

Cerro Tololo Inter-American Observatory
Kitt Peak National Observatory
US Gemini Program

NATIONAL OPTICAL ASTRONOMY OBSERVATORY



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1. INTRODUCTION

The highlights of FY 2001 at NOAO have been the commencement of Gemini science through the US program, a highly successful workshop on the concept of the US observing “system,” a change of director, and the development of a new long range plan.

Signs that the US community is taking immediate advantage of the Gemini research opportunities are seen in two programs supported by the USGP in its first season of observer support. Tod Lauer examined the brightness profile of the nucleus of M32. Bob Blum, in collaboration with Darren De Poy and Kris Sellgren of Ohio State, analyzed a set of narrowband CO images from the Galactic Center stellar cluster. Other science highlights from Gemini are described below. At the end of the report year, four instruments were available on Gemini North and four were to be offered on Gemini South. NOAO’s Phoenix infrared spectrograph was delivered to Pachón by Ken Hinkle and his team. US oversubscription of Gemini for 2002A is by factors of 3 to 5.

The First Workshop on the Ground-based O/IR System was held in Scottsdale, Arizona on October 27-28, 2000. According to the National Research Council’s decadal survey *Astronomy and Astrophysics in the New Millennium*, “US ground-based optical and infrared facilities ... should ... be viewed by the National Science Foundation (NSF) and the astronomical community as a single integrated system drawing on both federal and nonfederal funding sources. Effective national organizations are essential to coordinate, and to ensure the success and efficiency of, these systems. Universities and independent observatories should work with the national organizations to ensure the success of these systems.” Results of the workshop are summarized at http://www.nao.edu/gateway/oir_workshop/. Taking on its role in the system is part of NOAO’s new long-range plan.

Jeremy Mould arrived on February 15, 2001 to succeed Sidney Wolff as NOAO Director. In staff retreats in January and February, no change was proposed in the mission of NOAO—which is to enable research and discovery in US ground-based astronomy, and to promote public education, understanding, and support of astronomy—but new objectives arise from the decadal survey. The theme of NOAO’s new long-range plan is *Implementing the Decadal Survey*.

The process of developing a new long-range plan was inclusive and intensive. Working groups were formed in each of NOAO’s divisions and programs and for the ground-based priorities of the decadal survey. Their recommendations for the long-range plan were put to an internal review, chaired by Nick Suntzeff, modified, and then put to an external “Balancing Review,” chaired by Bob Kirshner. The resulting long-range plan balances new projects and existing services, is responsive to the decadal survey, and is affordable according to NSF’s budget guidelines for FY 2003-2007. The plan is available via the NOAO Web site at <http://www.nao.edu/dir/lrplan/>.

Prominent among the programs described in the NOAO long range plan is the New Initiatives Office (NIO), a two-year partnership between Gemini and NOAO to carry out pre-phase A studies for the Giant Segmented Mirror Telescope, the top ranked ground-based O/IR facility of the decadal survey. The NIO was formed in January 2001 and progress to date is reported below.

2. SCIENTIFIC RESEARCH

Samples of science conducted during FY 2001 at NOAO facilities are presented below.

2.1 Cerro Tololo Inter-American Observatory (CTIO)

2.1.1 *Galaxy Cluster Found Using Gravitational Distortion*

Astronomers have become accustomed to dark matter, even if they are not quite sure what it is. If one counts up all the luminous matter in the local universe, one will find that the amount of luminous baryonic matter is about 0.5% of the closure mass for the Universe and is only a fraction of that predicted by Big Bang nucleosynthesis (4% of the closure mass). From CMB measurements and the power spectra of mass structures in the Universe, the total mass (non-baryonic and baryonic) of the Universe is about 30% of closure, implying that the total mass is 8 times the baryonic mass.

Results from the kinematical estimates of dark matter in clusters of galaxies support this large amount of non-baryonic dark matter, but the value (0.19 ± 0.04 Carlberg et al. 1997, CNOC project) is smaller than the CMB derived value. Whether this difference is significant is hard to tell at this point. But all these lines of research point to a hidden assumption in the measurement of dark matter in the local universe: we tend to look for dark matter in the presence of luminous matter. By measuring kinematical masses in clusters or the scale of mass fluctuations, we are looking at places where we know there is luminous matter. But there is no reason to believe dark matter must clump where there is luminous matter.

T. Tyson, D. Whittman (Lucent Technology's Bell Labs), and collaborators have formed the Deep Lens Survey to search for mass concentrations independent of the content of the luminous matter present in the concentrations. In a pioneering study using 3-D mass tomography, they have used the CTIO 4-m Blanco telescope with the Mosaic imager to measure the gravitational shear and photometric redshifts, to locate mass clusters along the line of sight. By analyzing the shear of field galaxies as a function of redshift, they have pinpointed a small cluster of galaxies, which was then verified using spectroscopy at the Keck telescope. This becomes the first large mass structure to be found based on its total dark mass (which produces the shear). In the future, they will be able to locate any dark mass structures along lines of sight, to make the first direct measurement of clustering of dark matter, including mass clusters that have no luminous mass.

2.1.2 *High Spatial Density of Halo White Dwarfs*

The spatial density of halo white dwarfs was announced by B. Oppenheimer (UC Berkeley) and collaborators in *Science* magazine (April 2001). Using proper motions based on digitized sky survey plates, they verified 38 cool white dwarfs from a sample of 69 objects with the CTIO 4-m Blanco telescope and facility RC spectrograph. The color of these white dwarfs is consistent with old ages of 10 to 13 Gyrs. This is a surprising result because it is a factor of 10 times the white dwarf density based on standard models of the stellar evolution of the solar neighborhood subdwarf population. Modern white dwarf theory predicts that the oldest white dwarfs become bluer as they fade and cool due to the presence of H₂ molecules. The large space density of these white dwarfs implies that Oppenheimer et al. have detected at least 2% of the dark matter of our Galaxy's halo.

From their survey at Mount Stromlo Observatory, the MACHO microlensing survey project has detected 17 to 19 events towards the LMC (with photometry provided in part by the CTIO 0.9-m telescope). They interpret these results as the detection of a population of 8% to 50% of the Galactic halo dark matter, in unseen objects roughly the mass of a white dwarf. Since the Oppenheimer results are only a lower limit to

the spatial density of cool white dwarfs, the white dwarfs found in their survey may be consistent with the MACHO results.

These results have stimulated a lively debate. Part of the controversy comes from the MACHO results where there may be a possibility of self-lensing of a foreground or thick disk in the LMC. The spatial densities from MACHO confirm two earlier studies. R. Ibata et al. (2001, ApJ, 532, L41) found a similar space density based on a smaller survey using similar techniques through which three halo white dwarfs were discovered. R. Méndez (CTIO) and D. Minniti (2000, ApJ, 529, 911) inferred a similarly high spatial density of white dwarfs from very deep HST imaging. In the latter survey, they associated the faint blue stellar population with white dwarfs out to 2kpc. Second epoch HST images in a few years will test this association.

Other authors have challenged the interpretation by the Oppenheimer group. In letters to *Science*, B. Gibson and C. Flynn, and D. Graff have independently questioned the calculation of the space density. The space density of white dwarfs derived from the Oppenheimer study would require a very non-standard initial mass function of halo stars. N. Reid, K. Sahu, and S. Hawley have argued that the Oppenheimer sample is the kinematical tail of the rotating thick disk population of white dwarfs, and are not cool halo white dwarfs.

While there may be disagreement as to whether the Oppenheimer group has detected halo white dwarfs, there is general agreement that the technique and discoveries of the Oppenheimer group will revolutionize the study of the early populations of stars in our Galaxy. As stated by Reid, et al. in their ApJ paper (astro-ph/0104110): “Besides providing further insight on cooling processes during the final stages of evolution of degenerate dwarfs, statistical analysis of the sample can provide important information on the star formation history of the Galaxy.”

Jeremy Mould reviewed these developments at a recent workshop on “White Dwarfs and Dark Matter,” hosted by the University of British Columbia (http://www.astro.ubc.ca/WD_workshop/talks/index.html).

2.2 Kitt Peak National Observatory (KPNO)

2.2.1 The Fossil History of Chemical Enrichment in the Early Galaxy

Stars in the halo of the Galaxy are largely deficient in heavy elements relative to those in the solar neighborhood. The chemical compositions of the most element-poor stars were produced by a few—and possibly only one—previous generation of star formation and element enrichment. Neutron-capture elements (with atomic numbers greater than 30) act as sensitive tracers of the properties of the first generation(s) of stars. They can be produced by the rapid “r”-process in supernova explosions and in the slower “s”-process, thought to originate in the double-shell burning phase of low and intermediate-mass asymptotic giant branch stars.

To investigate the relative abundances of heavy elements produced by neutron capture, a sample of 70 metal-poor stars was observed with high-dispersion spectrographs on the KPNO 4-meter and Coudé Feed telescopes. The results were published in the *Astrophysical Journal* in November 2000, as the thesis of Debra Burris, then at the U. of Oklahoma, with collaborators Caty Pilachowski and Taft Armandroff (NOAO), Chris Sneden (U. Texas), John Cowan (U. Oklahoma), and REU student Henry Roe. The neutron-capture elements Sr, Y, Zr, Ba, La, Nd, Eu, and Dy were measured for 43 objects, and Ba only for the additional 27.

They found that the scatter in abundances of n-capture elements is greatest for the stars of the lowest heavy element abundances. This increased scatter is attributable to the inhomogeneity of material out of

which stars were formed in early Galactic history, presumably because of different amounts of supernova ejecta in different star formation sites. The heavier n-capture elements were formed predominantly by the r-process at the earliest times. This result is deduced from the change in the Ba to Eu ratio, from a pure r-process value in the lowest abundance stars to the solar value, where the Ba was produced by the s-process and Eu by the r-process. Significant production of r-process elements began when the iron to hydrogen ratio (the standard measure of heavy element content) was enriched to 0.13% of the solar value. This result is consistent with the picture that r-process elements are produced in the explosions of massive stars (Type II supernovae) in a narrow range of initial masses, from 8 to 10 solar masses. Enrichment of r-process elements up to that point must have arisen from even more rare, more massive stars with shorter lifetimes to the supernova phase. The production of the lighter n-capture elements, particularly Sr, at earliest times is clearly more complex, and does not follow the production pattern of solar abundances. Some mixture of r- and s-process origin is required to explain the observations. The s-process contribution from low-mass asymptotic giant branch stars has a relatively sharp onset when overall abundances reach 0.6% of the solar value. The existence of s-process elements in lower-abundance stars suggests that the earliest s-process sources arise in stars more massive than those known to be responsible for the main s-process in solar abundance objects.

This stellar archaeology provides the critical details from which the properties of the first generations of Galactic star formation can be deduced.

2.2.2 The Challenge of Investigating Large-Scale Flows in the Universe

In simulations of the growth of cosmological large-scale structure, the accepted parameters for mass and dark energy density lead to models that have very low-amplitude density fluctuations on scales of a hundred megaparsecs. The finding of Lauer and Postman in 1994 that there was a large-scale bulk flow of about 700 km/s on a scale of over 200 Mpc was therefore extremely surprising. It implied a very large-scale density fluctuation, inconsistent with essentially all the basic models. Their result prompted the initiation of several large-scale observational investigations to test the validity of their result.

One major program was carried out at NOAO facilities, with its first report in the *Astrophysical Journal* of December 2000. Stephane Courteau (U. British Columbia), J. Willick (Stanford, deceased), Michael Strauss (Princeton), David Schlegel and Marc Postman (STScI) described their “Shell flow” program of combining accurate distances and radial velocities of a whole-sky sample. They measured all the bright spiral galaxies in a radial velocity shell, centered at a universal expansion velocity of 6000 km/s with a width of 2500 km/s. They used a technique pioneered by Tully and Fisher, which combines the rotational velocity of the spiral disk and the total apparent brightness to produce a high-accuracy determination of the absolute luminosity. They followed the lead of Lauer and Postman in producing a whole-sky sample with great care taken to eliminate systematic differences in photometric brightness measurements from the telescopes in the two hemispheres. They used the 0.9-meter telescopes at CTIO and KPNO for photometric imaging in the V and I bands, and the 4-meter telescopes at both sites to obtain spectra in Hydrogen alpha for disk rotation and redshift measurements.

Their result is consistent with the overall bulk motions of the shell of galaxies at a distance of 60 megaparsecs being zero in the reference frame of the cosmic microwave background. That result is consistent with the models that predict the absence of massive attractors on large spatial scales and is inconsistent with the results of Lauer and Postman. These results of Courteau et al. fit well with the current theoretical framework, and lead to the speculation that the different technique of Lauer and Postman was subject to some small cosmic variance that produced a spurious signal. A follow-up program is underway as an approved survey program for NOAO observing.

This key cosmological observation was possible because CTIO and KPNO provided two-hemisphere access with comparable facilities.

2.3 Science from the Gemini Telescopes

Laird Close (U. Arizona), with colleagues D. Potter, W. Brandner, M. Lloyd-Hart, J. Liebert, A Burrows, and N. Siegler, observed a sample of brown dwarfs with the Hokupa'a/QUIRC AO system on Gemini North during US mini-queue observations in June 2001. One such target (2M1426) was found to have a close (0.15") binary component, about half as bright as the primary, and with redder J-K colors. The blended M9 binary spectrum can be modeled as a blend of an M8.5 primary and an L1-L3 secondary. They estimate a photometric distance of 18.8 pc with a primary mass of $M \sim 0.074 M_{\odot}$ and a secondary of $M \sim 0.066 M_{\odot}$. The separation was estimated to be $\sim 2.92 \text{ AU}$ and the period to be ~ 13.3 yrs. This object is one of only eight resolved binary brown dwarfs known, and one of the shortest period systems, which will aid greatly in the repeat observations needed to calculate its orbit. This new system will aid considerably in the calibration of the mass-luminosity-age relations for brown dwarfs.

A special session on "First Science with Gemini" was held at the AAS June meeting in Pasadena. Science highlights included:

K.E. Johnson (U. Colorado), with colleagues W.D. Vacca, H.A. Kobulnicky, and P.S. Conti, obtained OSCIR observations at 10 microns of the nuclear region of the starburst galaxy He2-10, as part of a program to understand massive cluster formation and evolution. Although the observations were limited by poor weather conditions, they were able to detect three enshrouded massive star clusters. Based on these observations, the bolometric luminosities of the clusters are 10^8 - $10^{10} L_{\odot}$, and the blackbody temperatures of the dust cocoons are estimated to be 80-120K. From these observations, the masses of the clusters are estimated to be 10^5 - $10^7 M_{\odot}$ and the clusters could be responsible for up to 30% of the total IRAS flux from He2-10.

A.W. Stephens and J.A. Frogel (OSU) used Hokupa'a/QUIRC on Gemini North to obtain JHK' images of the central regions of M33. They were able to determine the bolometric luminosity function and colors for the several brightest magnitudes of the M33 stars, in order to study the central stellar populations. With these high resolution images, they were able to estimate ages for the central stars and show the relative importance of the three central components: a young star forming disk, an intermediate age population, and the very old stellar component.

D. Devost (Cornell U.), with colleagues C. Robert and V. Charmandis, presented OSCIR observations of the nearby IR luminous galaxy NGC 3690. While the optical observations had shown the complex and disturbed morphology of this interacting galaxy, the OSCIR observations reveal a considerable number of massive starburst regions with a range of ages and luminosities. The dominant starburst region, B1, is deeply dust enshrouded, but it is resolved in the superb spatial resolution of the Gemini images. Comparisons were made with existing IR, optical, and UV images from ISO and HST, and the relative contributions of the diffuse emission was evaluated.

D. Depoy (OSU), with colleagues K. Sellgren and R.D. Blum, presented an analysis of the AO data on the Galactic Center, taken with Hokupa'a/QUIRC as part of the demonstration science observations. Deep H and K' observations of IRS16/SgrA* and an area to the northeast were reduced photometrically. The excellent spatial resolution (typically 0.15" in 600 sec exposures) allow reliable photometry on stars as faint as 18^{th} in K', some of the deepest imaging of the Galactic Center available to date. Stellar luminosity functions can be studied down to these faint limits to trace the star formation history and characteristics in these regions.

3. USER SUPPORT AND TELESCOPE IMPROVEMENTS

3.1 Cerro Tololo Inter-American Observatory (CTIO)

CTIO has moved closer towards its short-term goal of simplifying the complement of instruments available on its existing telescopes, so as to free resources for work on commissioning the SOAR 4.2-m telescope in 2003. The SOAR telescope will be equipped with instruments that are complementary to the wide-field instruments on the Blanco 4-m.

3.1.1 Blanco 4-m Telescope

Tuning and optimization of the telescope optics and thermal environment have continued, with the aid of sophisticated tools such as micro-thermal sensors distributed in the telescope tube, and an in-telescope dual image-motion monitor. Controlled tests serve to quantify the sources and amount of any remaining image degradation generated within or in the immediate vicinity of the Blanco telescope, and will allow us to establish procedures to minimize or eliminate them.

The Mosaic II Imager (<http://www.ctio.noao.edu/mosaic/>) has remained much the most popular instrument on the Blanco telescope, with several long-term surveys and many shorter programs supported. The Super-MACHO survey, lasting for five years, is about to begin. The Hydra Multi-object spectrograph has been upgraded with a new camera and low-noise SITe 2K×4K CCD (<http://www.ctio.noao.edu/spectrographs/hydra/hydra.html>); the larger format and better resolution of the new CCD allow full use of the complete complement of fibers.

Both the RC Spectrograph, upgraded with modern motors and motor-controller, and the Echelle Spectrograph have seen steady use. The use of these instruments is expected to continue for at least another year, given the delay of SOAR first light and the slow arrival of Gemini instruments. The Ohio State University Infrared Imaging Spectrometer (OSIRIS) has also seen regular use, and this is expected to continue through first semester 2002, until it is replaced by the Infrared Side-Port Imager, ISPI.

3.1.2 Instrumentation

The SOAR Optical Imager, the commissioning instrument for the SOAR telescope, passed its Pre-Fabrication Design Review in December 2000, and is now nearing the end of the fabrication phase (see: <http://www.soartelescope.org/sac/OpticalImagerDesignReview/OpticalImager.html>). The data system, which utilizes a Leach controller operating in a Linux/Lab VIEW environment, is well advanced, and is common to new instrumentation being built for both SOAR and Blanco.

The Blanco IR Side-Port Imager (ISPI) is approaching completion. A successful Pre-Fabrication Design Review was held in November 2000, and subsequent progress has been rapid. An engineering grade 2K HgCdTe array has been received and tests are proceeding. Commissioning has been delayed until mid FY 2002 due to the loan of one of the barium fluoride lenses to Gemini for use in Flamings. See <http://www.ctio.noao.edu/instruments/ir-instruments/ispi/> for more details.

The contract between SOAR and NOAO for the construction of the SOAR Nasmyth Instrument Support Boxes and Comparison systems has been let. The project is under the direction of ex-CTIO instrumentalist Thomas Ingerson. A concern is the delay of several months in the supply of the Instrument Support Box structure from RSI, although the final delivery date is not yet compromised. A Conceptual Design Review was held in October 2001.

Concepts for a facility Adaptive Optics system for SOAR were developed in FY 2001, and these will be presented to the SOAR Science Advisory Committee early in FY 2002. Pending approval, this work will continue to CoDR level by the end of FY 2002.

3.1.3 Existing Small, General-User Telescopes on Cerro Tololo

The 1.5-m, 0.9-m and 1.0-m YALO telescopes have continued in operation with only routine maintenance and minor improvements, the largest of which was the replacement of the motor system on the 1.5-m Guider Box. The 0.6/0.9-m Curtis-Schmidt telescope was closed to all users apart from the University of Michigan at the end of semester 2001A. The University of Massachusetts decided to transfer the 1.3-m telescope to CTIO at the end of FY 2001, following the completion of the 2MASS survey. The YALO consortium met and decided to continue operations on the 1.0-m telescope until the end of 2002. Various discussions have taken place with a view to establishing a larger consortium to operate some or all of the CTIO small telescopes from 2003 on.

3.1.4 Work in Chile to Control Light Pollution

The new Office for the Protection of the Skies of Northern Chile (<http://www.opcc.cl>) is now funded by a consortium consisting of the Chilean National Commission for the Environment (CONAMA), AURA (NOAO/CTIO and Gemini), ESO, and the Carnegie Institute of Washington's Las Campanas Observatory. The International Dark-Sky Association (IDA—see <http://www.darksky.org>) has already awarded a prize to the first director of the OPCC, Pedro Sanhueza, for his outstanding efforts towards controlling light pollution in Chile. The mayor of La Serena visited Tucson, the IDA, and NOAO in April 2001 in order to see at first hand how Tucson controls light pollution. An international conference on Controlling Light Pollution is to be held in La Serena in early March 2002.

Significant advances have already been made in the IInd, IIIrd and IVth Regions of Chile, where the major international optical observatories are located. Professor Enrique Piraino has been awarded the IDA's top lighting award for his work on the illumination of the Cruz del Tercer Milenio in Coquimbo (IVth Region), which is on a direct line of sight to the Gemini South telescope on Cerro Pachón.

The OPCC has worked in support of the introduction of 8,000 new full-cutoff *luminaires* in Copiapo (IIIrd Region, where the Las Campanas Observatory is located). These are the first street lamps designed specifically by a Chilean company to meet the new "astronomy-friendly" lighting regulations signed into effect in late 1999 by the President of Chile. Pedro Sanhueza has also been a featured speaker in a series of meetings with mining engineers and authorities in the IInd Region near Antofagasta. The most probable threat to the skies over Cerro Paranal would be from mines which could be developed nearby.

3.1.5 Educational and Public Outreach

CTIO supports a number of education and public outreach activities that benefit both the US and Chilean communities. The NSF's Research Experiences for Undergraduates (REU) program at CTIO once again hosted four US students during the Chilean summer (January through March) 2001 (for more details, see http://www.ctio.noao.edu/REU/ctioreu_2001/ctioreu2001.html). All four of the 2001 REU students and both of the 2001 PIA (Chilean) astronomy students plan to present posters at the January 2002 AAS meeting in Washington, D.C. CTIO scientific and engineering staff supervise and mentor a small number of graduate and undergraduate ("Semester/Summer Abroad") students involved in scientific research throughout the year. Students are generally supported with money from grants, staff research funds, and/or through their home institutions.

Support of Local K-12 Science Education in Chile is provided by a collaboration between CTIO, Gemini, AURA, the University of La Serena and other local groups through the “Planetario Móvil” (Mobile Planetarium) program and Chile’s Explora-Conicyt project. In order to participate in the Mobile Planetarium program, local teachers volunteer to attend workshops on astronomy and astronomy education once each week over four weeks. The teachers develop a plan to integrate astronomy into classroom lessons and activities. Only after participation in this educational program is the planetarium brought to the teacher’s school for a day of astronomy. Students present their work, give talks, attend lectures by participating professional staff and visit the planetarium. Over a 4-month period (May – August 2001), 70 teachers at 30 different schools attended the workshop. Some 11,897 students visited the planetarium during the school year and gave presentations, with 640 parents in attendance. Eight professional scientists and engineers volunteered to give lectures and answer questions. Photographs of some of these activities can be found at <http://www.ctio.noao.edu/AURA/planetario/>.

Weekly tours of the telescopes on Cerro Tololo continue to be well attended with group sizes of approximately 40 people and larger groups during holiday periods. Tour groups include organized class trips of students of all ages (elementary through university) and local families. Class groups often reserve space as much as six weeks in advance.

3.2 Kitt Peak National Observatory (KPNO)

KPNO marked the near-completion of its long-term reinvestment to improve the delivered image quality of the Mayall 4-meter telescope. Two instruments saw successful commissioning and initiation of science operations. WIYN enjoyed a year of stable operations, with median delivered image quality of ~ 0.7 arcsecond and only 4% usable time lost to technical failures. The new WIYN Observatory Director is vigorously pursuing development of a next generation of optical imagers for the facility.

3.2.1 Final Phase of Mayall Telescope Image Quality Improvements

The elements of thermal management and active optical control of the Mayall telescope retrofit have reached the final stage of integration into an effective system. Technical efforts for the year included re-aluminizing the primary mirror, with subsequent recollimation of the system led by C. Claver. Claver was able to verify good physical alignment between the optical axis of the primary and the physical center of the prime focus corrector. The precision of the encoding and control of the new f/8 secondary drive mechanism was increased to meet the demanding specifications of integration with 4MAPS, the primary mirror active support system. Full integration was achieved during summer shutdown. Implementation now depends only on some minor software modifications and verification of the form of correction as a function of telescope position.

The combination of mirror cooling during the day and air extraction over the primary at night makes a measurable difference in sampled wavefronts. Progress was made during summer shutdown on installation of a wavefront camera that will allow the 4MAPS zero point to be set at the start of every night, as is the standard procedure at WIYN. The guider/adaptor was modified to include the x-y stage on which the camera will be mounted. Completion of the project will occur in FY 2002, with installation of custom optics and the camera itself.

Remaining improvements from here are anticipated to be largely operational, with tighter control of the primary mirror front surface achieved through better control of the cooling set point and of the temperature of the building glycol coolant. Experiments will be undertaken to optimize the rate of guider correction as a function of conditions. This multi-year project is starting to pay off: test images during summer shutdown showed 0.65” FWHM at Cassegrain, and one of the first scheduled Mosaic observers reported extended periods of comparable quality in R and in B at the prime focus.

3.2.2 *New Instrumental Capabilities for the 4-Meter*

This year saw the commissioning and early science operations of FLAMINGOS, the University of Florida Near-IR imager and multi-object spectrograph. KPNO served as a partner to Richard Elston's team in the instrument development, by providing optical design resources and capital to fund the upgrade to a 2K×2K Rockwell HgCdTe array detector. In addition, KPNO mountain-based personnel supported some on-site improvements in handling and interface to the telescopes. The first test run was on the 2.1-m, and produced the first astronomical image taken with the 2K×2K format near-IR arrays. The field of view at the 2.1-m is some 20 arcminutes on a side, representing a major advance in wide-field near-IR imaging. The instrument is unique in that it has a fore-dewar containing the slit wheel that can be cycled for exchange of slit masks during the day, ready for a new set of fields at the start of observing. That capability is in extended commissioning, with improvements underway to the dewar and mechanisms, as well as the precision offset motions of the 4-meter telescope itself. The instrument is shared with Gemini South, and resides for half a year at each site. Upon its return to KPNO in November, the instrument is scheduled first at the 4-m, then at the 2.1-m for essentially every available night for the rest of the semester.

The other advance in instrumental capability is the upgrade to the CryoCam low-dispersion spectrograph, renamed MARS. The detector was changed to a very red-sensitive thick CCD from Lawrence Livermore Lab, the grism was made from a volume-phase holographic grating, and the collimator lens was re-made and coated with a high efficiency coating. The end-to-end system reaches 40% peak throughput, including the detector, has an order of magnitude higher efficiency than the previous version longward of 9000 Å, and is largely free of fringing. A. Dey, R. Lynds, and S. Barden devoted considerable time and effort in developing this low priority project through a heavily committed technical group. Combined with an implementation of the nod-and-shuffle technique, which offers high-precision cancellation of night-sky emission lines, this new mode offers extraordinarily competitive performance for far-red spectroscopy, aimed at moderate- to high-redshift galaxies and work on the calcium triplet feature and other important deep red diagnostics.

3.2.3 *WIYN Operations and Instrumentation*

For WIYN this year was characterized by stable, high-performance operations, a change in the Consortium management, the development of new instruments and new instrument concepts for the 3.5-m, and the success of a sub-consortium within WIYN in taking over the refurbishment and operations of the 0.9-m telescope.

With the installation of the tertiary air bag at the end of the previous fiscal year, improved focus control, and close thermal management, the median delivered image quality remained at ~0.7 arcsecond, close to the site-delivered median. The site engineer reports usable time lost to technical failure at around 4%, a component of which is attributable to the Hydra positioner, which is now slated for a performance upgrade.

With the advice of the Observatories Council and Users Committee, KPNO terminated its queue observing experiment at WIYN. The decision was budget driven, but was recommended for several reasons. The advantages of the queue were the ability to easily perform synoptic and target-of-opportunity observations, the effective execution of programs optimized to the moonlight background using the dark time on gray nights, filling cloudy and non-optimal time with TAC-approved science, and the ability to take advantage of conditions of exceptional seeing or transparency. The disadvantages were the cost of ~2.2 high-level FTE to support NOAO's 40% share of the time, the lack of a sense of ownership of data not taken personally by the observer (as gathered from a "customer satisfaction" survey), and the perception of the committees that the success of observing programs was not so dependent on the range of

seeing and transparency conditions as to justify the cost. The queue experiment was deemed to be a complete success, because it allowed us to find a sensible set of rules for prioritizing and executing programs, and served as a pathfinder for US use of the Gemini telescopes in queue mode.

The WIYN Consortium restructured its management of WIYN to reflect the status of relatively routine operations and the pressing need for a new generation of instrumentation. George Jacoby, formerly of the NOAO staff, was chosen for the newly created position of Director. He has vigorously pursued the development of a wide-field CCD camera to cover a one-degree diameter field, composed of orthogonal-transfer CCDs to allow local area fast guiding on-chip. The result was a proposal submitted to the National Science Foundation from a WIYN-based partnership, including NOAO and the University of Hawaii with participation by MIT Lincoln Labs, to develop prototype detector arrays, culminating in an orthogonal-transfer CCD mosaic imager, QUOTA, for use at the telescope.

Dave Sawyer, the Site Manager responsible for implementing the effective operational approach of WIYN, left the Consortium for the commercial world. His position was used to hire Pat Knezek, an experienced observer, who will take responsibility for a number of the distributed instrument upgrade projects. Her initial major task is overseeing the completion of the instrument adapter for the re-imaged Cassegrain focus being produced at the University of Wisconsin.

Good progress was made during the year at NOAO on the WIYN Tip/Tilt Module, which will enable fast guiding over a 4-arcminute field of view. The end of the fiscal year saw all the fabrication completed, except for the challenging third mirror of the system, which was delayed by difficulties at the vendor. As of this writing, the mirror is in house undergoing post-polishing. Although the diamond turning of nickel-plated aluminum is not a new technology per se, the precision required for this aspheric surface breaks new ground in technique and measurement. During the summer, the main instrument adapter was removed and upgraded to add the pickoff mechanism to address either the direct imager or the WTTM-fed imager. The vendor delay impacted the critical path of the project relative to last year's projection. The instrument is now on track for integration with the telescope starting in January 2002.

In response to the ongoing reduction of internal funds formerly devoted to operation of KPNO, the observatory offered the operation of the 0.9-meter telescope to proposals by outside consortia. The winner of the externally peer-reviewed competition was a partnership sponsored by the WIYN Consortium. Their proposal was favored because of the combination of science research opportunity and the effective educational component for undergraduates at partner institutions. This partnership will refurbish and operate the telescope. KPNO will loan them the CCD Mosaic imager for blocks when it is not scheduled on the 4-meter. In exchange, KPNO users will retain proposal-driven access to 40% of the Mosaic time on the 0.9-m, one of the most oversubscribed capabilities of KPNO when the telescope was privatized. The resumption of science operations is anticipated for November.

3.2.4 More on the Light Pollution Control Front

The Tucson metropolitan area adjacent to Kitt Peak is situated in Pima County. Last year's report described a sweeping reform of the county's light pollution ordinance. Salient features of that ordinance included a limit on the installation of new and remodeled outdoor lighting based on zoned land use and measured in lumens per acre, a requirement that all such lighting be full cutoff, and a strict cap on lighting limits in areas close to existing observatory sites. The measure was passed with the provision of a period of public discussion and revision. Commercial and lighting engineering interests realized then that the code was very strict, and engaged the Outdoor Lighting Code Committee heavily over the next year in gaining concessions for relaxing the limits, particularly in urban areas already zoned commercial. The zones of protection around observatories were revamped to recognize the inverse square law impact of night lighting on the sites in a simple and enforceable set of stepped radial zones. The revised code was

returned to the County Board of Supervisors, where it passed unanimously with endorsement by the astronomy and commercial communities. The County also mandated its own staff to assess County facilities and implement a plan to bring them into compliance. The next phase of action is an outreach effort by KPNO to the County and City inspectors, park and athletic departments, etc., to promote voluntary cooperation.

3.3 Support of the Gemini Observatory

The US Gemini Program (USGP) has 12 scientific staff members and four technical or administrative staff assigned to support US community access (see <http://www.noao.edu/usgp/noaosupport.html>) on these state-of-the-art 8-m telescopes. At the start of FY 2001, USGP staff members Stefanie Wachter and Patrice Bouchet aided in the QuickStart Queue observations on Gemini North, using the U. Hawaii AO imager (Hokupa'a/QUIRC) and the U. Florida mid-IR imager OSCIR.

NOAO received 78 proposals for the 2001A semester for Gemini North. Eight of these proposals were placed in a service mini-queue and executed by USGP staff in February (R. Schommer observing with OSCIR), June (S. Ridgeway and Laird Close with Hokupa'a/QUIRC), and July (P. Bouchet using OSCIR).

Observations using Gemini South were available for the first time in the 2001B semester, using the visitor instruments FLAMINGOS and OSCIR and the Acquisition Camera, a facility option on Gemini South. All observations of Gemini South for 2001B will be carried out in a QuickStart Queue, and USGP staff will assist in their support. On Gemini North the instruments available were Hokupa'a/QUIRC, GMOS, and NIRI, the latter two in queue modes. NOAO received 77 proposals for the 2001B semester, which offered >50% science time on Gemini North and ~25% science time on Gemini South.

Approximately 25 US astronomers participated in the MCAO system workshop in Santa Cruz in October 2000 (see <http://www.gemini.edu/sciops/instruments/adaptiveOptics/AOIndex.html>). USGP staff members R. Schommer, T. Lauer, and T. Armandroff aided in the organization of this meeting. Subsequently, several US participants, including R. Schommer, served on the committee for the Preliminary Design Review of the MCAO System for Gemini South, held in Hilo, Hawaii, on May 24 and 25.

In February 2001, the USGP hosted a technical workshop in Tucson on the reduction of Gemini AO data. Approximately 40 attendees heard informative presentations from both US principal investigators, USGP staff, and Gemini AO staff. A summary of the workshop, including presentations, is available at http://www.noao.edu/usgp/ao_workshop.html.

The USGP and the Canadian Gemini project office co-hosted a special session at the June AAS meeting on "First Science from the Gemini telescopes." Presenters from the US included A. Stephens (OSU), K. Johnson (U. Colorado), D. Depoy (OSU), C. Telesco (U. Florida), K. Luhman (CfA), and D. Devost (Cornell).

The US Gemini Science Advisory Committee met in Pasadena on July 2 and 3. R. Schommer, T. Armandroff, and C. Pilachowski made presentations on the status of the Gemini telescopes and instruments, the US instrumentation effort, and current operational modes. This stimulated a lively discussion on the scientific and operational priorities for Gemini. Six members from this group subsequently participated in the Gemini Science Committee meeting in Durham, UK, during July 9–11. R. Schommer chaired the Gemini Operations Working Group meeting on July 12 in Durham. Membership of the USSAC is described at <http://www.noao.edu/usgp/staff.html>.

3.4 Observing Time on the HET and MMT

As part of NSF's now-defunct Facility Instrumentation Program, the Hobby-Eberly telescope and the MMT have each agreed to make 27 nights available per year for six years to the community in exchange for NSF funding for new instrumentation. Both of these telescopes have been coming through commissioning periods and ramping up of operations, and NOAO has worked with the community and the staffs of the observatories to ease the transition.

The HET is entirely queue-scheduled and NOAO has agreed to provide all support services to the community for the use of time on this telescope. So far, about 68 hours of time have been awarded and 32 hours of program data obtained. These observations completed two programs and started two additional programs. Two other programs were awarded time and are being prepared for execution, while six could not be executed due to delays in instrument commissioning. These are being held over for execution at a later time.

The MMT program began in semester 2000A, so the results through 2001B represent two years for this program. Through the 2001B semester, a total of 36.5 nights have been awarded on the MMT for 15 different programs. Three of these programs are being held for execution in later semesters when additional instruments have been commissioned.

3.5 SIRTf, Chandra, and HST

For some time, NOAO has been aware of the double jeopardy that proposers face when they undertake projects that require observations from both space-based and ground-based facilities. In order to facilitate such projects, NOAO has made arrangements that will allow observers to apply for space- and ground-based observing time in a single proposal for selected programs. Certain conditions must be met: 1) the space- and ground-based data must both be essential for answering the scientific questions addressed by the proposal, and 2) the data must be archived and made available to the community in a timely manner. In addition, the amount of time that will be made available through this channel is limited; the goal is to strike a sensible balance among programs such as this one, surveys, and standard proposals.

For SIRTf, up to 10% of the time at NOAO facilities was made available in connection with the SIRTf Legacy program. In total, 155 nights were awarded to four successful proposals to be scheduled through January 2003. The successful proposals are:

- *The SIRTf Wide-area InfraRed Extragalactic Survey* (PI: C. Lonsdale)
- *Great Observatories Origins Deep Survey* (PI: M. Dickinson)
- *From Molecular Cores to Planets* (PI: N. Evans)
- *SINGS: The SIRTf Nearby Galaxies Survey—Physics of the Star-Forming ISM and Galaxy Evolution* (PI: R. Kennicutt).

Thirty-seven nights were scheduled for these proposals in FY 2001.

Up to 5% of the time on NOAO facilities has been made available for successful Chandra proposals. Two programs were awarded time from the Chandra Cycle 3 call, for a total of 13 nights. None of these nights were scheduled in FY 2001.

Up to 5% of the time on NOAO facilities has also been made available for successful HST proposals. In Cycle 11, 61 nights were awarded to 16 successful proposals. None of these nights were scheduled in FY 2001.

3.6 Survey Programs

NOAO's Survey program continued to grow in FY 2001, as three new surveys were selected to begin in semester 2000B, marking the program's third year of operation. The survey program, in which up to about 20% of the time on NOAO telescopes (excluding Gemini) is made available for proposals to carry out surveys, was initiated to address the need expressed by a substantial segment of the astronomical community in a 1997 NOAO workshop: *Supporting Capabilities for Large Telescopes*. Surveys are large observational projects that provide uniform data sets with wide-ranging applications and interest. Although survey proposals go through an equally rigorous scientific evaluation as standard proposals, survey proposers must also submit complete management plans for all aspects of the projects. The final allocation of telescope time to surveys is made by a "merging committee," which weighs the scientific and societal merits of survey and standard proposals explicitly and in competition.

The three new surveys that were approved to start in semester 2000B are:

- *Deep Ecliptic Survey*, PI: R. Millis (Lowell Observatory)
- *A Next Generation Microlensing Survey of the LMC*, PI: C. Stubbs (Univ. of Washington)
- *The Evolution of Galaxy Clustering at $1 < z < 2$* , PI: R. Elston (Univ. of Florida).

Several of the surveys started in previous years are nearing completion and are beginning to release the data products promised to the community as part of this program. The NOAO Deep Wide-Field Survey (<http://www.noao.edu/noao/noaodeep/>) and the Deep Lens Survey (<http://dls.bell-labs.com/>) have each released subsets of their reduced multi-band imaging.

Annually, NOAO convenes a meeting of all the PIs of ongoing surveys, in order to identify common problems and concerns and to establish good communication between the survey teams and the NOAO staff. At the meeting held in August 2001, much of the discussion focused on the difficulty and cost of the "back end" of the survey projects—the data reduction, generation of data products, and development of archives and archive interfaces. This issue had been previously identified and a proposed solution has become the centerpiece of the new Data Products Program, the creation of a NVO-compliant data archive with a uniform interface for reduced data from all NOAO surveys (as well as other coherent data sets). This solution was supported by the PIs, who agreed to participate in the definition of this archive.

4. NOAO AND GEMINI INSTRUMENTATION

The Instrument Projects Group (IPG) develops and produces major instruments for the NOAO nighttime telescopes, including those at KPNO, CTIO, and Gemini. The NOAO scientific staff conceives, directs, prioritizes, and evaluates the instrumentation projects; the engineering managers are responsible for meeting schedule, budget, and performance requirements. NOAO astronomers initiate new instruments in response to user requests, scientific staff interests, advances in technology, and announcements of opportunity from the Gemini Observatory.

Managing the instrumentation resources efficiently and in a manner satisfactory to both Tucson and Cerro Tololo is crucial to the success of our program. The Instrument Projects Advisory Committee (IPAC) provides scientific prioritization to the IPG. IPAC FY 2001 members were T. Armandroff (Chair),

S. Barden, R. Blum, L. Daggert, D. Joyce, M. Merrill, R. Probst, B. Starr, and A. Walker. IPAC meets with the instrumentation managers about once a month to review priorities, schedules, and budgets. IPAC develops the scientific content of the long-range plan, on the basis of input from the users through the Users' Committee and personal contact, from the WIYN and SOAR partners, and from the Gemini advisory structure through the US Gemini Program (USGP). Every instrument under development has an associated instrument scientist from the NOAO scientific staff. We believe that this arrangement is essential for successful development—each instrument must have an intellectual champion to see that the project meets its scientific performance goals. IPAC provides a venue where the interests of each site are fairly represented.

During FY 2001, our ongoing projects advanced, as described below.

4.1 Gemini Instruments

4.1.1 Gemini Near-IR Spectrograph (GNIRS)

The major instrument under production is the Gemini Near-IR Spectrograph (GNIRS). This project is the largest instrument ever undertaken by NOAO. It will provide long-slit capabilities with a range of dispersions through selectable gratings, covering the wavelength region from 0.9 μm to 5.5 μm at two pixel scales by means of interchangeable cameras that feed a single 1024 square ALADDIN-type InSb detector.

The project team spent most of FY 2001 in parts fabrication, which is nearly complete, even though the design of some components is still ongoing. All optics have been received, the optical bench fabrication was completed, and integration of parts with the optical benches began. GNIRS delivery is planned for August 2002.

4.1.2 Gemini IR Array Controllers

The first facility instrument for the Gemini North telescope is the Near-InfraRed Imager (NIRI), developed at the University of Hawaii. NOAO produced for NIRI a powerful array controller that has very low noise and high readout speed. That system passed its acceptance review and was delivered to Hawaii in FY 1998. An identical NOAO array controller will be used in GNIRS. During FY 2001, NOAO delivered, and Gemini accepted, a speed upgrade for the array controller to read out and transfer to the Gemini DHS one full frame per second. This work for Gemini is now complete.

4.1.3 GMOS/bHROS CCDs

NOAO is providing the integration of CCDs, CCD controllers, and relevant software for Gemini's GMOS and bHROS optical spectrographs. The CCDs are from EEV in the UK, and the controllers are SDSU-2. The CCDs, controller, and related software passed their acceptance tests and were delivered for GMOS 1 and 2 in previous fiscal years. During FY 2001, the NOAO team began work on the system for the bHROS bench optical spectrograph.

4.1.4 Gemini South Adaptive Optics (GSAO) Imager

NOAO submitted a proposal to Gemini to perform a conceptual design study as the first stage of development of a new instrument designed as a moderate-field near infrared imager to work with adaptive optics on Gemini South. As of the end of FY 2001, Gemini had not announced a decision regarding the submitted proposals. Subsequently, it was announced that study awards would be given to NOAO and to

the Australian National University based on the recommendation of the Gemini proposal review committee that included experts outside the Gemini Observatory.

4.1.5 US Gemini Instrumentation Program

One component of the US Gemini Instrumentation Program consists of instruments being built by NOAO for use on Gemini. Four such projects (Gemini Near-IR Spectrograph, Gemini IR Array Controllers, GMOS/bHROS CCDs, and the GSAO Imager study) are described above. A fifth NOAO project, modifications to the NOAO Phoenix instrument for use on Gemini South as a visiting instrument, is described below.

The other class of US Gemini instruments consists of those being built at other US organizations under the direction of the USGP. In the past, USGP ran the competitions in the US community and awarded the contracts, but this will change in the future as Gemini takes a more direct role in the procurement of their instruments. As it has in the past, the USGP will continue to provide advice and liaison to the instrument teams, and management oversight (including quarterly reviews of each instrument's progress via a site visit).

The Thermal Region Camera and Spectrograph (known as T-ReCS) is one of the final instruments of the initial complement of Gemini instruments. The supplier of this mid-infrared imager and spectrograph for the Gemini South telescope is the University of Florida (Charles Telesco, PI). All T-ReCS optics have been received and inspected, including the critical diamond-turned mirrors. All mechanical parts have been fabricated and assembled. The electronics have been fabricated and used to read out the science array and to move the mechanisms. At the end of FY 2001, software development is nearly complete and system integration has begun. The last USGP quarterly review of T-ReCS for FY 2001 took place on July 18. The T-ReCS team now plans acceptance testing on Gemini South in early 2002.

The first of the second-generation Gemini instruments is the Near-Infrared Coronagraphic Imager (dubbed NICI). NICI is funded by monies directed from the NASA Origins Program to NOAO via a proposal. NICI will provide a 1–5 micron infrared coronagraphic imaging capability on the Gemini South telescope. Mauna Kea Infrared (MKIR) was the successful competitive bidder for the NICI conceptual design study and the only respondent to an RFP for building the instrument. A conceptual design review of MKIR's concept for NICI, followed by a procurement review of their proposal, was conducted on April 18 and 19, 2000. Based on positive feedback from the review committee, USGP and MKIR negotiated a contract and Statement of Work for NICI procurement. The project plan calls for NICI to be delivered to Gemini South in summer 2004. The last USGP quarterly review of NICI for FY 2001 took place on June 20 (with another in early October). The Preliminary Design Review is scheduled for March 2002.

FLAMINGOS 2 is a concept for a near-infrared multi-object imaging spectrograph for the Gemini South telescope, developed by R. Elston and his team at the University of Florida. The FLAMINGOS 2 concept, which builds on the heritage of the FLAMINGOS imaging spectrograph, provides 1-2.5 μm direct imaging as well as multi-slit spectroscopy across a 3–4 arcminute field of view. A conceptual design review of FLAMINGOS 2 was held on April 28, 2000. A parallel review was conducted for a competing instrument, IRIS-2g (proposed by the Anglo-Australian Observatory). The Gemini review committee judged FLAMINGOS 2 to be more suitable for Gemini's needs and aspirations. At the end of FY 2001, the Gemini Observatory, USGP, and the University of Florida had agreed on a contract, Statement of Work, and work scope for the construction of FLAMINGOS 2, and were waiting on approval of overhead funding before proceeding with a request for contract approval.

4.2 NOAO Instruments

4.2.1 *WIYN Tip/Tilt Imager*

The WIYN 3.5-m telescope is the facility of choice on Kitt Peak for high-resolution optical imaging. In an effort to enhance our capabilities for high-resolution imaging over a moderate field, a tip/tilt imager is being constructed for WIYN. The WIYN Tip/Tilt Module (WTTM) is an optical/near-IR re-imaging system that utilizes fast tip/tilt compensation and includes real-time focus sensing. The WTTM field of view is 4×4 arcmin at a plate scale of 0.12 arcsec per pixel. The WTTM will be attached to the WIYN Instrument Adapter System, which will facilitate quickly changing between the WTTM and the Mini-Mosaic imager by simply moving a pick-off mirror (in response to changing atmospheric conditions, for example). WTTM activities during FY 2001 included mechanical fabrication, optics fabrication, software development, and acceptance testing. Some delay was incurred through difficulties in producing a high precision diamond-turned camera mirror, but the part was accepted just after the start of the new fiscal year. On-telescope tests of WTTM are now planned for January 2002.

4.2.2 *Phoenix*

Phoenix is a high-resolution near-infrared spectrometer that has been in productive scientific use on the KPNO 4-m and 2.1-m telescopes. Phoenix yields spectra with resolution up to $R = 70,000$ in the wavelength range 1–5 microns. An agreement was signed between NOAO/USGP and Gemini that specifies the modification of Phoenix for Gemini and how the instrument will be supported and maintained. This work was completed in FY 2001. NOAO and Gemini plan to make Phoenix available on the Gemini South telescope at the inception of scientific use of this telescope in early FY 2002. Phoenix will be shared equally between Gemini South and CTIO/SOAR.

4.2.3 *NOAO Extremely Wide-Field IR Imager (NEWFIRM)*

Wide field imaging, in the optical and infrared, is a long-term, key element in the observing capability of NOAO, both in support of 8-m telescopes and in its own right. During FY 2001, NOAO built on previous work for NEWFIRM by refining scientific requirements, evaluating the results of the Ball Aerospace and Technologies Corporation (BATC) study, and continuing an in-house conceptual design study. The following design goals have been formulated: 1) wide field of view (diameter of 27 arcmin) to complement the narrower fields of most 8-m telescopes, 2) 0.4 arcsec per pixel with a 4K×4K detector to perform an efficient survey with adequate sampling of the point spread function throughout the near IR bands of interest, 3) 1.0-2.4 micrometer bandpass to cover the J, H, and K near IR bands, and 4) place the instrument at the 4-m R-C focus to reduce complexity and maintenance costs. During FY 2001, a Project Manager was hired to lead the project, with a goal of holding a Conceptual Design Review in early FY 2002.

5. IMPLEMENTING THE DECADAL SURVEY

5.1 Giant Segmented-Mirror Telescope (GSMT)

In FY 2001, the AURA New Initiative Office (NIO) made progress toward achieving its primary goal, which is, as suggested in the decadal survey, to ensure:

“... broad community access to a 30-m telescope, contemporary in time to ALMA and NGST, by playing a key role in scientific studies leading to the creation of a Giant Segmented Mirror Telescope.”

NOAO has begun to involve a broad cross-section of the US community in identifying the key scientific drivers for a GSMT and the technologies needed to enable the challenging instruments critical to achieving GMST goals. In parallel, a core NIO engineering and science team comprising 10 FTEs is in place and working in Tucson, Hilo and La Serena. For much of the past six months, the NIO team has been focusing its energy on a system analysis of a “point design” concept for GSMT, with a goal of understanding the technical and cost issues that are central to successful design of an affordable telescope.

Formally established in January 2001, the New Initiatives Office is headed scientifically by a Project Scientist and a Systems Scientist and managed by a Program Manager. Key technical staff includes a core group assigned full time to the NIO plus a number of NOAO and Gemini staff supporting the work on a part time basis. The NOAO scientists who hold key positions in NIO are: Steve Strom (Project Scientist), Brooke Gregory (Systems Scientist), Sam Barden (Instrument Scientist), and Joan Najita (Science Coordinator).

The NIO opened a public Web site containing images and illustrations, technical reports, copies of presentations, collections of test results, and links to the sites of other groups exploring concepts for extremely large telescopes (www.aura-nio.noao.edu). The Web site is updated frequently to provide visibility into the scientific and technical activities of the NIO, as part of our commitment to advance community efforts to develop concepts for the GSMT.

5.1.1 GSMT Scientific and Technical Milestones Achieved in FY 2001

- Initial science case studies were completed, resulting in the adoption of an initial set of engineering requirements for GSMT. Key areas investigated were: (1) the origin of large-scale structure, (2) the assembly of galaxies, (3) stellar populations, and (4) the formation of stars and planetary systems.
- Based on these requirements, the NIO developed a “point design” optical and structural concept—a starting point for understanding key technical issues, along with cost and risk drivers.
- An adaptive optics systems concept—integral to the performance of GSMT—has been designed, its performance modeled, and key technical issues for future studies identified.
- Concepts for GSMT instruments have been explored: (1) an innovative prime focus multi-object spectrograph; (2) a deployable integral field unit spectrograph; (3) near- to mid- IR high resolution spectrographs; (4) an MCAO imager.
- A program for site evaluation was initiated in Chile resulting in the identification of multiple candidate Extremely Large Telescope (ELT) sites in northern Chile.
- An international meeting aimed at identifying common issues and coordination among ongoing ELT site evaluations was held in Chile and resulted in the formation of multiple collaborative efforts among stakeholders.
- Wind-loading tests on Gemini North and South were completed, providing both a sound basis for comparison of measurements with predicted structural responses and a valuable database to guide understanding of the effects of wind buffeting on the design of ELTs.

5.2 The Large-aperture Synoptic Survey Telescope (LSST)

The Large-aperture Synoptic Survey Telescope (LSST) is one of three major new ground-based facilities recommended for construction during the coming decade by the AASC. With the capability of providing a digital survey of the entire visible sky every week or so to a deep limiting magnitude (~ 24 in a single optical band), the LSST will take advantage of developments in telescope and detector technology and computational hardware and software to open up new domains of astrophysical research. It would, for example, be possible to detect within a decade about 90 percent of all the Near-Earth Objects (NEOs) with diameters greater than 300 m, i.e., nearly all of the objects that would inflict significant damage should they impact Earth; the data would also make it possible to derive orbital parameters and thus assess the degree of the threat. The LSST will also open up the domain of studies of time variable objects and will have applications in a variety of fields of research, including the use of weak lensing to enable mass tomography—the mapping of the distribution of total matter, bright plus dark, out to $z=1$, thereby constraining models of the Universe, and to the study of stellar populations in order to understand how our own Galaxy was assembled.

The goal of the NOAO LSST program is to work with the community, including especially the University of Arizona, to develop over the next two years a costed proposal for construction of the telescope and instrument and to develop the data management system.

Over the past year, several workshops have been held, both at NOAO and elsewhere, culminating in a three-week workshop at Aspen, to define key science programs that would be enabled by the LSST and to explore design concepts and issues.

Dennis Zaritsky of the University of Arizona has initiated a draft science requirements document. This document will be fleshed out through a series of small targeted science workshops in FY 2002. The science areas that we will focus on are: 1) detection of moving objects; 2) detection of variable objects; and 3) deep imaging with good image quality to detect weak lensing. These three projects stress the telescope requirements in different ways. A small science working group will then optimize the requirements to meet as many of the key science goals as possible.

A substantial amount of work has already been completed on optical design by engineers at Lawrence Livermore, optics fabrication and testing at the University of Arizona, and optical alignment at NOAO. A primary focus for the coming year will be developing viable concepts for the instrument.

Data management is the primary challenge of the LSST project. We can expect to generate up to five terabytes of data per night; certain information, particularly about variable, transient, and moving objects, must be made available in near real time; and the cost curve inferred from such projects as 2MASS and Sloan must be reduced by a factor on the order of five for the LSST project overall to be affordable. Andrew Connolly of the University of Pittsburgh has agreed to lead the planning effort for the data management system, and will be appointed in FY 2002 as the first “extended staff member” of NOAO.

5.3 NOAO and the National Virtual Observatory (NVO)

NOAO has continued to play a major role in the development of the National Virtual Observatory (NVO). The past year saw the initiative begin to take shape around the work of the national Interim Steering Committee, on which D. De Young serves. A proposal to build the NVO infrastructure was written by this committee and submitted to NSF’s Information Technology Research program. This successful proposal was granted funding totaling \$10 million over five years. As a result of this effort, NOAO will participate in the development in areas of administration, management, and policy as well as technical work concentrating on the design of a “data access layer” for archives. D. De Young, who has been named first

NVO Project Scientist by the Interim Steering Committee, will lead the programmatic work and D. Tody will lead the technical work.

NOAO staff also continued to participate in peripheral NVO efforts throughout the year. D. De Young organized a workshop on *Theory and the NVO* in Tucson in March 2001. De Young also helped organize a two week long summer workshop at the Aspen Physics Center on the NVO.

The effect of the NVO on NOAO's program is not limited to direct participation in the project. Present and planned activities at NOAO are also directed at making the Observatory a viable partner in the NVO and ensuring that the O/IR community represented by NOAO is able to take full advantage of the NVO capabilities as they come on line. To this end, NOAO has inaugurated a Data Products Program, with the goal of creating an O/IR node for the NVO. Initial goals of this program include the establishment of an archive to serve as a repository and point of distribution for large, coherent data sets—including the data products of the NOAO survey program. Resources for this new program include the group of software engineers previously known as the IRAF group, who, together with new hires, are focusing on this new direction.

5.4 The Telescope System Instrumentation Program (TSIP)

Throughout the decadal survey report, the new paradigm of the “telescope observing” system provides context for the initiatives. This paradigm is based on the idea that it is the combination of public and private facilities, working in a complementary manner, that will allow the US to maintain its leadership position in world astronomy. As an idea, the “system” is simple: let the public facilities focus on providing capabilities that are (a) too large for individual institutions, (b) demand universal access, or (c) are complementary to those being provided by the private observatories. In practice, the system is chaotic because the self-interest that drives decisions is not well coupled to consideration of the capabilities provided in other places. The Telescope System Instrumentation Program (TSIP) was developed by the Panel on O/IR Astronomy from the Ground to provide motivation for the observatories that make up the O/IR ground-based system by providing funding to the independent observatories to build large, expensive instruments that will increase the capability of the system, and by providing access to the private large telescopes, to the entire community.

NOAO took two major steps in FY 2001 toward making the system a reality. In October 2000, T. Boroson and A. Dressler (OCIW) organized a national workshop on the Ground-Based O/IR System. This workshop, held in Scottsdale, Arizona (a neutral site), brought together over 70 astronomers from a very broad range of institutions to discuss the state of the system, and to develop, through scientific arguments, a prioritized list for potential new capabilities. To facilitate this public discussion, a System Committee was established for the purposes of both organizing the workshop and providing a group that could extend the community perspective into a strategic plan for the system. Along with traditional O/IR astronomers, this committee included astronomers who work primarily in other wavebands but also depend on O/IR data, and administrators who are familiar with similar planning processes in other areas. The workshop report, available at <http://www.noao.edu/system/workshops/>, details the process and the results, and it has served as a guide for continuing discussions with funding agencies and policy makers. One component of the report is a list of the instrumental capabilities that would be seen to enhance the system.

The second step taken by NOAO was the development of a plan for the administration of TSIP itself. This activity was a consequence of initial efforts within NSF/AST to identify a small fund to get TSIP started, but was raised in visibility by the explicit language in the FY 2002 federal budget allocations that identified \$3–\$4 million explicitly for TSIP. Because TSIP is not a grants program but is more complicated—involving agreements to build instruments, contract monitoring, and the need to provide community support for access to independent facilities—NOAO can provide added value to this service.

Based on the experience gained in establishing the US Gemini Project Office, an implementation plan for TSIP was developed, with well-defined processes for soliciting and evaluating proposals, and an oversight activity that would not seem too intrusive to the independent observatories. This plan was circulated to ACCORD, the AURA committee on which the independent observatory directors sit, and together with comments from that group, was submitted to NSF/AST. NOAO was subsequently instructed to compose a solicitation for proposals to TSIP based on the submitted plan, and that work is underway. It is expected that the TSIP solicitation will be issued early in FY 2002, marking the beginning of the high priority program laid out in the AASC report.

5.5 Site Characterization for New Large Facilities

Although our efforts are focused on the GSMT and LSST, formal or informal collaborations continued with CELT, ESO, Cornell U., U. Tokyo, and the Mexican institutes UNAM and INAOE. The analysis of archival satellite cloud and water vapor images of northern Chile was completed. The same data set is now being used for a similar analysis of SW USA and Mexico, in a collaboration with CELT. A contract was negotiated, again in a collaboration with CELT, to provide an equivalent analysis for Mauna Kea.

A weather station was assembled and moved to Cerro Honar, at 5200 m altitude near the Chajnantor ALMA site, and DIMM measurements were taken in a one-week campaign. A similar DIMM is now working regularly on Cerro Tololo, and two more shipped to Hawaii for tests on various Mauna Kea summit positions, work led by Gemini. A strong component of future work is characterizing the turbulence around and above prospective sites; as part of this a portable Profilometer to measure the vertical turbulence structure at low resolution is being constructed. Results from this will be compared to numerical models and direct measurements by other techniques.

6. COMPUTER SUPPORT AND NETWORK SERVICES

6.1 Tucson

The downtown Tucson computing facilities continue to evolve as older systems are replaced by newer, more cost-effective and easier-to-maintain systems. In particular, the FreeBSD system that provides e-mail, DNS, and FTP service for NOAO-Tucson and Kitt Peak was upgraded.

Also, several older disk drives on various CCS systems failed during the year and were replaced by more reliable, and also larger, disks. Similarly, older laser printers were replaced by newer, more capable, ones. The proliferation of desktop workstations, PCs, and X-terminals to scientists' and engineers' offices has slowed as saturation is approached; however, many desktop systems were upgraded to faster systems over the course of the year.

The network infrastructure in the downtown Tucson office building continued to be upgraded during FY 2001 to increase performance and reliability. Several additional Ethernet switches were installed to connect more systems to the backbone network. Preparations continued to support the DS-3 (45 Mbps) data line from Tucson to Kitt Peak, which is expected to be available in FY 2002.

A new e-mail system that provides more capability (including a Web-based interface) and security (including virus scanning) than the previous system was installed in FY 2001, and the existing firewall system was strengthened.

6.2 Kitt Peak

During FY 2001, the conversion of infrastructure systems running on older Sun or VxWorks systems to Linux systems running on PC hardware continued. The mountain network infrastructure continued to be upgraded. These upgrades were financed by a High Speed Networking grant from NSF's program on Advanced Networking Infrastructure. This same grant will be used to fund a DS-3 (45 Mbps) data line from Tucson to Kitt Peak, which should be available in FY 2002.

6.3 CTIO – La Serena

The computing infrastructure in La Serena serves as the hub of CTIO computing facilities, serving the needs of scientific staff, engineers, secretarial staff, and visiting astronomers using a variety of computing hardware and operating systems. Over the past year, our shift to the Linux/PC workstations has continued as we have upgraded and replaced older Sun workstations. The vast majority of the scientific and technical staff now use Linux, which provides for easier, more uniform computer support and software maintenance. Several older laser printers have been replaced by network printers, allowing use from the diverse set of platforms, from workstations running Linux and Solaris to PCs running various flavors of Windows and MacOS. A poster printer bought out of FY 2000 funds has been installed for preparation of posters for scientific and technical presentations.

Systems security has been a leading concern during FY 2001, due to the numerous viruses and worms which have been reported over the last year. We have established procedures for dealing with virus reports, heightened awareness among our users, and installed improved virus detection software. The CTIO communications section details more security-related activities.

In order to both boost security and also better serve our user community, we have installed a new WWW server outside our La Serena firewall, allowing for quicker access to information from the outside while also allowing us to improve security inside our network.

6.4 CTIO – Cerro Tololo and Cerro Pachón

The CTIO mountain network now consists of resources on both Cerro Tololo and Cerro Pachón. Our Cerro Tololo computing environment has been fairly stable, relying mostly on a network of Sun workstations to serve the data acquisition and analysis needs of visiting astronomers. Our slow migration from Sun workstations to Linux is just beginning, as older workstations need to be replaced. The operators' interface at the 1.5-m telescope was upgraded to a Linux workstation in FY 2001, and the 4-m console will be upgraded in FY 2002. We have also begun some restructuring of the network on Cerro Tololo to break out portions of high traffic (such as the cluster of machines which control our Mosaic camera on the Blanco 4-m). These efforts will continue in FY 2002, including extension of the network to both the technicians' dorm (for quick remote analysis of simple problems) and the astronomers' dorm.

The construction activities of the SOAR telescope on Cerro Pachón have included significant computing infrastructure installation. A connection to the communications backbone has been established with help from Gemini, providing high-speed network link from Cerro Pachón to Cerro Tololo and down to La Serena. The SOAR construction team has started to work with the CTIO computing staff to integrate SOAR into the CTIO computing environment.

6.5 CTIO – Communications

The computer networks between La Serena, Cerro Tololo, Cerro Pachón, and the outside world are the foundation of the computing infrastructure of not only CTIO, but also Gemini-South. The network

provides for data transfer, remote access to machines on the mountain, remote support of instruments and astronomers, remote observing, and also audio and video transmission for teleconferences and video conferences. CTIO and Gemini have been working together closely to improve the internal and external connectivity to levels which can support the flow of data, audio, and video traffic necessary to the operation of the combination of all of the CTIO, SOAR, and Gemini telescopes.

The most significant and noticeable improvement in our network infrastructure has been the installation of an OC-3 (155 Mbps) microwave communications backbone between La Serena, Cerro Tololo, and Cerro Pachón. This project, funded by the NSF through joint grant to CTIO and Gemini, was completed in FY 2001 and put into service almost immediately, providing high-speed network connectivity between La Serena and the telescopes and support systems on the mountaintops. This upgrade from 2Mbps to a shared 155Mbps line has already enabled remote support of our major Blanco 4-m instrument, the Mosaic imager, and provides a foundation for future remote support and remote observing.

Our external connectivity situation has also improved in FY 2001, and is set to improve even more in FY 2002. In mid-FY 2001, through negotiations with our current commercial Internet provider, Intel, we obtained an upgrade from our inadequate 512Kbps link to a 2Mbps link to the outside world shared between CTIO and Gemini. This provided a significant improvement, allowing for some additional data traffic and, for the first time, video conferencing over the network (a significant cost savings over the ISDN phone lines we had been using for video conferencing). However, this bandwidth is still inadequate for the operations of the observatories. So we have jointly applied to the NSF for funding for a high-speed (of approx. 10Mbps or more), high-reliability international Internet connection. Funding for this was approved in the end of FY 2001 and we have begun the process of looking for an Internet provider who can provide the bandwidth. We plan to have this new connection in place by mid-2002.

Network security has been built in to these connectivity upgrades. With the installation of the high-speed internal backbone, firewalls were installed at all sites (Cerro Tololo and Cerro Pachón, in addition to the existing unit in La Serena) to provide secure access to the mountaintop networks. At the end of FY 2001, in collaboration with Gemini, we purchased an intrusion detection system (IDS) to be put on the external Internet connection to monitor and filter incoming data streams. We plan to filter out viruses and other malicious traffic at the IDS before they even get into our network. Security will continue to be a high priority, as we install new networking hardware and computing resources. We are investing in significant staff training at both the network and operating systems levels to provide the necessary local security expertise.

7. OFFICE OF PUBLIC AFFAIRS AND EDUCATIONAL OUTREACH (PAEO)

7.1 Educational Outreach (EO)

NOAO's Educational Outreach group is responsible for managing and developing the national observatory's programs that train teachers and astronomers to communicate scientific research principles and the latest discoveries in astronomy to pre-college students. EO also facilitates graduate and post-doctoral student opportunities at KPNO and CTIO.

7.1.1 Teacher Leaders in Research-Based Science Education

Educational Outreach group was awarded up to \$1.8M over the next five years by the NSF Educational and Human Resources Directorate to develop "Teacher Leaders in Research Based Science Education" (TLRBSE). The newly funded TLRBSE program leverages the success of its predecessor, "The Use of Astronomy in Research Based Science Education (RBSE)." TLRBSE will reach a much larger number of teachers with more diverse needs, while facilitating authentic research in classroom settings and

addressing the national educational concerns of teacher retention and renewal. NOAO Education Outreach Officer Suzanne Jacoby is the Principal Investigator. Co-investigators on the TLRBSE program include Travis Rector of NOAO (who will be moving to NRAO, but continuing his involvement), Donald McCarthy from UA/Steward Observatory, and Jeffrey Lockwood from TERC.

This program includes a Summer Institute and year-round Distance Learning Course that is in the process of being formally accredited through the University of Arizona. It is designed to promote skills in leadership and inquiry-based pedagogy for middle and high school teachers. The inaugural TLRBSE workshop took place from July 9-20, 2001, with 10 teacher veterans of the RBSE program in attendance. All of them participated in extensive focus groups to determine the program content and flow for future years, and they conducted observing runs on Kitt Peak and Sac Peak.

Dara Norman joined the staff of CTIO via an NSF Astronomy and Astrophysics Postdoctoral Fellowship. She will spend part of her time exploring ways to develop the NOAO Deep Lens Survey as source material for a localized RBSE research project.

7.1.2 Project ASTRO-Tucson

Project ASTRO continued strong into its sixth year at NOAO Tucson, having formed more than 250 ongoing partnerships between astronomers and teachers to bring hands-on activities into science classrooms, indirectly reaching more than 13,000 students and counting.

In February, PAEO hired Connie Walker, a PhD astronomer formerly with Steward Observatory, to serve as its new Senior Program Coordinator with responsibility for Project ASTRO, bringing a new level of scientific authenticity to the program. Project ASTRO began the year with record numbers (32) attending its annual follow-up workshop in March, which focused on an activity partners could build, take with them and immediately use in their classrooms, while simultaneously increasing the NOAO department's educational resources available for checkout. In April, C. Walker presented at the Project ASTRO Site Leaders Meeting in Boston, attended by representatives from all 11 sites in the National Network.

Education poster papers were presented on Project ASTRO-Tucson and TLRBSE at the June 2001 AAS meeting in Pasadena. NOAO outreach astronomer T. Rector participated in a special session on "Outstanding Programs in Education and Public Outreach." Poster papers on ASTRO and RBSE were presented at the January 2001 AAS meeting, and the three NOAO RET teachers from summer 2000 attended, with two presenting papers as well.

The Fall 2001 Project ASTRO workshop was held in September, and included lectures from noted planetary scientist/artist William K. Hartmann and comet hunter David Levy, along with a group trip to the Kitt Peak Visitor Center. For the third consecutive year, Joni Chancer and Gina Rester-Zodrow, authors of "Moon Journals: Writing, Art, and Inquiry through Focused Nature Study" presented at the workshop. Nearly 60 participants attended.

7.1.3 Research Experiences for Teachers (RET)

NOAO did not participate in the NSF's RET program this year in order to focus its resources on preparing a competitive TLRBSE proposal (which was successful) and on continued active participation in the REU student program. We plan to renew our participation in the RET program in FY 2002.

7.1.4 Other NOAO Programs for Teachers

In August, PAEO received notice that its proposal to the NSF Internship in Public Science Education Program was successful, providing \$100,000 over the next three years for two primary tasks: working with local teachers on creating activities and materials for classroom visits to Kitt Peak, and developing classroom materials, online and hardcopy, for making use of NOAO science discoveries in the K-12 classroom.

7.1.5 Research Experiences for Undergraduates (REU)

NOAO continues its long-standing participation in the National Science Foundation's Research Experiences for Undergraduates program, preparing future generations of professionals who will sustain US preeminence in astronomy and contribute to a scientifically literate nation. Eight undergraduate students worked closely with NOAO Tucson staff for a 10-12 week period during the summer of 2001, developing skills as scientific researchers and furthering their professional development. (Four more students worked with staff of the National Solar Observatory, with direct logistical support from PAEO.)

7.1.6 Graduate Education

NOAO continues to support a significant fraction of US PhD theses in optical ground-based astronomy, including travel support. NOAO also participates in the NASA-funded Arizona Space Grant Consortium, which sponsors an undergraduate intern at NOAO in space science. NASA also provided funding for two African-American undergraduates from South Carolina University to work as research assistants in the summer 2001 REU program, under the new Undergraduate Research Program in Astronomy (URPA) program.

The GNIRS project initiated a summer internship for four University of Arizona undergraduates interested in instrumentation to work in the NOAO Engineering and Technical Services department, and NOAO's WIYN partners had an undergraduate student and a graduate student assist with work on the Tip/Tilt imager project in Tucson during summer 2001.

Finally, an REU-like instrumentation internship for two Chilean university students is supported by CTIO, and runs concurrently with REU program in La Serena.

7.2 Public Outreach

NOAO's Public Outreach group manages all activities at the Kitt Peak Visitor Center, including the center's educational exhibits and retail operations, three daily tours of Kitt Peak observatories, the Kitt Peak docent program, and the increasingly popular fee-based nighttime observing experiences for both the general public and advanced amateurs.

The new Public Outreach Manager and Public Outreach Coordinator hired last year immediately revitalized numerous aspects of the Kitt Peak Visitor Center and its programs, with greater plans in store for FY 2002, including the development of an Interpretive Master Plan for the visitor center and its grounds.

7.2.1 Kitt Peak Visitor Center

Repairs and improvements to the Visitor Center already underway include completion of the replacement of the outside patio area, a variety of repainting and new signage (including a durable outdoor banner featuring a brilliant color image of the Rosette Nebula), more cost efficient interior lighting, new

furniture, and improved wall coverings. In 2002, the focus will turn to new and upgraded exhibits, including the International Gemini Observatories and spectroscopy.

A related marketing push began with a redesigned Kitt Peak brochure, which is being distributed by a more aggressive service that reaches all of Southern Arizona and the region's airports. Another element of this marketing plan is better-coordinated Web information with sites such as the Tucson Metropolitan Convention and Visitors Bureau, the Southern Arizona Attractions Alliance, and the Arizona Office of Tourism.

The Kitt Peak Docent training program has been enriched to reflect current trends in volunteer utilization. The program was expanded to an intensive seven-week course. Topics such as basic astronomy, the natural/cultural history of the mountain, customer relations, and interpretation have been added to enhance this popular volunteer program. This training was augmented further with exchanges between Kitt Peak and staff at other Tucson-area attractions and museums. A comprehensive new policy and procedures manual was also developed to improve the quality and consistency of the program presented by the guides who host the popular Nightly Observing Program and Advanced Observing Program. (Images produced by the AOP continued to be a popular resource for astronomy media in FY 2001.)

7.2.2 *Visitors to Kitt Peak*

Of the estimated 50,000 visitors and/or tourists who came to Kitt Peak in FY 2001, over 30,000 took a formal tour—self-guided or with a KPNO docent—or participated in one of the popular observing programs for the general public. Several hundred special tours were provided for schools, university groups, film and video production companies, and media reporters, including the Australian correspondent for *Science* magazine, the science reporter for the *Christian Science Monitor*, and representatives of the National Film Board of Canada and Tennessee State University.

**Public Affairs & Educational Outreach (PAEO)
Kitt Peak Visitor Center
Summary of Annual Visitors
(12 Months Ending 9/30/01)**

<i>Group/Program</i>	<i>Visitors</i>
General public tours	18,438
Self-guided tours	6,400
School groups K-12	1,028
Special tours	469
Nightly Observing Program	3,812
Advanced Observing Program	124
Total Visitors	30,271

7.2.3 *External Coordination*

NOAO hosted the April 2001 meeting of the Southwestern Consortium of Observatories for Public Education (SCOPE), a cooperative organization of research institution-based visitor centers in the Southwest that promotes public awareness of astronomy through access and education. Two NOAO representatives attended the August 2001 SCOPE meeting in Sunspot, NM.

The consortium includes Kitt Peak National Observatory, the National Solar Observatory, Apache Point Observatory, McDonald Observatory, the National Radio Astronomy Observatory/Very Large Array, and Whipple Observatory. SCOPE is currently completing an outreach-oriented poster about large sky survey programs, and then will consider a new joint project in 2002.

To further increase the visibility of Kitt Peak and its awareness factor with Tucson visitors, NOAO joined the following organizations as an active participant: the Southern Arizona Attractions Alliance, the Tucson Association of Museums, the National Association for Interpretation, and the Association of Science and Technology Centers, Inc.

7.3 Media and Public Information

NOAO's media and public information group coordinates news releases, media events and visits, fact sheets, posters, the *NOAO Newsletter*, and other visual products that explain NOAO's latest research and organizational activities. It also coordinates NOAO's public Web presence and external use of NOAO imagery, and serves as the primary response point for public inquiries and general e-mails.

7.3.1 Press Releases and Image Releases

NOAO hired a new public information officer/science writer in August 2000, later named manager of the renamed and restructured as the NOAO Public Affairs and Educational Outreach group in January 2001.

NOAO issued 13 formal press releases in FY 2001, along with several other image-only news releases and joint media efforts with STScI and JPL, among other organizations. These releases produced uniformly strong coverage in the space and astronomy media, regular coverage in the two local Tucson daily newspapers, and several breakthroughs into national (and international) media organizations such as the AP and Reuters wire services, *USA TODAY* newspaper, CNN.com and BBC.com. An NOAO release on the passing of noted infrared astronomer Dr. Fred Gillett led to an obituary in the *New York Times*.

Several of these press releases were issued in connection with meetings of the American Astronomical Society, where the NOAO Public Information Office also raised the general profile of the organization with astronomy reporters, and participated as an active member of press officer strategy sessions.

NOAO established a clear coordination policy with the Gemini Observatory to support their issuance of press releases, via text writing support and our strong working relationship with continental US media and the American Astronomical Society press operations. The NOAO PIO traveled to Hilo for initial coordination meetings, followed by several telecons; a major Gemini-wide media and public outreach meeting is planned for spring 2002.

7.3.2 Special Products

The PAEO Photo Lab produced a major new in-house exhibit for the January 2001 AAS meeting, featuring a vast image file from the NOAO Deep Wide-Field Survey that contains 300,000 galaxies and stars, and an interchangeable sidebar information panel that was updated for the June 2001 meeting. This display was also used at a meeting of the International Dark Sky Association, and it served as a special visual focal point in the NOAO Tucson lobby during major meetings.

PAEO also produced a special color poster on the GSMT, several educational outreach posters, an informational handout on the LSST, and new postcards of the Moon and the Horse head nebula for the two AAS meetings in FY 2001.

The PAEO manager and Photo Lab staff also led the design and production of two major new color glossy publications highlighting NOAO actions to implement the decadal survey. A large-format, three-page, foldout brochure was included with all 2,100 copies of the September 2001 *NOAO Newsletter*, and an in-depth, 16-page report version was sent to a list of 300 astronomers, directors of research organizations, and senior officials.

The format of the *NOAO Newsletter* underwent a major revision following the transfer of its editorial responsibility to the PAEO manager, both in content and appearance. These improvements included a move to a saddle-stitched printing process that greatly increased the visual appeal and durability of the newsletter.

7.3.3 Web-Based Outreach

An entirely new streamlined and simplified NOAO home page debuted to positive reviews in April 2001. It features 13 primary links versus four dozen on the old page, with the top five links grouped to attract the casual Web surfer from the general public, and a regularly updated main image. The Project ASTRO-Tucson Web pages were completely redone to greatly improve their usability and begin to provide classroom resources, such as MPEG video clips of planetary cratering experiments. NOAO outreach-related Web pages received more than 2.5 million hits in FY 2001.

NOAO purchased multipurpose Webcasting hardware and software in FY 2001 and conducted initial tests. Two media briefings are planned for FY 2002, patterned after the much more costly and time-intensive “Space Science Updates” presented by NASA Headquarters.

The PAEO Web designer worked extensively with S. Wolff of the NOAO scientific staff to design templates for a proposed new electronic journal, the *Astronomy Education Review*, which should make its debut early in FY 2002.

7.3.4 Image Requests

The NOAO Image Gallery Web page was redone in concert with the new NOAO home page to make it more visually attractive and user-friendly, including a more prominent “Search” function. The NOAO Image Use policy was rewritten to make it more readable and to provide some common examples of usage, which has helped reduce the number of related questions. More than 600 individual requests to use NOAO images for commercial and non-commercial applications were reviewed and processed, including approved requests for use in calendars, amateur astronomy software packages, children’s educational magazines, textbooks, and the new “Astro-Monopoly” board game.

7.3.5 Public Information

NOAO received and responded to more than 4,100 individual requests for information on astronomy and the public programs of NOAO, including telephone calls, e-mails, and walk-ins. PAEO hired a new full-time PAEO Administrative Coordinator who has greatly increased the quality and speed of our public information response services, with most answers sent within 1-2 days of receipt of the query.

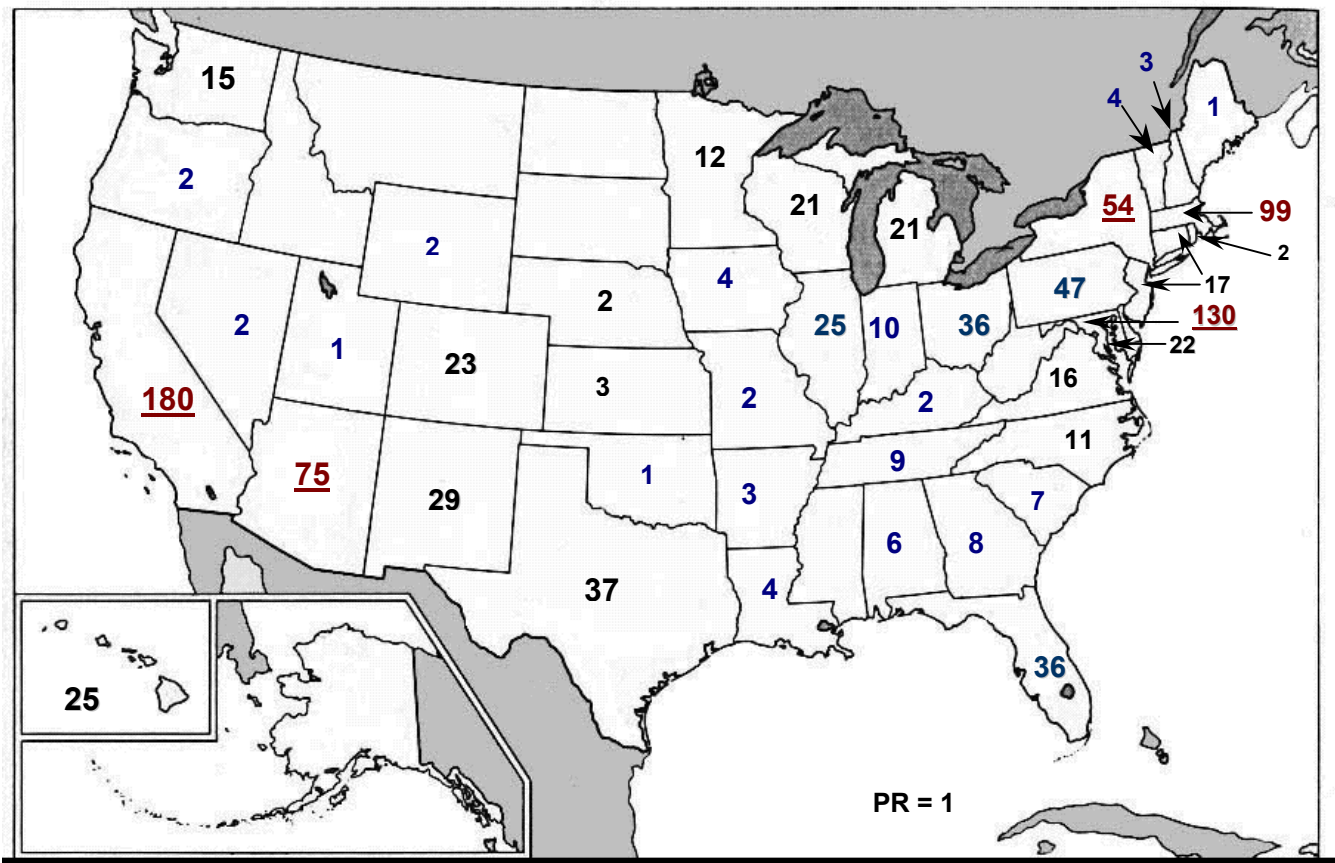
NOAO ANNUAL REPORT FY 2001
APPENDIX A

OBSERVING AND USER STATISTICS

A.1 Demographics of NOAO Users (PI's, Co-I's, Students, Collaborators)

The map below shows the states of origin of the US PI's, Co-I's, and collaborators associated with proposals awarded observing time on NOAO telescopes. In the 12 months ending July 31, 2001, the total number of scientists associated with observing proposals (excluding NOAO scientific staff observers) was **1,028**. (Each individual observer is counted once only, even if several visits or programs were involved.) NOAO telescope time was made available to scientists from nearly all US states, and as is usually the case, scientists from states with important astronomy departments or institutions (e.g., California, Maryland, Arizona, Massachusetts, New York) account for over 50% of total NOAO users in this period.

States of Origin of 1,028 PI's and Co-I's
Awarded Observing Time at NOAO Telescopes
12 Months Ending 7/31/01



A.2 Cerro Tololo Inter-American Observatory (CTIO)

CTIO Observers, Co-I's, and Collaborators by Type & Origin				
12 Months Ending 7/31/2001				
(Total Proposals = 161; Total Institutions = 102)				
<i>User Type</i>	US	Foreign	Total	<i>% Total</i>
PhDs	278	125	403	75%
Grad. Students (Thesis)	18	10	28	5%
Grad. Students (Other)	43	24	67	12%
Undergrad. Students	14	3	17	3%
Technicians & Others	14	11	25	5%
Total Users	367	173	540	100%

In the 12 months ending July 31, 2001, 161 observing programs were carried out at CTIO. These involved 540 scientists (226 observers and 314 collaborators) from 102 US and foreign institutions. Visiting astronomers were assigned 89.9% of the scheduled telescope time, and the remaining 10.1% was assigned to staff.

Total institutions represented by the above visits:

US Institutions (66)

Alma College	Naval Research Lab.
Appalachian State U.	New Mexico State U.
Arecibo Observatory	Ohio State U.
Arizona State U.	Pennsylvania State U.
Bell Labs	San Francisco State U.
Bob Jones U.	Southwest Research Inst.
California Inst. of Tech.	STScI
Carnegie Mellon U.	State U. of New York
Chandra X-Ray Center	Swarthmore College
Columbia U.	U. of Arizona
Cornell U.	U. of Birmingham
Fermi Nat. Acc. Lab.	U. of California, Berkeley
Gemini Telescope	U. of California, Irvine
Georgia State U.	U. of California, Sta. Cruz
Gettysburg College	U. of Chicago
Harvard-Smithsonian CfA	U. of Florida
INAOE, Mexico	U. of Hawaii
Iowa State U.	U. of Illinois
Johns Hopkins U.	U. of Kansas
L. Livermore Nat. Lab.	U. of Massachusetts
Louisiana State U.	U. of Michigan
Lowell Observatory	U. of Minnesota
Macalester College	U. of New Mexico
Massachusetts Inst. of Tech.	U. of North Carolina
Michigan State U.	U. of Notre Dame
Middlebury College	U. of Pennsylvania
NASA/Goddard	U. of South Carolina

U. of Texas
 U. of Virginia
 U. of Washington
 U. of Wisconsin
 US Naval Observatory
 Valparaiso University
 Vatican Observatory
 Villanova U.
 Wellesley College
 Wesleyan U.
 Williams College
 Yale U.

Foreign Institutions (25)

Chungbuk Nat. U., Korea
 DAO, Canada
 Durham U., UK
 Edinburgh U., UK
 Imperial College, UK
 Keele U., UK
 Kokugakuin U., Japan
 Korea Astronomy Obs.
 Liverpool John Moores U.
 Max-Planck Inst., Germany
 Nagoya U., Japan
 Osaka U., Japan

Oss. Astron. di Roma, Italy
 Oss. di Torino, Italy
 Paris Obs., France
 U. College London, UK
 U. de Montréal, Canada
 U. of Bristol, UK
 U. of Cambridge, UK
 U. of Melbourne, Australia
 U. of New South Wales
 U. of Toronto, Canada
 U. of Vienna, Austria
 Yonsei U., Korea
 York U., Canada

Latin American Inst. (11)

CIDA, Venezuela
 ESO, Chile
 Las Campanas Obs., Chile
 Obs. Astron., Córdoba
 U. Católica de Chile
 U. de Chile
 U. de Concepción, Chile
 U. de La Serena
 U. de Sao Paulo, Brasil
 U. de Zulia, Venezuela
 U. Fed. Rio de Janeiro

A.3 Kitt Peak National Observatory (KPNO)

KPNO Observers, Co-I's, and Collaborators by Type & Origin*				
12 Months Ending 7/31/2001				
(Total Proposals = 176; Total Institutions = 194)				
<i>User Type</i>	US	Foreign	Total	<i>% Total</i>
PhDs	361	94	455	72%
Grad. Students (Thesis)	40	2	42	7%
Grad. Students (Other)	55	7	62	10%
Undergrad. Students	32	0	32	5%
Technicians & Others	36	4	40	6%
Total Users	524	107	631	100%

*Investigators on multiple programs may be counted more than once.

In the 12 months ending July 31, 2000, 176 scientific programs, 42 of which were thesis programs, were carried out. Associated with these programs were 631 individual scientists.

Astronomers using the observatory during this period represented 127 US institutions and 67 foreign institutions. The top five represented were:

Institution	PI's
Harvard-Smithsonian Center for Astrophysics	41
University of Arizona	26
Space Telescope Science Institute	21
University of Florida	18
California Institute of Technology	17

A.4 US Gemini Program (USGP)

US Gemini Program Observers, Co-I's, and Collaborators by Type & Origin				
12 Months Ending 7/31/2001				
(Total Proposals = 38; Total Institutions = 50)				
<i>User Type</i>	US	Foreign	Total	<i>% Total</i>
PhDs	96	12	108	90%
Grad. Students (Thesis)	3	0	3	3%
Grad. Students (Other)	8	0	8	7%
Undergrad. Students	1	0	1	1%
Total Users	108	12	120	100%

*Data include 40 programs that were scheduled for classical observing or assigned to Bands 1, 2, or 3 for queue observing at the Gemini North telescopes during the 12 months ending 7/31/2001 (Semesters 2000B and 2001A).

For the 12 months ending July 31, 2001, 40 US programs either were scheduled for classical observing or were assigned to Bands 1, 2, or 3 for queue observing on the Gemini North telescope. This actually represents 38 proposals; two proposals were scheduled under two different Gemini reference numbers to be run at different times.

In Semester 2000B, the International Gemini Observatory (IGO) ran a QuickStart queue. Thirteen US programs (12 proposals) were assigned to this queue: 5 in Band 1, 5 in Band 2, and 3 in Band 3. Nine of these programs received data.

In Semester 2001A, 15 US programs were scheduled for classical observing, including nine in mini-queues: four for OSCIR and five for Hokupa'a. Seven of the mini-queue programs were attempted; two got no data due to weather and equipment problems. All of the other classical programs were attempted; two got no data due to technical problems.

NIRI queue observing was also scheduled for Semester 2001A, with a total of 12 US programs (11 proposals) assigned: 4 to Band 1, 5 to Band 2, and 3 to Band 3. Unfortunately, these queue observations were not executed due to problems with the instrument. The 40 scientists and 15 institutions associated with these programs are included in the numbers shown below.

The 38 total proposals comprised 120 scientists and students, representing 50 institutions, and include three graduate students observing for their thesis, eight graduate students not observing for their thesis, and one undergraduate student.

A.5 NOAO Tucson Headquarters Building

During the 12 months ending September 30, 2001, an estimated 5,024 visitors were received at the NOAO Tucson headquarters building.

**NOAO ANNUAL REPORT FY 2001
APPENDIX B**

PUBLICATIONS LISTS

**B.1. Cerro Tololo Inter-American Observatory
October 2000 through September 2001
(Total = 149)**

Albrow, M.D., et al 2001, ApJ, 549, p. 759, “PLANET Observations of Microlensing Event OGLE-1999-BUL-23: Limb-darkening Measurement of the Source Star”

Albrow, M.D., et al. 2001, ApJ, 556, L113, “Limits of the Abundance of Galactic Planets from 5 Years of PLANET Observations”

Alcock, C., et al. 2000, ApJ, 542, p. 281, “The MACHO Project: Microlensing Results from 5.7 Years of Large Magellanic Cloud Observations”

Alcock, C., et al. 2001, ApJ, 550, L169, “MACHO Project Limits on Black Hole Dark Matter in the 1-30 M_{\odot} Range”

Alcock, C., et al. 2001, ApJ, 552, p. 259, “MACHO 96-LMC-2: Lensing of a Binary Source in the Large Magellanic Cloud and Constraints on the Lensing Object”

Alcock, C., et al. 2001, ApJ, 554, p. 298, “The MACHO Project LMC Variable Star Inventory. X. The R Coronae Borealis Stars”

Allen, R.L., Bernstein, G.M., Malhotra, R. 2001, ApJ, 549, L241, “The Edge of the Solar System”

Alves, D.R., Bond, H.E., Onken, C. 2001, AJ, 121, p.318, “CCD Photometry of the Globular Cluster NGC 5986 and its Post-Asymptotic Giant Branch and RR Lyrae Stars”

Anthony-Twarog, B., Twarog, B.A. 2000, AJ, 120, p. 3111, “CCD $uvbyH\beta$ Photometry in Clusters. II. The Nearest Globular Cluster, NGC 6397”

Asplund, M., et al. 2000, A&A, 353, p. 287, “The R Coronae Borealis Stars – Atmospheres and Abundances”

Baron, E., et al. 2000, ApJ, 545, p. 444, “Preliminary Spectral Analysis of the Type II Supernova 1999em”

Barrado y Navascués, D., et al. 2001, ApJS, 134, p. 103, “Very Low-Mass Stars and Brown Dwarfs of the Young Open Cluster IC 2391”

Battinelli, P., Demers, S. 2000, AJ, 120, p. 1801, “A Carbon Star Survey of the Local Group Dwarf Galaxies. II. Pegasus, DDO 210, and Tucana”

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- Bing-Chih Chen, A., et al. 2000, AJ, 120, p. 2569, "Spectral Energy Distribution and Abundances of NGC 288 Stars"
- Bing-Chih Chen, A., et al. 2001, AJ, 121, p. 309, "Constraining the Local Reddening Distribution of SA 98 By Star Counts"
- Blum, R.D., Conti, P.S., Daminieli, A. 2000, ASP Conf. 221, eds. Alloin, Olsen, Galaz (ASP), p. 109, "The Stellar Content of Obscured Galactic Giant H II Regions"
- Blum, R.D., Daminieli, A., Conti, P.S. 2001, AJ, 121, p. 3149, "The Stellar Content of Obscured Galactic Giant H II Regions. III. W31"
- Bronfman, L., May, J., Luna, A. 2000, ASP Conf. 217, eds. Mangum, Radford (ASP), p. 66, "A CO Survey of the Southern Galaxy"
- Chandar, R., Bianchi, L., Ford, H.C. 2000, AJ, 120, p. 3088, "Spectroscopy of Star Cluster Candidates and H II Regions in NGC 6822"
- Chapman, S.C., McCarthy, P.J., Persson, S.E. 2000, AJ, 120, p. 1612, "Radio Galaxy-Selected Clusters at High Redshift and Associated Extremely Red Object Overdensities"
- Chun Yu, K., et al. 2000, AJ, 120, p. 1974, "A Multiwavelength Study of Outflows in OMC-2/3"
- Clocchiatti, A., et al. 2001, ApJ, 553, p. 886, "The Type Ic SN 1990B in NGC 4568"
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- Comerón, F., et al. 2001, A&A, 366, p. 796, "Possible Star Formation in the Halo of NGC 253"
- Corradi, R.L.M., et al. 2001, ApJ, 553, p. 211, "The Southern Crab from a New Perspective"
- Costa, E., 2001, A&A, 367, p. 719, "CCD Astrometry of Faint Compact Extragalactic Radio Sources. II."
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- Forbes, D. 2000, AJ, 120, p. 2594, "The Serpens OB2 Association and its Thermal "Chimney""
- Forte, J.C., et al. 2001, AJ, 121, p. 1992, "The Globular Cluster System of the Low-Luminosity Elliptical Galaxy NGC 1427"
- Francis, P.J., et al. 2001, ApJ, 554, p. 1001, "A Pair of Compact Red Galaxies at Redshift 2.38, Immersed in a 100 Kiloparsec Scale Ly α Nebula"
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- Smith, D.R., et al. 2001, ASP Conf. 237, eds. Brainerd, Kochanek (ASP), p. 397, "Galaxy-Galaxy Lensing in the LCRS Fields"

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APPENDIX C**

NOAO MANAGEMENT ROSTER

Jeremy Mould, Director, from 02/15/01 (previous Director, S. Wolff)

Todd Boroson, Deputy Director

Richard Green, KPNO Director/NOAO Associate Director

Malcolm Smith, CTIO Director/NOAO Associate Director; Director, AURA Observatory Support Services (AOSS) in Chile

Robert Schommer, Director, USGP/NOAO Associate Director

Steve Strom, Director of Science Research/NOAO Associate Director

Alistair Walker, Deputy Director, CTIO

Larry Daggert, Manager, Engineering and Technical Services

Karen Wilson, Financial Manager, from 11/01/01 (replacement for G. Blevins, retired)

Larry Klose, Manager, Central Administrative Services (CAS)

John Dunlop, Manager, Central Facilities Operations (CFO)

Steve Grandi, Manager, Computer Infrastructure Support (CIS)

Doug Isbell, Manager, Public Affairs & Educational Outreach (PAEO)

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APPENDIX D**

SCIENTIFIC PERSONNEL STATISTICS

D.1. Hired

<i>Date</i>	<i>Name</i>	<i>Position</i>	<i>Division/Unit</i>
11/01/00	Hugo Schwarz	Associate Astronomer	CTIO
11/01/00	Nicole van der Blik	Assistant Scientist	CTIO
11/27/00	Behzad Abareshi	Software Engineer II	ETS
12/04/00	Barry M. Starr	Engineering Supervisor	ETS
12/08/00	Kathie Coil	Admin. Coordinator for Education Outreach and Public Information	NOAO
12/15/00	Kevin Krisciunas	Research Associate	CTIO
01/29/01	David Gasson	Scientific Programmer	NOAO/CCS
02/01/01	Andrei Tokovinin	Associate Astronomer	CTIO
02/05/01	Michael Fleming	Scientific Programmer II	NOAO/CCS
02/12/01	Constance Walker	Sr. Program Coordinator	NOAO/PAEO
02/26/01	Oliver Wiecha	Engineering Supervisor	SOAR
03/01/01	Mario Urrutia	Secretary 2	CTIO
03/19/01	Heidi Schweiker	WIYN 0.9-m Site Manager	WIYN
04/04/01	Jeremy Mould	Acting Director, NOAO	NOAO
04/16/01	Rich Fedele	Public Information Manager	NOAO/PAEO
06/01/01	Dara Norman	NSF Fellow Research Associate	CTIO
06/04/01	Patricia Knezek	Assistant Scientist	WIYN
06/18/01	Michele De La Pena	Sr. Scientific Programmer	CCS
06/18/01	Richard Shaw	Scientist	CCS
07/23/01	Derek Guenther	Engineer	ENG

D.2. Completed Employment

<i>Date</i>	<i>Name</i>	<i>Position</i>	<i>Division/Unit</i>
11/19/00	Suzan Ecker	Secretary 3	CTIO
11/28/00	Edward Ajhar	Research Associate	NTSS
12/26/00	Patrick Nelson	Scientific Programmer II	CCS
03/01/01	Thomas Ingerson	Support Scientist	CTIO
08/31/01	Glenn Tiede	Research Associate	NTSS
08/31/01	Joseph T. Mortimer	Safety Officer	CFO
09/10/01	Donald W. Hoard	Research Associate	CTIO
09/10/01	Stefanie Wachter	Assistant Astronomer	CTIO
09/14/01	I. Glen Blevins	Financial Manager	CAS
09/30/01	Roger Smith	Engineering Project Mgr.	CTIO

D.3. Changed Status

<i>Date</i>	<i>Name</i>	<i>Position</i>	<i>Division/Unit</i>
02/02/01	Sam Barden	Promoted from Scientist to Sr. Scientist	NOAO
02/02/01	Chuck Claver	Promoted from Assistant Scientist to Associate Scientist	NOAO
02/13/01	Taft Armandroff	Promoted from Associate Astronomer to Astronomer/Tenure	NOAO
02/15/01	Sidney Wolff	Transfer from NOAO Director to Astronomer/Tenure	NOAO
02/16/01	Oliver Weicha	Transfer location from Tucson to CTIO	NOAO to CTIO-SOAR
02/23/01	Buell Jannuzi	Tenure granted	NOAO
03/01/01	Juan Serrano	Associate Engineer	SOAR
03/12/01	Nalin Samarasinha	Promoted from Research Associate to Assistant Scientist	NOAO
04/01/01	Rodrigo Alvarez	Electronic Tech. 2	CTIO
04/01/01	Ramon Galvez	Senior Engineer	CTIO
04/01/01	Esteban Parkes	Engineer	CTIO
04/01/01	David Rojas	Engineer	CTIO
04/01/01	Stephen Heathcote	Associate Astronomer/Tenure	CTIO to SOAR
06/01/01	German Schumacher	Sr. Engineer Manager	CTIO to SOAR
07/01/01	Joan Najita	Promoted from Assistant Astronomer to Associate Astronomer	NTSS
07/01/01	Marcela Urquieta	Secretary 2	AOSS to CTIO-SOAR
07/23/01	Doug Tody	Promoted from Chief Programmer to Technical Director	CCS
08/16/01	Victor Krabbendam	Project Engineer	NOAO to CTIO-SOAR