

ReSTAR Meeting Summary

Renewing Small Telescopes for Astronomical Research

The ReSTAR committee met on May 14-15 at NOAO in Tucson to begin its discussions concerning the future of small and moderate aperture telescopes through the next 10 years, particularly in the pre- and post-LSST and Pan-STARRS era. In attendance were Charles Bailyn (Yale University), Michael Briley (University of Wisconsin Oshkosh), Chris Clemens, (University of North Carolina), Jennifer Johnson (Ohio State), Deidre Hunter (Lowell Observatory), Robert Joseph (University of Hawaii), Steven Kawaler (Iowa State), Lucas Macri (NOAO), Randy Phelps (Sacramento State), Caty Pilachowski (Indiana), and Michele Thornley (Bucknell University). Tom Barnes attended representing the National Science Foundation and Todd Boroson attended representing NOAO. Suzanne Hawley (ARC Observatory Director) and George Jacoby (WIYN Observatory Director) attended as representatives of the group of private observatory directors.

The NSF View - Tom Barnes addressed the hope of the NSF in asking NOAO to establish the ReSTAR Committee in response to the Senior Review Report. The Committee should consider the system of telescopes available to the U.S. community in a comprehensive way, considering the suite of large, moderate, and small aperture telescopes working together to achieve the scientific goals of the community. The Senior Review report provides guidance on the key aspects of our charge: to identify the first-rank science that can and should be done with telescopes of small and moderate aperture, to work with the community to establish the scientific case for these telescopes, and to define what capabilities are needed to carry out first-rank science with them. Our recommendations will need to address both community needs in the next few years, and in the era of GSMT, JWST, ALMA, and LSST in the next decade. We are to consider not only the renewal of existing telescopes, both federal and non-federal, but also the need for new telescopes, new instrumentation, and new operating modes.

In discussion, the Committee identified many of the key issues that confront us.

- The role of small (< 2 meters) and moderate (2-5 meters) aperture telescopes is much more multi-faceted than that of the largest telescopes >6 meters.
- Many models have been developed in the community for the construction and operation of small and moderate aperture telescopes, and there are lessons to be learned from these experiences. One example is the successful SMARTS consortium, which operates four small telescopes at Cerro Tololo.
- Our system of federal and non-federal telescopes sometimes operates inefficiently, with considerable duplication of expensive instrumentation, much of which is used only a small fraction of the time at any one facility.
- The community continues to struggle with the challenge framing the scientific questions to be addressed with small and moderate aperture telescopes in a context of big-telescope science.

- The mix of scientific programs on small and moderate aperture telescopes, including both traditional "PI science" programs requiring modest amounts of time and large survey programs requiring significant fractions of time on individual facilities, introduces a tension in the allocation of resources. Understanding how to balance the needs of both types of programs with limited telescope access is a challenge.
- Small and moderate aperture telescopes provide opportunities for university instrumentation programs to explore new technologies and to develop new instrumentation concepts that may prove valuable on larger aperture telescopes, as well as to develop human capital in astronomical instrumentation.
- Our attachment to facilities that have made significant contributions to astronomical knowledge over decades and that are continually renewed with new instrumentation, sometimes makes it difficult for us to determine when it may be more cost effective to close those facilities to replace them with new ones.
- Many small and moderate aperture telescopes have invested in new instrumentation for imaging, both wide field and high spatial resolution and both optical and infrared, but investments in spectroscopy have lagged behind.
- Time resolved imaging and spectroscopy is also an unmet need. Telescopes with apertures of 1 meter are probably too small for time-resolved, spectroscopic programs, where apertures of 3 meters are larger are more useful.
- Operating private consortia has proved to be a difficult challenge because of limited resources for operations, management, and technical support. NOAO may appropriately play a role in management and operations, but the need to build to standards and specifications to reduce support costs drives construction and fabrication costs up.
- We must consider how the role of small observatories will change in an era of large survey instruments. Followup and precursor observations will clearly be important, but how will the availability of large datasets and effective tools for data mining change how people do science?
- The different roles and strengths of public and private observatories must be considered carefully in the formulation of an effective system of small and moderate aperture telescopes.
- How does one determine how much access is needed to telescopes of small and moderate aperture? The number of nights needed for public access at different apertures is clearly driven by the potential for accomplishing front line scientific goals, but other criteria are also important, including education and training, technology development, etc.

The Committee enumerated many different ways that small and moderate aperture telescopes contribute to the health of astronomy and the astronomical community.

- PI science programs
- Large surveys
- Education and training
- Technology development
- Infrastructure for supporting instrument building groups
- Leveling the playing field for large telescopes

- Time domain science programs, including those that require telescopes spaced longitudinally for long time coverage
- Calibration of data from larger, ground-based telescopes and from space telescopes.
- Programs requiring multiwavelength and/or multi-technique observations

The ReSTAR Charge - The charge of the committee is available on the ReSTAR website. We concluded that telescopes could be considered most effectively in three groups, those with apertures larger than 6 meters, those in the range from two to 6 meters, and those smaller than two meters. Larger telescopes are served by the TSIP program and face different issues than do the mid-sized telescopes. Smaller telescopes of 1-m aperture also face a different set of challenges and probably would benefit from a different structural solution for community access than for the mid-size telescopes. Our charge is to focus on the mid-size and smaller aperture telescopes, and our goal is to produce a science-justified blueprint for a system of telescopes of 1-6 meters available for community access. Our blueprint should include the components required to meet community needs, including numbers of nights and clearly defined instrumental capabilities and operational modes that enable front line science.

Comments from ACCORD Liaisons - George Jacoby, Director of the WIYN Observatory and Suzanne Hawley, Director of the ARC observatory, are participating as liaisons with the nascent group of private observatory directors organized through ACCORD. Jacoby noted that the ReSTAR Committee could have a significant impact on the landscape of astronomy during the period between decadal surveys and other National Academy reports. He described the role of ACCORD (AURA Coordinating Council of Observatory Research Directors), for whom an important goal is the construction of 20-30-m telescopes. Jacoby urged the ReSTAR Committee to focus on the science that drives the need for small and moderate aperture telescopes, and to produce a blueprint that truly addresses scientific need. He noted that the 3rd System Workshop, held last November under the auspices of NOAO and ACCORD, included a recommendation for well-instrumented small and mid-sized telescopes to support "big science" initiatives. We need to look not only at the capabilities of individual facilities but at the capabilities of US system as a whole.

Suzanne Hawley, Director of the ARC Observatory, reported on a discussion held among the directors of mid-sized telescopes under the auspices of ACCORD. The meeting included the directors of nearly all of the 2-m to 5-m telescopes in the U.S., both public and private, and including the StarFire Optical Range telescope and AEOS 3.5-m on Haleakala.. The directors looked at common issues and concerns to begin to explore ways to solve common problems. Their discussions included a preliminary exploration of the formation of a broader system of telescopes in the U.S., including both public and private facilities, offering community access. The level of interest among the facilities varied widely, but most directors saw that increased public access to private facilities, in return for federal support for new instrumentation or operations, might be of mutual benefit. The fraction of time that might be available for public access to private facilities varied from a few nights per year up to perhaps 100 nights per year.

Borosan noted that it is the ReSTAR Committee's task to set the requirements for a national system of small and moderate aperture telescopes, and the owners and operators of these telescopes will be involved in deciding how those requirements can be addressed.

The Private Observatory Directors are collecting information about their several sites; that information can be made available to the community through the ReSTAR website. A list of U.S. public and private facilities is included below.

KPNO	McDonald	UH 2.2m
Mayall 4m	2.7m	Lowell DCT 4.2m
WIYN 3.5m	2.1m	SDSS 2.5m
2.1m	CFHT 3.6m	Mt Wilson 2.5m
CTIO	IRTF 3.0m	MROI
SOAR 4.2m	MDM 2.4m	2.5m
Blanco 4m	WIRO 2.3m	10 X 1.4m
ARC 3.5m	USAF	CHARA
Palomar 5m	SOR 3.5m	NPOI
Lick 3m	AEOS 3.6m	PTI
Steward 2.3m	OCIW DuPont 2.5m	

One issue that will need further discussion is the need for user support, standardization, and quality control to assure effective utilization of non-federal telescopes through public access.

The Landscape Today - The Committee turned to a overview of the current state of ground-based, OIR facilities and capabilities, including the literature on the science and productivity of small and mid-sized telescopes in the past decade, a summary of NOAO user statistics for small and mid-sized telescopes and of existing collaborations between NOAO and community groups, a report on the TSIP program, and a brief tour of U.S.-based, mid-sized telescopes.

Concerning the literature on the science and scientific productivity of small and mid-size telescopes, the Committee found little guidance concerning the role of such telescopes in the coming decade when ALMA, LSST, JWST, and perhaps GMST will dominate the astronomical landscape. It is clear from the literature, however, that small and mid-size telescopes continue to be both scientifically productive and cost effective.

Letizia Stanghellini provided an analysis of recent requests for and allocations of telescope time on small and mid-size telescopes at NOAO, including the number of requests received, the number scheduled, oversubscription factors, the length of observing runs, and the instrumentation most frequently requested. The most requested instrumental capabilities are optical imaging, optical low resolution spectroscopy, infrared imaging, and optical high resolution spectroscopy. These account for 93% of the requests, with the remainder of the requests divided among many different capabilities.

Todd Boroson reviewed the TSIP program, generally considered to be successful both for providing funding to enable significant new instrumentation for large (>6-meter) telescopes, and for providing public access observing time on those telescopes. WIYN, a 3.5-m telescope, has also benefited from TSIP funding, but generally mid-size telescopes have found the TSIP funding formula too costly. TSIP funding has been between \$2-4M per year, and has obtained some 244 nights of observing time on large telescopes allocated through the NOAO TAC process.

Science Themes for Small and Mid-Sized Telescopes - The Committee explored what will likely be important science themes for small and mid-sized telescopes between now and 2016. By 2016, Pan-STARRS, LSST, ALMA, and JWST will be in operation and GSMT may also be operating, and all will be factors in defining important observational programs for ground-based, OIR telescopes of all apertures.

The committee noted many surveys, either underway or planned, that will also impact the use of small and mid-size aperture telescopes, including UKIDSS (UK Infrared Deep Sky Survey), VISTA, the UKIRT Hemisphere Survey, the CFHT Legacy Survey, the Dark Energy Survey, and many more. Followup observations on small and mid-sized telescopes will continue to leverage the scientific productivity of these large surveys. Specialized optical imaging (e.g. narrow band filters or high spatial resolution), deep and wide field infrared imaging, and moderate and high resolution optical and infrared spectroscopy will continue to be important capabilities. The impact of large surveys will not be limited to followup observations but will also affect traditional observing programs as well, likely increasing sample sizes and providing ancillary data to support ground-based programs.

Our charge includes defining not only instrumental capabilities but also operational modes that will enable front line science with small and mid-size telescopes. Operational modes that will enlarge the scientific opportunities in the next 10 years include time-domain scheduling, a rapid response capability, a queue observing mode, and remote observing for classically scheduled observational programs. Effective utilization of new operating modes and the availability of massive new surveys and survey facilities will drive the need for cultural changes in how astronomers use telescopes. Small and mid-sized telescopes will play an important role in preparing the community to take best advantage of the resources becoming available in the next decade.

A variety of issues were identified by the Committee for further discussion.

- How can the various operating modes be optimized to produce the best science?
- How can multi-instrument and multi-wavelength programs be better integrated into the system to improve productivity and lower risk?
- In which cases should triggers for followup observations of TOO events be community driven (for example, for rare events of high scientific priority), and in which cases should triggers be PI driven?

- What processes need to be in place to trigger TOO observations when high priority events occur? In the era of LSST, TOO events may be too numerous to rely on a "hands on" system for implementation.
- How important is a balance in capability between north and south, and between surveys and "PI" science programs? LSST is planned for the southern hemisphere, while the balance of non-federal small and mid-size telescopes is in the north.

Among the most difficult questions to answer is the question of how many nights on small and mid-size telescopes must be available to support the needs of the community. Demand for NOAO facilities has dropped, and the current level of requests for nights may be limited by several factors: the decline in the number of nights available, the community perception of facilities' closings, a shift toward access through private or non-federal facilities, and the very real decline in efficiency and performance due to aging instruments and control systems. Oversubscription factors on some telescopes remain large and may also discourage many astronomers from applying for time.

Toward a System of Small and Mid-Size Telescopes - The Committee's goal is to create a blueprint for developing a system of small and mid-sized telescopes, including the specific capabilities that will enable front line science with such telescopes and maximize their scientific productivity. Our blueprint should include reliable cost estimates for improving telescopes, building new instruments, and operating telescopes to support the general community. New modes of operation that enable new science should also be part of the system. In some respects, our blueprint should also be a roadmap, defining how the system might evolve as the impacts of LSST, ALMA, JWST, and GSMT become more real.

The Committee sees real benefit for the community in developing a system of effective and competitive small and mid-size telescopes. Such a system can provide multi-wavelength access and access to the time domain, as well as make more effective use of scarce instrumentation resources by avoiding duplication on many telescopes. Access to more specialized instrumentation by the wider community may also be facilitated through a system approach.

Our focus in exploring and characterizing a system of small and mid-sized telescopes needs to remain on front line science. We need to identify key science that can only be done on such telescopes as well as science drivers that lead us to particular capabilities.

The committee explored the advantages of coupling grants with telescope time as a good way to maximize the science. This approach avoids the double jeopardy of trying to get both funding and telescope time through different processes. But such coupling could also disadvantage users supported through agencies and sources other than NSF.

Community Input - The Committee emphasized the importance of broad participation by the U.S. astronomical community as we develop a blueprint for a system of small and mid-size telescopes. We discussed both the type of comments we hope to hear from the community and the mechanisms for collecting the community's comments.

The Committee agreed to pursue several mechanisms for soliciting community input.

- NOAO will develop a website with a specific form for community comments. The community will be informed about the website through an AAS email announcement, an NOAO email announcement, an NOAO Newsletter article, and a handout at the AAS meeting in Honolulu.
- We will mail a specific request to department chairs encouraging faculty discussions and offering to visit institutions that are willing to host regional discussions about the formation of a system for small and mid-sized telescopes.
- We will explore notices in various discipline-related newsletters such as the Star Formation newsletter, the Standard Stars Newsletter, etc. There is a concern that this approach will lead to an imbalance in input from different areas of astronomy.
- Each member of the Committee will directly contact a dozen or more colleagues to personally solicit input, particularly in the form of science cases for telescopes of small and mid-sized apertures.

We will also seek advice from Roger Blandford, who chaired the Senior Review, on assessing community needs for small and mid-size telescopes.

Finally, we will coordinate with the ACCORD group and the NOAO Users Committee to make sure those groups are apprised of our progress.

In framing our communication with the astronomical community, we need to be mindful of the community's long-standing concerns about the priority of federal funding for small and mid-sized telescopes in a world of big-telescope aspirations. We need to make clear that the Senior Review strongly endorsed the role of small and mid-size telescopes and that the NSF and NOAO are committed to making sure these telescopes are funded adequately to support front line science. NOAO's current efforts to renew the infrastructure at CTIO and KPNO should be highlighted. It is also important for people to know they will have the support needed to make use of non-federal facilities participating in the system. NOAO and NSF are committed to making a profound change in their support of small and mid-size telescopes.

The focus of community input needs to be on the science case for small and mid-size telescopes. The science case serves as the "design reference mission" for developing a system of such telescopes. While the science case cannot cover all science that the community will want to carry out on small and mid-size telescopes, it should fill parameter space so that the needed capabilities can be well specified and costed. We also understand that the science case written in 2007 may not accurately forecast the science to be done in 2014. We need to be sure the community has the capability to do what it will need to do into the next decade.

Getting clear, useful, and well-focused input from the community is vital. Our web-survey needs to be designed to elicit the basis for a strong science case for the operation of small and mid-size telescopes. Below is a starting list of ideas for survey questions suggested by the Committee.

- Select or rank the instrumental or operational capabilities most useful to you as a user of small or mid-size telescopes. Include "other" to be specified by the person completing the survey.
- Ask for the science cases to be described in a quantitative way - how many nights will be needed, what types of observations are needed?
- Ask why users have/have not applied for NOAO time recently
- Ask what avenues have been explored to gain access in other ways than through NOAO. Ask what support requirements (documentation, telescope and instrumentation assistance) are needed to use a non-federal telescope effectively in a system supported with federal dollars?
- What special operations modes would be particularly useful? What new science is enabled by remote observing, service observing, time domain scheduling?
- What are the "killer apps" for 2-4 meter class telescopes?
- What is the science that needs to be done, and done with these telescopes.
- What is the level of demand for small and moderate aperture telescopes?

What do we need from NOAO? Additional information from NOAO would be useful for the Committee. NOAO will provide a table showing its current and pending commitments of time on various NOAO facilities through partnerships and agreements with other institutions.

NOAO may also carry out a review of the recent literature to illuminate current trends in the usage of small and moderate aperture telescopes.

The Science Case - In preparation for our second meeting, which will focus on the preparation of a science case, the ReSTAR Committee formed seven subcommittees. Their task is to solicit comments from colleagues, to review comments submitted by the community, and to synthesize that input into coherent science cases to be discussed with the full committee at our next meeting in July. The seven subcommittees are:

- COSMOLOGY (+DARK MATTER, DARK ENERGY - Salzer (chair), Johnson, Macri, Joseph
- STRUCTURE AND EVOLUTION OF GALAXIES: Hunter (chair), Macri, Thornley, Joseph, Salzer
- BLACK HOLES / ACCRETION / HIGH ENERGY PROCESSES: Bailyn (chair), Joseph, Briley
- STAR FORMATION / ISM: Weintraub (chair), Phelps, Hunter, Thornley
- STELLAR PHYSICS: Johnson (chair), Briley, Clemens, Kawaler
- EXTRA-SOLAR PLANETS: Briley (chair), Kawaler, Weintraub
- SOLAR SYSTEM: Hunter (chair), Johnson

Drafting the Report - The Committee agreed that two important threads should dominate our report. First, the report should be science-based, and emphasize the science case that drives the need for access to small and mid-size telescopes. Second, the report should echo the six principles that defined and guided the thinking of the Senior Review. Those six principles are

- Optimizing the Science
- Optimizing the Workforce
- The Public Dividend
- Bridging Artificial Divisions
- Engaging the University Community
- Astronomy without Borders.

Future Meetings - Our next meeting will take place in July and may be held in Arlington at the NSF. The committee will be polled to determine whether July 19-20 or July 30-31 would be preferred. NSF staff and others in the Washington DC area (including Kevin Marvel, Bill Smith, and Jay Frogel) may be invited to attend as well.

Our third meeting will take place in October near an airport hub. We will explore whether a meeting at Fermilab might be possible.

Our fourth and final meeting will take place in December in Tucson.