



from
the **Director's Office**

The Decadal Survey—Implications for NOAO

Todd Boroson

The role of the national observatories within a changing international landscape of astronomical research and facilities was a fundamental topic of discussion for the Astronomy and Astrophysics Survey Committee (AASC). Inspired by the report of a cross-panel (representation from all relevant panels) on the national observatories, the policy panel and the “O/IR Astronomy from the Ground” panel converged on a philosophical approach for the community that leads to a new vision of the complementary roles of NOAO, the independent observatories, and the funding agencies. This philosophical approach is that the entire suite of facilities and capabilities for ground-based O/IR astronomical research should be viewed as a single system—and that improvements in that system should go forward in a coordinated way.

For NOAO, the major tasks are:

- To lead the development of a strategic plan for the “system.” That planning must involve all segments of the community. An implementation process must be established that affords some accountability in ensuring that investments are made in service of the strategic plan.
- To lead efforts for the community in the development of facilities that are too big or expensive to fit within the resources of a single institution. These may be carried out as national projects, collaborations with US institutions, or international partnerships. In all these cases, NOAO should represent the interests of the US community.
- To provide those capabilities that are, by definition, community-wide or are considered complementary to those available through the independent observatories.

For the universities and independent observatories, the major tasks are:

- To work with NOAO on the planning process for evolution of the system.
- To develop those facilities that are appropriately within the scope of the independent observatories, and to develop acceptable mechanisms for sharing access to these with the rest of the community.
- To assume the responsibility for small telescopes needed for their students and faculty.

The AASC recognized that this role of overseer, or steward, for the system is a new one for NOAO, and one which NOAO is not now structured to undertake. Thus, the committee recommended that NOAO, AURA, and the NSF work together to develop and implement a transition plan, and that this plan and NOAO’s progress in carrying out this new role be reviewed periodically.

Within this new context, several new initiatives that suppose NOAO involvement are put forward in the AASC and panel reports.

Giant Segmented-Mirror Telescope

The Giant Segmented-Mirror Telescope (GSMT) is the highest priority large ground-based initiative (second, after NGST, for space and ground combined). GSMT is a 30-meter class, AO-equipped, optical and infrared telescope that will provide complementary capabilities to (and will be coeval with) NGST. Through observations at high spatial and spectral resolution, GSMT is expected to make major contributions to our understanding of star and

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planet formation, formation and early evolution of galaxies, and the star formation history of nearby galaxies. A wide-field, seeing-limited mode will permit extremely large-scale spectroscopic surveys to explore such topics as the evolution of large-scale structure and the detailed history of the stellar population of the halo of the Milky Way. GSMT is envisioned to be developed as a partnership, as either a US public/private effort or an international effort. NOAO is expected to initiate a strong program to position the community for effective participation.

Large-Aperture Synoptic Survey Telescope

The next priority of the O/IR panel is the Large-Aperture Synoptic Survey Telescope (LSST). This is a 6.5-meter class, wide-field telescope with the ability to map the entire accessible sky to 24th magnitude (in one optical band) over the course of three nights. Through a single set of observations—and an innovative operations mode—LSST would revolutionize our knowledge of astronomical sources that vary or move. Observations with LSST would locate 90% of all Near Earth Objects down to 300 meters in size, enable computation of their orbits, and permit assessment of their threat to the Earth. It would discover and track objects in the Kuiper Belt and monitor a wide variety of variable objects, including the optical afterglow of gamma ray bursts, distant supernovae, and micro-lensing events. By combining data from multiple observations, very deep images could be produced through which it would be possible to infer the structure of dark matter through weak lensing. LSST is seen as an effort that is inherently national in scope. The challenge may not be the design and construction of the telescope or camera, but rather the computing hardware and software that can process the data stream and allow several groups to discover and follow up certain types of objects in real time. NOAO is expected to lead the effort to develop this facility on behalf of the entire community.

Telescope System Instrument Program

The highest medium-size priority of the entire AASC is the Telescope System Instrumentation Program (TSIP). This initiative is a renewal of the Facilities Instrumentation Program (FIP) at the NSF that was established as a result of the McCray Committee report. The FIP funded large instruments for the independent observatories in exchange for telescope time provided by those observatories to the entire community. The TSIP differs in two important ways from the old program. First, its goal is explicitly to foster the development of the system of public and private facilities, and so decisions within it are guided by the system strategic planning that was described above. Second, the exchange rate between funds and telescope time has been cut in half. Half of the funds are seen as support for the independent observatories' improvement of the suite of capabilities, and half are seen as providing broader access to the elements of the system. The TSIP is to be budgeted at \$5 million per year. NOAO's participation in this program is closely connected to its role of coordinating the evolution of the system of facilities, as described above.

National Virtual Observatory

The highest priority small program recommended by the AASC is the National Virtual Observatory. This initiative, developed by the panel on Theory, Computation, and Data Exploration, involves the integration of all major astronomical archives into a system linked through common standards and interfaces and incorporating powerful tools for data mining. NVO will enable professional astronomers, educators, and the public to take advantage of the huge amount of data from existing and planned surveys (such as LSST). NVO will require coordinated support from both NASA and the NSF, since it will serve both space- and ground-based communities. Although details for the structure and management of the NVO are still being developed, NOAO might well play a role in coordinating efforts on behalf of the ground-based community.



NOAO and the Decade Survey

Sidney Wolff

In the previous article, Todd Boroson summarizes those recommendations of the Astronomy and Astrophysics Survey Committee (AASC) that apply directly to NOAO. I strongly endorse those recommendations and will do whatever I can to see that they are implemented. In particular, I am very pleased that the survey gave strong support to several initiatives that have appeared over the past two years in NOAO's own long-range plan (see also the report of the NOAO Users' Committee, which can be found at the end of the *Director's Office* Section of the *Newsletter* and which was prepared before the publication of the AASC report). I am even more pleased that the survey recommends changes in NOAO's mission *and* in the way that NOAO and the independent observatories work together in order to address the challenges presented by the increasingly ambitious questions that astronomers will attempt to answer over the next decade.

An Observing System

Perhaps even more significant than the AASC projects are the recommendations concerning the need for a systems approach to the observing facilities available to the US community. One of the true strengths of US astronomy is that it supports a diversity of approaches in a variety of institutional settings. However, many of the projects that we would like to carry out over the next decade transcend the resources of any single institution. Examples include not only the AASC recommended projects—the NVO, the LSST, and the GSMT—but also such efforts as developing robust multi-conjugate AO systems, optimizing the strategy for instrumenting large telescopes, providing for follow-up of the time-variable objects discovered by the LSST, the building of much larger formats for IR arrays, etc. Some degree of national coordination must become the norm if US astronomy is to be competitive internationally in this new century. What form that coordination should take, and how

we ensure that individual creativity will still have room to flourish, are topics that have been debated not only within the decade survey committees, but also by NOAO and the independent observatories. The fact that we all recognize the need to work together in new ways makes me hopeful that we can put a mechanism in place—an effective national organization, as the decade survey calls it—that is truly national in scope and that engages not only NOAO but the independent observatories and the observing community as well. I will be working with the directors of the independent observatories and others in the community over the next several months to try to develop a way to coordinate large efforts in US astronomy.

AASC Recommended Projects

Several specific projects are highlighted in Todd's summary of the AASC recommendations, and NOAO will support all of them. Accompanying articles by Steve Strom describe in more detail some of the progress we have already toward realizing them. Here I will only summarize the status briefly:

Giant Segmented-Mirror Telescope (GSMT)

There are several technical issues that must be resolved before a 30-m class telescope can be built with confidence about cost, performance, and schedule. NOAO, working closely with Gemini and AURA, has sponsored a number of workshops on science requirements as well as technical issues, and we are currently working out the costs and schedule for the technical studies that will be required. We have also had informal discussions with the other groups currently exploring 30- to 100-m telescopes about optimizing our collective investment in technology development and sharing the results of the studies that we each commission independently.

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Large-Aperture Synoptic Survey Telescope (LSST)

An optical design for a wide-field survey telescope has been developed by Roger Angel (Steward Observatory), Ted Dunham (Lowell), and collaborators. An initial working group meeting, jointly sponsored by Steward, Lowell, and NOAO, was held in Tucson to explore the science programs that could be accomplished with such a telescope and to begin to flow down the science requirements to the telescope, instrument(s), and data handling systems. With the support for this concept from the survey committee, we will now begin to involve the community more broadly in working out the science requirements and developing a fully costed proposal for this facility.

Telescope System Instrumentation Program (TSIP)

Equipping the new generation of large telescopes with state-of-the-art instrumentation must be one of the highest priority tasks for this decade. The independent observatories and NOAO have been working on a white paper for how to implement a program that would provide observing time to the community in return for support of major instruments at the independent observatories. The ability to access time on multiple telescopes will benefit the entire community. Open access is the key to ensuring that a complete range of observing capabilities is available to US observers. No single telescope will be able to address the full suite of astrophysical problems because each large telescope is likely to have only a few (two or three) highly capable, facility class instruments at any given time. The reason is only partly due to limitations in funding. Instruments for 8-m class telescopes typically cost \$3–5M or even more, and it simply makes no economic sense to have many of these sitting around unused. Also, the capacity for building major instruments is limited, and most institutions can undertake only one or possibly two instruments on this scale at any one time. The consequence is that each large telescope is likely to provide a limited number of options in terms of

field of view, wavelength coverage, and angular and spectral resolution. The ability to access the full range of capabilities, no matter where they are located, will therefore benefit *all* astronomers.

National Virtual Observatory (NVO)

The NVO concept has been developed by Alex Szalay, Tom Prince, and others, as well as by the theory panel of the AASC. Several workshops have already been held, including one at NOAO, to develop an implementation plan and schedule for the NVO. The goal of the NVO is the creation of an information infrastructure for astronomy—a system of federated multi-wavelength databases that can be accessed and queried remotely with a common user interface. This virtual observatory will be as effective a tool for discovery as the physical observatories that we already operate.

Ground-based astronomy lags the space community in terms of archiving data, and many issues remain to be resolved about what types of ground-based data have sufficient multiple uses to be candidates for archiving, how requirements for making data archivable will affect observing protocols and calibration procedures, etc. To begin exploring these issues, NOAO has initiated two programs that require that data be archived and made available to the community: 1) several surveys are currently in progress at NOAO on objects ranging from nearby stars to galaxies at high redshifts, and 2) we are making time available to support the SIRTf Legacy program and large Chandra programs. These two initiatives will help us gain experience in developing observing protocols, constructing pipelines, and querying archived datasets for the types of targeted surveys (as opposed to all-sky surveys like Sloan and 2MASS) that are likely to be undertaken by the NOAO user community.



Planning the GSMT

Steve Strom

A decade from now, astronomers will have access to major new tools on the ground (ALMA) and in space (NGST). To exploit these tools fully will require a new generation optical/infrared telescope with angular resolution matched to ALMA, sensitivity sufficient to characterize the faintest sources imaged by NGST, and a combination of field of view and collecting area matched to efficient study of the first emerging large-scale structures in the distant universe—a major scientific driver for both ALMA and NGST.

The minimum-size facility capable of satisfying these requirements is an ~ 30-50 m diameter telescope, capable of delivering diffraction-limited images (Strehl ~ 0.5) at wavelengths 1 micron and longward during atmospheric conditions which enable adequate adaptive corrections (thereby providing 10 mas images matched to ALMA), with sensitivity to faint sources enabling R ~ 5000 spectroscopy at I(AB) ~ 27 mag (sufficient to obtain redshifts and global kinematics for $z > 1$ galaxies), and with a native-seeing field of view sized to enable efficient statistical studies of large-scale structure on spatial scales ~100 Mpc at $z > 1$ via multiplexed spectroscopy of hundreds of background QSOs and thousands of galaxies simultaneously. In practice, this requires fields of projected linear size no smaller than 10 Mpc (at $z > 1$, this corresponds to ~ 20 arcmin for $h \sim 100$). A facility (which for the moment we call the 'Giant Segmented-Mirror Telescope,' or GSMT) providing this combination of sensitivity and angular resolution will not only be an essential complement to ALMA and NGST, but will also enable science qualitatively different from that of current generation ground- and space-based O/IR telescopes.

Owing to the central importance of developing GSMT before the end of the next decade, NOAO has established a New Initiatives Office (NIO),

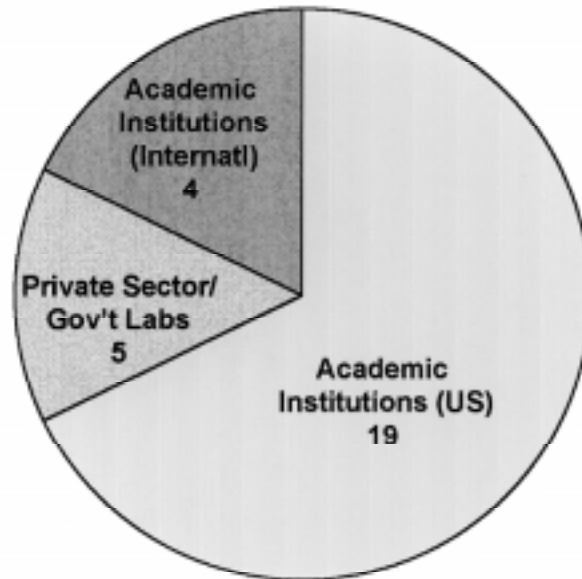
charged initially with developing viable design concepts for next generation telescopes—ranging from the 30-50 m GSMT to an 'ultimate' ground-based telescope of size ~100 m—before the end of 2002, and establishing the appropriate partnerships for completing a ~30-m telescope before 2012, in time to complement NGST and ALMA.

NIO resides within NOAO's new Planning and Development Office, has an initial core staff drawn from both NOAO and the International Gemini Project, and is guided by advice provided by a steering committee comprising senior representatives from NOAO, Gemini, the major US independent observatories, and from government laboratories and the DoD.

It is recognized from the outset that design and development of GSMT represents a substantial effort whose ultimate success will depend on the combined efforts of the NIO, the US independent observatories, industry in the US, and possibly international partners—both astronomical and industrial. Our underlying strategy is first to build a strong US technical position capitalizing on the combined capabilities of the national observatories and independent observatories, and second to engage potential partners—both national and international—in a constructive way that will achieve mutual aims. Over the past nine months, NIO staff working with the community have begun to identify key science drivers; critical enabling technologies; performance requirements; design options; technical issues and challenges, including those for a baseline instrument complement; essential design studies; and a process for identifying and evaluating potential sites for GSMT.

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These efforts have been divided among eight task groups, which together have engaged the talents of scientists and engineers drawn from a broad cross section of the astronomical community and the private sector. Through the auspices of AURA, NIO has established close contacts with the California Extremely Large Telescope (CELT) and ESO Overwhelmingly Large Telescope (OWL) projects with the aim of coordinating efforts to achieve mutual goals rapidly and at lower combined cost. We plan to synthesize the efforts of the task groups by mid-May, and before mid-June to present NSF AST and MPS with a roadmap for a nationally based effort to explore the designs and technologies critical to developing a GSMT concept. The roadmap will also describe the mechanisms by which NOAO–NIO proposes to engage the talent and energies of the university community and private sector in carrying out enabling studies for GSMT.



Academic and Private Sector Participants in GSMT Workshops.

Planning New Approaches to Surveys and Data Exploration

Steve Strom

In the past, astronomical experiments have typically been constrained by the need to select small samples, often strongly guided by a priori assumptions. We can now plan far more objective approaches based on deep images of wide areas of the sky spanning a range of wavelengths, or spectra of millions of objects.

The past decade has witnessed the advent of a number of ambitious surveys that take advantage of the revolutions in digital detectors and computing power to carry out unbiased surveys of the sky. The initial returns from these first generation digital surveys are already impressive—ranging from the discovery of galaxies at $z > 5$, to gravitational micro-lensing events, to methane-dominated T dwarfs (a link between stars and planets).

As we look ahead, the astronomical community stands poised to take advantage of the continuing breathtaking advances (factor of two increases each 18 months) in computational speed, storage media, and detector technology in two ways: (1) by carrying out new generation surveys spanning a wide range of wavelengths and optimized to exploit these advances fully; and (2) by developing the software tools to enable

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discovery of new patterns in the multi-terabyte (and later petabyte) databases that represent their legacies. In combination, new generation surveys and software tools can provide the basis for enabling science of a qualitatively different nature—by searching for coincidences, new patterns, unexpected correlations, and transient phenomena from examination of an ever-changing, polychromatic “movie” of the universe.

Fast networks, intelligently structured archives, archive inquiry tools, and fast computing platforms will enable large numbers of scientists to access these data. The richness of these databases promises scientific returns reaching far beyond the primary objectives of the survey. For example, repeated imaging surveys aimed at developing a census of Kuiper Belt objects can provide the basis for discovering supernovae at $z > 1$. Indeed, the multiplier effects of survey databases can be enormous—witness the world-wide explosion of research ignited by the Hubble Deep Field, drawing both on the primary database itself, and on observational campaigns with large telescopes driven by the HDF database.

In order to enable the ground-based community to exploit these opportunities for enabling qualitatively new science, PDO is working with other units within NOAO and with the broader astronomical community to:

- Provide options for carrying out major surveys with KPNO and CTIO facilities, for archiving survey images and/or spectra along with derived catalog data, and for tools to enable exploration of the resulting databases.
- Work proactively to bring into being, fund, and participate vigorously in a “National Virtual Observatory” that will:
 - Develop a systems approach to data acquisition, calibration, quality assurance, pipelining, and archiving aimed at minimizing the cost and time to complete;
 - Identify common software and hardware needs among proposed surveys and develop models to minimize overall cost to the community;
 - Provide efficient access to multiple archives comprising the image databases and derivative catalogs from multiple surveys;
 - Identify potential collaborations among national centers and/or laboratories (e.g., NRAO, NOAO, IPAC, STScI, CXC, HESARC) in order to minimize infrastructure costs;
 - Identify potential collaborations with scientists in other disciplines facing similar information technology problems, and with the private sector; and
- Develop a suite of data mining tools to enable exploration of huge, multi-wavelength databases, and the capability to uncover new and unexpected patterns and phenomena.
- Explore the scientific drivers and resulting requirements (telescopes; instruments) for qualitatively new kinds of surveys which, for example, might open the domain of time and space variability through repetitive deep mapping of the sky, and open the domain of large-scale galaxy redshift and stellar population studies through spectroscopy of large samples.

During the past nine months, PDO has:

- Worked very actively and closely with a community task force comprising representatives from the university community, the private sector, NRAO, and the NASA archive centers to develop a “white paper” outlining the vision, functions, structure, funding levels, management models, and implementation cadence for the NVO. NOAO hosted a key meeting of the task force in March 2000, which provided the framework for the white paper, currently scheduled to be presented to NSF in June 2000.

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- Worked closely with the NOAO Surveys and Data Management (SDM) group to develop a framework for restructuring and supplementing NOAO software and data management efforts to enable efficient pipelining and archiving of wide-field imaging data, and to access the resulting databases efficiently. Having these elements in place is key to NOAO's vigorous participation in NVO.

The PDO and SDM group are presently preparing a proposal to the NSF seeking the resources both to enable these efforts and to provide funding for teams in the community who are awarded time to carry out surveys on NOAO facilities. Such funding will allow these teams to fund pipelining and other data reduction efforts critical to populating a community-accessible archive.

The PDO is currently developing plans for a workshop aimed at defining the facility and instrumentation options, and other requirements for a next generation survey system.



Enabling Ground-Space Programs

Steve Strom

Research programs in astronomy increasingly involve multi-wavelength studies, often requiring access to multiple ground- and space-based facilities. However, with few exceptions, individual PIs or teams must propose to two (or more) separate telescope allocation/proposal evaluation committees—thus implicitly subjecting their programs to multiple reviews and multiple jeopardy.

As a natural evolution of the processes developed over the past five years by NOAO aimed at enabling access to the full suite of ground-based

telescopes available through NOAO via a single proposal, NOAO through PDO undertook to explore options for “one stop shopping” for proposals involving ground and space components.

During fall 1999, PDO staff along with their counterparts at the SIRTf Science Center and the Chandra X-Ray Center developed processes to enable proposing IR and X-ray programs involving a significant ground-based component. In particular, teams proposing to carry out either Chandra “long” proposals (total time exceeding 300 Ksec) or SIRTf Legacy programs can now also include as part of their proposal a request for time on NOAO facilities provided that the space- and ground-based components comprise a coherent program—one in which *both* components are critical. The proposals will be evaluated for technical feasibility by NOAO staff, but reviewed solely by the Chandra and Legacy TACs, respectively. In each case, up to 10% of the time available on all NOAO-accessible telescopes (with the exception of Gemini) will be reserved for such programs.

Representatives of the NOAO director along with the SSC and Chandra director will review programs recommended for acceptance by their TACs with the goal of minimizing duplication and optimizing the use of time on NOAO facilities.

In turn, individuals or teams awarded Chandra or SIRTf Legacy time will be obliged to make their combined datasets publicly available and readily accessible on timescales consistent with (or shorter than) the governing proprietary rights policies at each institution.

The advantages to the community are the ability to propose coherent programs involving significant ground- and space-based components without the burden and uncertainty of multiple reviews; and the public availability, typically within a year or less, of large, rich databases that in most cases will offer significant opportunity for important archival research. Moreover, individuals or teams centered at

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institutions lacking assured access to large ground-based facilities will be able to propose such coherent programs on an equal footing.

As part of the effort to establish this new opportunity, PDO has also suggested to the directors of NOAO, SSC, and CXC mechanisms by which the quality of programs awarded time via these new options can be evaluated relative to programs accepted via the normal NOAO TAC system.

REPORT OF THE 1999 NOAO USERS' COMMITTEE

The Users' Committee met in Tucson on 5 and 6 January 2000. This report was prepared by Committee members:

Robin Ciardullo	Pennsylvania State University
Richard Elston	University of Florida
Robert Joseph (Chair)	University of Hawaii
David Lambert	University of Texas
Larry Ramsey	Pennsylvania State University
Evan Skillman	University of Minnesota
Anthony Tyson	Bell Laboratories
Charles Woodward	University of Wyoming

Two additional members, Jill Bechtold (University of Arizona) and David Turnshek (University of Pittsburgh) were not able to attend this meeting.

INTRODUCTION: The Strategic Vision for a "NEW NOAO"

The Users' Committee was delighted to hear the presentations from NOAO senior management which outlined a new strategic vision for NOAO, one that sees NOAO as an integral part of the entire US national optical/infrared astronomical enterprise. We wholeheartedly support the concept of a US national observatory whose primary role is one of leadership on issues of importance to the entire US optical/infrared community, including the private observatories. To function in this way NOAO must work with and complement the private observatories, so as to make a comprehensive system of expertise and facilities that will continue to support the most outstanding optical/infrared astronomical research in the world. This includes taking leadership in eliciting the best ideas of the entire community in planning new telescopes and developing new instruments.

The Committee believes this role also includes development of technologies and techniques that benefit the entire optical/infrared community, especially those that are too large and require too much in financial or expertise resources for private observatories and university groups to carry out on their own. We particularly

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emphasize a key ingredient that is required if this “new NOAO” vision is to succeed: NOAO must collaborate with private observatories and university groups in developing these technologies and techniques, including development of instruments for NOAO, Gemini, SOAR, and WIYN.

The Users' Committee hastens to add that scientific and technical leadership in US optical/infrared astronomy requires high scientific and technical reputation and achievement. These are essential if the private observatories and university groups are to be persuaded to adopt this vision. We believe such leadership requires that NOAO scientific staff have adequate time to pursue personal scientific research using the instrumental and observatory facilities they support and help to develop.

Having said this, the Committee emphasizes that NOAO also has a fundamental responsibility to support telescopes. Realizing that the current NOAO is over-committed, we do wish to stress that the restructured NOAO should build on NOAO's unique strengths: US access to Gemini, CTIO, the 4-meter Mayall and Blanco telescopes with dedicated wide-field instruments, SOAR, and WIYN.

The final general comment the Users' Committee wishes to add, in its enthusiastic endorsement of the vision articulated for a new NOAO, is that this vision requires a corresponding *practical plan*, one that brings about a rapid cultural change within NOAO and that makes the US community aware of this cultural change. We did not see such a plan, but we hope one is in fact in development. In particular, we believe NOAO is already over-committed in a number of areas, and to implement the proposed vision will require some restructuring of NOAO and bringing in people with new and different skills. We encourage NOAO to “clear the decks” in completing present commitments so it can move rapidly to the new roles of leadership and partnership with the entire US optical/infrared astronomy community.

The Users' Committee has separated its report into two sections, the first dealing with near-term issues, “The Present,” and the second addressing plans for “The Future.”

THE PRESENT

Participation in the National Virtual Observatory

Over the past two decades there has been significant investment (most notably by, but not limited to, NASA and NRAO) in the archiving of observations and the software tools that make these archives accessible and useful to the entire user community. The community finds great value in these archives, and astronomical research has benefited significantly by the development of accessible, useful archives.

These publicly available archives have been labeled the “National Virtual Observatory” (NVO) and, while the name is new, the archives are not. For the most part, NOAO has not been a major contributor to the development of archival databases or the software that makes them useful. With the decision to dedicate a fraction of observing time to survey programs, NOAO has changed its stance and made a commitment to actively engage in this activity. This decision was strongly endorsed by last year's Users' Committee and again by this year's Committee.

However, the Users' Committee feels that progress on this activity has been disappointing. Specifically, the logical goal of having a publicly accessible archive of MOSAIC observations (from the surveys in the first instance, but ultimately for all MOSAIC observations in the longer term) has not yet been achieved. The success of the Surveys Program, in terms of scientific achievement and in acceptance by the community, is critically dependent on the timely delivery of all Survey Program observations in an accessible, useful archive. We recommend that this goal should have a very high priority within the next twelve months at NOAO.

The Committee notes that Todd Boroson will be taking the lead on managing this effort and we see this as a very positive step. We also endorse the decision essentially to adopt “off the shelf” tools for constructing the archive.

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NOAO also presented plans for developing software tools that enhance the NVO ("data mining tools"). The Users' Committee recognizes merit in development of these tools and the importance of NOAO participation in determining the future plans for the NVO. However, we are unanimous in our opinion that all NOAO efforts in the near term should be concentrated on contributing to the NVO through the addition of accessible, useful archives. When NOAO has fulfilled the obligations outlined below in producing proper archives from existing surveys using NOAO facilities, then will be the time to discuss development of data-mining tools.

In short, when the Users' Committee meets next year, we hope to hear from NOAO about scientific results from outside teams using data from the Deep-Wide Survey.

Surveys

The Users' Committee commends NOAO for its experiment with time allocation for large surveys in the Survey Program. As the over-subscription makes very clear, there is strong support in the community for this mode of observing. Although it is too soon to evaluate the scientific success of the Program, or whether 20% is the appropriate fraction of time allocated for this mode of observing, we support the continuation of the experiment. We do note, however, that the Survey Program places additional requirements on the NOAO staff. Specifically, it requires that:

- NOAO develop a way to assess the progress of the surveys. For each program, a set of milestones must be identified and a schedule towards those milestones must be followed. It is important that NOAO ensure that the observers are making adequate progress toward their scientific goals, and that NOAO itself is making adequate progress towards its goal of making the data products available to the entire astronomical community.
- NOAO make the TAC aware of potential conflicts in access to a particular region of the sky in the time allocated to surveys and other

highly rated science programs. For example, a five-year commitment to a 4-m survey that takes up most of spring dark time could unacceptably limit access to an important part of the sky.

- NOAO maintain the capabilities of both the telescope and the instrument over the lifetime of the survey. The properties of the survey (such as the image quality) must not degrade over time.
- NOAO publicize the details of each survey to the astronomical community and inform the community that the surveys' products are public. We suggest that an abstract of each survey and such parameters as the survey area, filter, exposure time, setup, and sample data products be placed on NOAO's web page.

The Users' Committee recognizes that the large volume of data associated with surveys places an additional burden on the survey observers. The committee is concerned that, as currently structured, only well-financed teams are in a position to apply for NOAO time under the Survey Program. We request that NOAO develop mechanisms to enable less well funded groups to conduct surveys.

SIRTF and Chandra

The Committee reviewed the proposals to commit NOAO time in support of SIRTF Legacy and Chandra Cycle 2 programs.

The SIRTF Legacy proposal envisions up to 10% of all NOAO time (including Gemini telescopes) for approximately two years beginning with the 2001 Spring semester. This time is to be distributed uniformly with respect to time of year and lunar phase, and will be allocated by the SIRTF Legacy TAC with NOAO input on technical matters.

The Users' Committee supports NOAO participation in the SIRTF Legacy program, especially in view of the fact that it encourages rapid and widespread community response to a

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unique scientific database. However we do have some concerns, particularly about how NOAO has handled participation in this program.

Although the scientific case for NOAO direct support of SIRTf Legacy programs is strong and the requirement that data acquired be made available promptly to the public is admirable, the Users' Committee is concerned that there was apparently no external review of this potentially large commitment of NOAO time. (We note that such reviews and User Committee involvement did precede the decision to implement the Survey Program.) Indeed, it is not obvious that the SIRTf Legacy commitment was widely reviewed inside NOAO. The benefits of open discussion prior to a firm commitment should be obvious to an NOAO that is seeking wider support within the astronomical community.

The Users' Committee noted that the *SIRTf TAC* would grant time on *NOAO* telescopes (subject to the limit set in the agreement). We are concerned that, in allocating all of the agreed time, SIRTf Legacy programs of lesser quality and urgency than standard PI programs may be granted time. It does not seem reasonable that the community's involvement in the SIRTf TAC process, through NOAO, will be limited to provision of technical comments.

A similar proposal was discussed for NOAO support of large programs in the Chandra Cycle 2. This was also proposed for a level of 10% of NOAO telescope time, excluding Gemini time, and would begin in Fall 2000 and run through the Spring 2002 semester. The Committee recognizes the scientific case for complementary X-ray and optical/infrared observations. Additionally, we recognize the merits of broadening NOAO's constituency to include high-energy astrophysicists who previously may not have had direct experience in ground-based observing.

The Committee's concerns regarding the Chandra Cycle 2 proposal are similar to those for the SIRTf program, but exacerbated in this case. Perhaps most significant is the fact that the Chandra program is

not a legacy database open to the entire community. The Chandra proposal does not ensure that the TAC which awards Chandra and NOAO time would have *anyone* with optical/infrared expertise as a member. We recognize that capable X-ray observers may be unfamiliar with optical/infrared telescopes and techniques, making queue observing an attractive option, but this is a mode not presently implemented by NOAO. There will also be a need for Target-of-Opportunity observations, another mode not (routinely) implemented at NOAO. We therefore see the Chandra proposal as requiring substantial NOAO personnel resources, offered gratis, while NOAO already has an over-committed staff with a number of projects behind schedule.

In light of these concerns, the Committee recommends that:

Select committees be formed to review both the SIRTf and the Chandra proposals. If the committees deem either of these to be of high priority, then

NOAO explore obtaining additional resources from SIRTf and/or Chandra CXC on ways to compensate NOAO and its users for the time ceded to SIRTf and/or Chandra and for the expense of running queue and Target-of-Opportunity observations.

NOAO explore why proposals for the SIRTf/Chandra programs cannot be reviewed by the NOAO TAC. Because we do not understand why this cannot be done, we urge NOAO to explore this option, rather than giving the SIRTf and Chandra TACs time on NOAO telescopes up to some pre-defined limit. It hardly needs to be added that NOAO should inform the optical/infrared community of this possible use of NOAO time, since it will reduce the time available for standard PI observing programs.

More generally, the Committee is deeply concerned by the erosion of NOAO telescope time available to individual observers. If to the 20% allocated to

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Surveys were added 10% for SIRTf and 10% for Chandra, for the next several years there would be no more than 60% of the time available for open competition by individual observers. *It is the unanimous opinion of the Users' Committee that this small a fraction is unacceptable.* We recommend that any pre-allocation of NOAO telescope time should leave on the order of 75% of the telescope time available for open competition.

Unique 4-Meter Wide-Field Capabilities

The Mayall and Blanco 4-meter telescopes should still be regarded as the jewels in the crown of NOAO. The Users' Committee is particularly pleased with the results of work on improving the image quality of both these telescopes, firstly by the CTIO staff and more recently at KPNO.

Of particular significance is the fact that these two telescopes were built with focal planes to accommodate 8 × 10 inch² photographic plates, giving them unique wide-field capability in the panoply of US telescopes. Innovations in detector technology have now ushered in a new era of discovery using such wide fields: phenomena spanning large angles, rare object detection, and finding rare events. One recent example is the evidence for an accelerating universe, based on imaging supernovae with a mosaic of CCDs. *The wide-field capabilities of these two telescopes are unique among public and private observatories, and will remain so for the next few years.*

The Users' Committee endorses the emphasis on wide-field astronomy that NOAO has committed to these telescopes: the MOSAIC and Hydra instruments, and the survey programs that will add value to their prime science. We emphasize that the full scientific potential will be achieved when data from these are archived in a user accessible database. We encourage NOAO to maintain the highest delivered image quality and instrument and telescope performance for these unique US facilities, and to fulfill its commitments to produce the corresponding data archives.

WIYN Queue

The WIYN telescope has been supporting queue-scheduled observing for several years now and the efforts of the NOAO staff have resulted in a significant payoff: the scientific advantages and disadvantages of queue observing and the associated operational problems are now much better understood. The scientific benefits are now clear, the problem of dealing with observers' expectations has been recognized, and the strategies for optimal use of queue observing have been defined. Thus, the "experiment" with queue observing has been successfully completed.

Future support of queue observing on the WIYN is unlikely to produce additional insights into the values of queue observing; therefore, the decision to continue supporting this opportunity should be judged solely on a cost/benefit analysis of the scientific yield. The benefits of queue observing are threefold: the ability to take advantage of optimal observing conditions, the enabling of synoptic and other time-constrained programs, and the ability to follow through on the commitment to complete the most highly ranked programs. Overall, it appears that, while queue observing is certainly not a significantly less productive use of telescope time, it is also not a dramatically more productive use of telescope time. The main value of queue observing lies in the alternative opportunities that it provides.

Thus, recognizing the severe limitations on the current level of support available within NOAO, the Users' Committee recommends that WIYN-queue observing not be continued at this time.

The Users' Committee would like to emphasize that the experiment with the WIYN queue is an example of the type of investigation of astronomical *techniques* that the National Observatory can perform which benefits the entire community. In order to realize the full benefits of the experiment, NOAO should rapidly complete the following measures:

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- The results of this experiment must be communicated to the Gemini program, to other US observatories, and to the larger astronomical community. This requirement can only be fulfilled through the publication of a complete description of the lessons learned in a refereed publication (perhaps the "Astronomical Instrumentation" section of the PASP). This also helps ensure that NOAO receives credit for its initiative in investigating this important observing mode.
- Since NOAO has developed a new constituency through the availability of time-constrained observing, it is important that this constituency be made aware of other opportunities for continuing this type of science. For example, within the larger system of telescopes available, the IRTF has been supporting target-of-opportunity observations, and ARC and HET are ideally suited for this type of work. NOAO could also consider implementing a Target-of-Opportunity program on one or more of its telescopes.

Instrument Development

It is clear that a timely and successful completion of the Gemini Near-Infrared Spectrograph (GNIRS) must remain the top priority for NOAO instrument development. Secondly, priority should be given to expeditiously finishing instruments currently in the queue such as SQIID and the WIYN tip/tilt.

Proposals for two new starts were presented to the Users' Committee—NGOS and NEWFIRM. NGOS is a high-efficiency, wide-field (20-40 arcmin), multi-slit optical spectrograph. The high efficiency is based on volume-phase holographic grating technology at least partly developed at NOAO. NGOS appeared to have a well thought-out role in the measurement artillery of NOAO observatories. In this context the Users' Committee was a bit disappointed that, having seen this project presented at the meeting a year ago, it is

not further along. The Committee recommends that NGOS be given the top priority of these two projects. Although no schedule was proposed, we recommend that NGOS be brought to a Conceptual Design Review promptly.

The Committee found that the case for NEWFIRM, a 4K×4K wide-field (30×30 arcmin²) infrared imager, while interesting, is less compelling than NGOS. (We note that this concept was presented to the Users' Committee last year and little appears to have been done since, which emphasizes again the over-commitment of NOAO staff and the need for collaborative work on instrumentation.) We do appreciate that such an instrument is a logical follow-up to the recommendations from the Supporting Capabilities Workshop, but NGOS is also, and in our judgment NGOS should be given top priority.

The Committee noted that all new or planned instruments are anticipated for Kitt Peak. We appreciate that CTIO has received Hydra II and MOSAIC II lately, but it is not clear why new cutting-edge instruments always seem to go to Kitt Peak in their first incarnations. We question whether the Instrumentation Program Advisory Committee is really functioning as intended, i.e., to implement balanced instrument development programs for both sites.

Finally, the Committee notes that the instrumentation program presented was entirely in the context of the old way of doing business, viz., Tucson instrumentalists developing instruments for NOAO telescopes. We emphasize that the strategic vision outlined in the *Introduction* to this report would suggest that NOAO foster collaborations and partnerships with other groups to help in design and development of new instruments such as NGOS and NEWFIRM. If NOAO is to fulfill its role as a strategic leader and facilitator for all of US optical/infrared astronomy, it is essential that such collaborations become the default method of doing business. This will also help to get new instruments developed quickly.

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Gemini

The Users' Committee commends the exemplary leadership shown by Todd Boroson in managing the US Gemini Project Office (USGPO) over the past few years. In many ways the vision and style he has demonstrated anticipated the vision outlined for the "New NOAO" discussed throughout the Users' Committee meeting. We heartily endorse the appointment of Bob Schommer as his replacement and congratulate NOAO management in appointing talented members from its staff in both Tucson and La Serena for such responsibilities.

The Committee endorses the broad outlines of the plan proposed for supporting the US community in its use of the Gemini Observatory and it agrees that making Gemini a resounding scientific success for the US community should be the top priority for NOAO in the near term. The identification of NOAO "mirror" support astronomers for each instrument makes good sense, and the Committee feels that it is essential to use Science Verification commissioning time (or any other means) as soon as possible to get each of these people out to Hawaii to observe using the instruments they will support. Early use of the Gemini instruments for a variety of observations, followed by the associated data reduction and calibration, will enable the mirror astronomers to properly support the US community in achieving rapid success with Gemini.

The Committee discussed the question of establishing a Gemini "Observing Center" in Tucson probably longer than was warranted; after all, the resources to establish and maintain it are probably not large. However, there was a consensus that to achieve the best and most efficient use of Gemini, at least at the outset, requires that US "classical observers" go to Hawaii and Chile and learn firsthand the subtleties of Gemini observing, by working with the Gemini support staff directly.

The Committee does believe that it would be most valuable if US astronomers were able to use Gemini to obtain optical or infrared "snapshots" of objects they are working with in other spectral regions. It

was not clear whether this requires creating a US queue mode to supplement the Gemini queue, and whether this US queue would be facilitated by having a Tucson-based control center, rather than having the US observer(s) for the queue working from Hilo or La Serena; we suggest these practical implementation issues are best left to the USGPO. However, we do note that support of a US snapshot mode will require significant resources if the data are to be reduced and presented to users in the way to which the US community has become accustomed in the case of Hubble Space Telescope snapshots.

The Committee was asked to consider a US queue-observing program using the University of Hawaii Adaptive Optics system on Gemini North. We believe this is an ideal "snapshot" mode; however, this AO system cannot be run remotely at present. If it were to be operated from a putative Tucson-based control center, this would require some man-months of software effort and the assistance of Gemini and University of Hawaii personnel (that we believe would be forthcoming).

The Committee is unanimously opposed to committing substantial effort by the IRAF group to developing software to analyze adaptive optics data. Instead, we suggest that effort should go to investigating adaptive optics data reduction packages developed and used at other observatories such as the Canada-France-Hawaii Telescope and at ESO.

The Committee also discussed the question of loaning CRSP to Gemini on an interim basis to provide some near-infrared spectroscopic capability in the near term. We suggest that IRS might be a much better instrument for this role, since it is cross-dispersed and has higher spectral resolution, although it only covers the 1-2.5 μm spectral region.

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Balancing Competing Priorities at CTIO

Because the staffing level at CTIO is rather lean, and new demands on staff time are emerging with the advent of Gemini South and SOAR, the Users' Committee was asked to provide its view on balancing priorities at CTIO. At the outset the Committee wishes to reaffirm a general principle that applies to the scientific staff throughout all of NOAO: *The best way to ensure that the performance of observatories (i.e., telescopes, instruments, and services) is optimized, is that the support staff use those facilities regularly to carry out independent, front-line personal research.* In addition, we emphasize that scientific leadership requires scientific credibility. If NOAO is to carry out the leadership role envisioned in the *Introduction* to this report, the staff must be seen to be doing noteworthy personal research.

In the particular case of CTIO, the Users' Committee is concerned that a potentially high turnover rate of technical and scientific staff to other observatories could jeopardize the operation and instrumental support of the 4-m and 1.5-m telescopes. We recommend that AURA review personnel compensation policies that introduce inequities between CTIO and other southern observatories, and introduce some mitigation. Such inequities could otherwise result in CTIO staff being lured away. In a similar vein, it seems to us that CTIO staff is especially lean and is less able of coping with a hiring freeze than some other parts of NOAO.

The Users' Committee recommends that CTIO vigorously pursue operational and staffing strategies to build on the unique capabilities of the Blanco telescope for wide-field optical/infrared imaging, and multi-object spectroscopy. We certainly do not want to see effort diverted from the Blanco 4-m tip/tilt system.

The Users' Committee recommends that CTIO pursue acquisition of a commercial AO system (as part of the NOAO cost-sharing agreement with the SOAR consortium), and design a work-package schedule that guarantees delivery of a debugged and

fully functional system by SOAR first light. Natural guide star AO is a solved problem, and in a context of very lean staffing, it would be far more cost-effective to buy such a system.

The Users' Committee regrets that operational pressures may lead to the curtailed use and/or closure of the smaller telescopes at CTIO. These facilities currently provide the US astronomical community with unique observing opportunities. We recommend that CTIO explore possible collaborative operation of these facilities (e.g., university groups, NASA, or private consortia) that would reduce direct operational costs and minimize impact on the Observatory staff workloads.

The Users' Committee appreciates the modest efforts of the CTIO staff to provide expertise in the ongoing site evaluation of Pachón and Tololo, as well as sites within the Chajnantor area. However, we see these activities at the bottom of the priority list. The unique strength of CTIO, and therefore highest priority, is the Blanco telescope. Its wide field and aperture give it an absolutely vital role in US and international astronomy.

THE FUTURE Cornerstone Facilities

A New Wide-Field Telescope

Telescope development has undergone a revolution in recent years with a number of 6-10 m telescopes appearing at various sites north and south. These facilities all tend to emphasize high angular resolution over relatively narrow fields. The advent of these new facilities emphasizes the need of all astronomers, including those working at the private observatories, for a new wide-field telescope of larger aperture than the 4-m Blanco and Mayall telescopes. These 4-m telescopes were built over 20 years ago, with 1 arcsec delivered image quality (DIQ) as a goal. Technology now exists that would allow a factor of fifty increase in throughput over the current 4-m telescopes/cameras in a new 7-m class, 3-degree-field telescope. Moreover, the DIQ

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would improve by at least a factor of two, as demonstrated in smaller new-technology telescopes. The combination would yield an improvement in time-to-limiting-flux of over 100.

Deep wide-field probes of the universe will produce qualitatively new science; moreover such surveys will provide critical input to the efficient use of the narrow-field 8-10 m telescopes. In particular, such surveys would provide the large sample of Kuiper Belt Objects (KBOs) required to make a major step forward in understanding how the Solar System formed, and it would also provide the census of potentially devastating Near-Earth Objects (NEOs) needed to understand how such objects have affected the evolution of life on Earth, as well as the potential threat to Earth from impact by a large NEO. These same data could reveal faint transient events, including the optical counterparts of Gamma-Ray Bursters, and reveal new supernovae. Wide-field weak-lensing shear observations would lead to a direct test of the foundations of cosmology.

Technological advances also make such a telescope now feasible. Recent advances in large detector array fabrication and efficient processing and analysis of terabyte databases in near real-time promise efficient data collection and dissemination.

The Users' Committee believes there is community-wide interest in such a facility, interest that cuts across subdisciplines and private vs. public institutional interests. We see such a project as a key first step in the transformation of US optical/infrared astronomy into the genuinely national enterprise envisioned in the *Introduction* to this report. The Committee recommends that NOAO begin leading national effort on this cornerstone facility by organizing a workshop that brings together the ideas of the entire community for discussion and identification of technological issues.

A New Very Large Telescope Project

A new generation of large ground-based telescopes is being studied worldwide. As is described in the *Introduction* to this report, the Committee sees

NOAO as the natural focus for a broad US community effort directed at developing the next generation of large ground-based telescopes. The Committee commends the efforts of the NOAO Planning and Development Office in pursuing this project, but we note that all the people presently working on this concept are either from NOAO or Gemini, with the sole exception of Larry Ramsey. This is obviously not the way to garner the best ideas and catalyze the broad US astronomical community. We recognize that such a facility is many years away and that NOAO staff have more urgent commitments to fulfill. However, it is a given that this project will require a long development time, and almost certainly will demand participation in an international collaboration. It is critical that in the US we begin to think about such a project, whether it be a large single dish or an interferometric array. We encourage NOAO to continue at a low level of staff effort to work with the entire US community in developing and analyzing ideas for such a project.

Future Instrument Development

Both the increasing pressure on NOAO resources and the increasing complexity of new instruments demand that NOAO move away from its traditional model of developing all its instrumentation from scratch in-house. The Committee endorses the proposed new way of doing business in that NOAO works closely with and forms partnerships with the national community to instrument its telescopes and others. NOAO must also play a central role in helping to coordinate instrument development for the broader astronomical community to minimize costly duplication of facilities. Only by working in partnership will NOAO and the broader US community be able to maximize the scientific impact of its facilities and instrument program.

More generally, the National Observatory is the best place to lead well-focused research and development efforts to develop new technology that will be needed for the next generation of large

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instruments. NOAO has done this in the development of InSb detectors and new grating technology, which will continue to benefit the entire astronomical community. The Committee envisions collaborations and possibly outright grants to university groups to develop new technology for astronomy. We encourage NOAO to develop this role as a national resource in technology and techniques that benefit the entire US astronomical community.

Education and Public Outreach

One of the most important missions of scientists today is to promote public understanding and support of science in the US. Astronomy has a unique role in doing this: more than any other discipline, astronomy has the ability to capture the public's imagination and motivate students to pursue careers in science. NOAO is to be commended for its efforts in education and public outreach (EPO). Its creative initiatives are models for programs around the country. In particular, the Research Based Science Education (RBSE) program is a model for science outreach. The 0.9-m telescope's wide-field nova patrol of the Andromeda galaxy has captured the attention of high school students around the country. We urge that this program continue; the small amount of resources it requires is well worth the effort.

More generally, the Committee encourages NOAO to see itself as a resource center for all optical/infrared astronomical EPO efforts in the US. The National Observatory is the logical organization to serve in this role. We envision the EPO section of NOAO as the place to which astronomers would turn for advice with their own EPO efforts and guidance toward resources available. Strengthening the EPO efforts of the community in this way cannot help but improve the visibility of NOAO and the NSF, and in the long run will lead to a stronger scientific base for astronomy and the Nation.

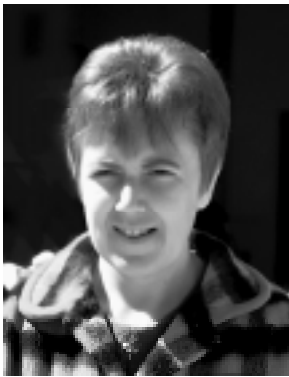


Best Wishes and Thanks to Jeannette Barnes

Caty Pilachowski and Sidney Wolff

Each year, AURA makes an award for excellence in service to NOAO. For the year 2000, this award was presented to Jeannette Barnes for 38 years of outstanding service. The award was given on April 28, Jeannette's last working day at NOAO. To the dismay of staff and visitors alike, Jeannette is retiring.

Jeannette Barnes started working for KPNO in 1961. She soon became a mainstay of the Observatory, always focused on the goal of helping visitors and staff extract their science from the complexities of telescopes, instruments, and computers. Jeannette has a wonderful knack for anticipating trends and re-inventing her job to position herself to meet the future needs of both the astronomical community and the Observatory. As her vision became reality and these future needs became current imperatives, Jeannette was in the center of activity.



Visitors from the '60s and '70s will remember Jeannette's tireless efforts to assist observers starting runs on Kitt Peak, as well as her significant contributions to the establishment and calibration of Stromgren photometry. The many users of the Intensified Reticon Scanner at the #2-36" benefited as well from Jeannette's hard work to bring that instrument on-line.

In the early 1980s, Jeannette was in the middle of the activity to move NOAO's data reduction and analysis software from fragile and specialized programs that could only be run on the computers in the Tucson Headquarters building to robust, portable, and extensible programs that could run anywhere. She became the liaison between the programmers that built the Image Reduction and Analysis Facility (IRAF) and the astronomical community—she tested IRAF; she taught IRAF; she lobbied for changes in IRAF; and above all she evangelized IRAF through newsletters, tutorials, cookbooks, workshops, conferences, and endless telephone and e-mail conversations. Jeannette and her team's efforts helped to make IRAF the indispensable tool for astronomers that it has become.

In the 1990s, Jeannette was in the forefront of activities to use the Internet to increase the productivity of astronomers and the efficiency of astronomical institutions. She helped the American Astronomical Society and its journals enter the era of electronic publishing with electronic submission of papers in LaTeX and on-line publication. She recognized early on the potential of the World Wide Web for the efficient dissemination of information and spearheaded the effort to convert NOAO's manuals, documentation, and newsletters for on-line use. She has preached the usefulness of e-mail and the Web inside NOAO and has helped to re-engineer many internal processes to make use of these technologies.

Today, Jeannette is heavily involved with the NOAO telescope proposal process. She was a part of these efforts from the beginning through her expertise in electronic publishing and the Internet. Jeannette's contributions have culminated with today's Web-based proposal submission system that enables astronomers to do "one-stop" proposing for observing time on the telescopes at KPNO, CTIO, Gemini, HET, and the MMT, and that enables NOAO to efficiently process, review, schedule, and coordinate these proposals.

We know that the many users of NOAO join us in congratulating Jeannette on receiving the AURA Service Award, in wishing her the very best in her retirement, and in thanking her for all she has contributed to the success of so many scientific programs carried out at NOAO.