilities are more limited.

Metrics for Measuring Success

The *raison d'être* for ReSTAR is both to respond to the community concern that there is insufficient access to telescope time and state-of the-art instruments, and also to deploy astronomical resources more strategically and efficiently by taking a system point of view of both non-federal and federally-funded observatories. In a time of scarce resources, measuring the success and impact of ReSTAR investments is essential. The committee notes the difficulties of interpreting the most commonly used metric, oversubscription rate, particularly in the lag between the announcement of a new capability and full community acceptance. Possibly better metrics include measuring changes in the number of distinct individuals PIs winning public access observing time, the number of new individuals applying for or receiving public access observing time, the number of nights offered, or the number of nights used with instrumental capabilities identified as ReSTAR priorities. Measuring success in meeting the second goal is more difficult. One diagnostic would be an increase in the percentage of nights each instrument is in use on a telescope rather than sitting idle. An increase in publication rates associated with infrastructure improvements and new instrument capabilities on individual facilities could also serve as a meaningful metric, although the timescale for such impact to be apparent will likely vary with the type of instrumentation and could be measured in years.