NATIONAL OPTICAL ASTRONOMY OBSERVATORIES

FY 1996 PROVISIONAL PROGRAM PLAN

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I. INTRODUCTION AND OVERVIEW

This document presents an overview of the program that NOAO plans to carry out during FY 1996. The primary component of this program is the continued operation of observing facilities for the observing community at all three sites. There will, however, be reductions in the number of facilities operated, in the level of services provided, and in the number of instruments made available—all occasioned by the reduction in budget for support of operations.

As essential as operating facilities is an ongoing development program for both telescopes and instruments in order to ensure that what we offer to the community is competitive with the best facilities available world wide. Some of the key milestones in the development program in FY 1996 are:

**GONG.** First simultaneous operation of all 6 stations in the network; reduction of data and distribution to the community.

**WIYN.** Initiation of science operations.

**Phoenix.** First telescope testing of this high resolution 1-5 micron spectrometer.

**Optical Mosaic.** Completion of fabrication of mechanical parts; completion of hardware and software to enable parallel operation of 8 CCDs (Arcon).

**Aladdin.** Completion of initial phase of project to develop 1024 × 1024 InSb arrays; assessment of yield and development of strategy for future foundry runs; deployment of first large array (if any are obtained) in the Cryogenic Optical Bench.

**DLIRIM.** Implementation of diffraction-limited (at 3.5 microns) imaging capability at the 4-m Mayall telescope; completion of service observing with DLIRIM for community proposers.

**KPNO 4-M Telescope.** Implementation of automatic control systems for cooling the observing floor, the oil, and the primary mirror.

**CTIO 4-M Telescope.** Completion and commissioning of f/14 secondary for IR astronomy; test of tip/tilt capability for secondary; initiation of three-year program to upgrade telescope control system.

**RISE.** Complete first instrument package.

**Vacuum Tower Telescope.** Install thermal control of entrance window and evaluate performance; commission Mark II correlation tracker.

**Solar Cameras.** Complete two fast (6 frames/sec) CCD-based (1024 × 1024) data acquisition systems.

**NIM 2.** Initiate fabrication of an improved near-infrared vector magnetograph.

**He 10830 Video Filtergraph.** Commission instrument and use to support SoHO.

**McMath Seeing.** Evaluate and develop error budget as preliminary stage of a project to improve image quality.
**Gemini work packages.** Complete negotiation of work scopes for CCD arrays, IR arrays, near-IR spectrometer; develop plan for obtaining CCD controllers and IR array controllers; initiate competition to design mid-IR imager.

A major effort over the next year will be to define in detail the approach to restructuring NOAO in order to lower operating costs. After development of that plan, and after approval is obtained from AURA and the NSF, we will let the first contracts.

A similar list of milestones was included in the program plan for FY 1995. Their status three quarters of the way through the fiscal year is as follows:

**Begin operation of three GONG sites in March; begin six station operation in August if funds permit.** First light at three sites—Tucson, Teide, and Learmonth was achieved on schedule, and this mini-network is now in operation and returning data. Distribution of these data to the helioseismology community will begin shortly. Funds were found to complete the deployment of the remaining three stations this fiscal year.

**Beginning of WIYN science operations.** Science operations are scheduled to begin on 17 July. Problems remain with the servo system, which was designed by Wisconsin, and with the encoders, which were provided by L&F. These problems are being addressed by an NOAO engineering team. Responsibility for the software for the control system has recently been transferred formally from Wisconsin to NOAO; while the system is usable, many improvements will be required for efficient observing. The instrument adapter system will not be commissioned until early 1996.

**Commissioning of Hydra/MOS on the WIYN telescope.** The commissioning is well advanced, and scientific use will begin in July.

**Installation of f/14 IR secondary on CTIO 4-m.** Figuring of the secondary is now in progress in the Tucson shops, and first telescope tests are scheduled for December.

**Commissioning of active primary mirror support system for CTIO 4-m.** The active support system has been successfully tested in the telescope. The ensemble of image quality improvements has improved the median image quality by about 30 percent, and subarcsec images are now seen routinely.

**Implementation of two new large-format CCDs under ARCON at CTIO.** A Loral 1K x 3K and a STIS 2048K x 2048K, the latter with four readout amplifiers, have been placed into operation. The VEB controllers have been withdrawn from service.

**Completion of Aladdin demonstration project with USNO, SERC to produce 1024 x 1024 square InSb IR arrays.** The first two 1024 x 1024 arrays have been delivered and tested. The second array meets the performance specifications except that, because of problems with bonding, there were only 900,000 usable pixels. The detector was taken to the telescope for a single run and was used successfully to obtain images. We expect to obtain two additional arrays by the end of June. At this juncture the yield remains unknown, and so it is premature for any but well-funded groups that are willing to assume significant risk to invest funds in additional foundry runs.

**Implementation of mini-mosaic 4K x 4K CCD array.** The foundry run to produce 2K x 2K CCDs with 15 micron pixels for the mini-mosaic yielded only a few potentially usable devices, and these devices were compromised during thinning, which is being carried out at Steward. We have completed two foundry runs of 2K x 4K devices for the large (8K x 8K) mosaic imager. We do not yet know the yield because we are still in the initial stages of processing. If any 2K x 4K devices remain after construction of the large mosaic, they may be used to produce a mini-mosaic.
Experiments with high-resolution imaging at KPNO: Diffraction-limited imaging at 3 microns on the 4-m and tip-tilt imaging on the 2.1-m, both with COB. Diffraction-limited imaging at 3.4 microns was obtained at the 4-m telescope through a shift-and-add technique implemented in software. We are now building hardware that will make it possible to implement this technique in real time. COB with this capability will remain at KPNO for only one year before it is shipped to CTIO. Seventeen observing proposals for shift-and-add observations were scheduled in the fall semester. Gatley and Merrill will obtain the observations for the community. Tip-tilt imaging at the 2.1-m was successfully demonstrated during the last fiscal year, and no further experiments have been carried out at this telescope.

Possible collaborations with Starfire Optical Range. NOAO explored the feasibility of supplying an infrared camera to Starfire in return for observing time. This collaboration seemed almost ideal since it would give us access to both a large telescope and an adaptive optics system for relatively low cost. Despite strong initial interest on both sides, we have decided to terminate this effort. The requirements on performance imposed by Starfire became increasingly ambitious, thereby raising the cost to NOAO; the instrumentation program resources were committed to support CTIO as well as KPNO, thereby leaving fewer resources for this initiative; the KPNO users recommended against giving up the imaging camera since there is no replacement for it in the near term; and the two scientists involved, Ridgway and Probst, now plan extended absences from Tucson. We will continue to try to establish a collaborative program in adaptive optics, with ARC being one possibility.

Completion of mechanical fabrication for the high-resolution IR spectrograph, Phoenix. Fabrication of the parts will be completed by the end of July; assembling, testing, and commissioning will be carried out during the next fiscal year.

Fabrication of new correlation tracker for Sac Peak Vacuum Tower Telescope. A design based on FFT cross correlation has been selected and specified using commercially available hardware components, which have been purchased. Fabrication is expected to finish early in FY 1996.

Begin fabrication for Near-Infrared Magnetograph-2 for McMath/Pierce Telescope. The preliminary design review indicated that the optical design should be modified and retraced before ordering the Fabry-Perot etalon (the major capital expense of the project). The redesign has been accomplished, and fabrication will begin early in FY 1996.

Major new release of IRAF (2.11); integration of GUI and scientific applications. The IRAF Users Committee has indicated that they prefer more frequent, smaller releases rather than occasional major releases. Consistent with this recommendation, two intermediate releases occurred during the year. The highest priority improvement not included in these releases, and originally scheduled as part of 2.11, is the ability to read FITS files directly from disk into IRAF. The project to integrate graphical user interfaces with the scientific applications is ongoing, and a release with this capability is planned for FY 1996.

This program plan should be read in the context of NOAO’s long range plan as developed at the AURA workshop in Albuquerque and described in a document submitted earlier this year to the NSF. Because the program plan describes only what we plan to do in FY 1996, not all of the elements in the long range plan are addressed here. Most specifically, we have not yet identified the resources to make progress on adaptive optics for nighttime astronomy or to replace the existing 4-m telescopes with larger aperture facilities. Also, the planning for the restructuring of the NSO facilities is at a very preliminary stage and is not discussed here.
II. SCIENTIFIC PROGRAM

A. Changes in Staffing

The role of staff research at NOAO has been a subject of debate during the past year. Is in-house research central to the mission of the national observatories? Or is research a derived function? That is, do we have an in-house research program because our mission—operation of state of the art observing facilities—requires a strong scientific staff that will inevitably perform high quality research?

What has not been debated is the need for excellence in the scientific staff at NOAO. What is also not debatable is the fact that budget stresses have greatly increased the functional responsibilities of the staff, and this increase has in turn begun to compromise the amount of research performed in house. The size of the scientific staff has been reduced through attrition. Few of the vacancies created by staff retirements have been filled with new scientific staff; and because we have not cut back on user support at the same rate as the budget has been reduced, many functions that used to be handled by support staff are now being carried out by the scientific staff. It should also be remembered that we do not provide any personnel to assist staff directly with their research. We have no graduate students, post-docs are free to do research in any area, and staff members cannot compete for additional support from the NSF. Many staff members do have NASA grants, but this support cannot be used to any significant degree for ground-based research.

### Scientific Staff

<table>
<thead>
<tr>
<th>Location</th>
<th>FY 1987</th>
<th>FY 1995</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTIO</td>
<td>15</td>
<td>12</td>
<td>-20%</td>
</tr>
<tr>
<td>KPNO + ADP</td>
<td>33.6</td>
<td>23.5 (21.26)*</td>
<td>-30% (-37%)*</td>
</tr>
<tr>
<td>NSO</td>
<td>15</td>
<td>15.5</td>
<td>+3%</td>
</tr>
<tr>
<td>USGP</td>
<td>0</td>
<td>2 (1.5)*</td>
<td></td>
</tr>
<tr>
<td>GONG</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>RISE</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Central</td>
<td>6.25</td>
<td>5</td>
<td>-21%</td>
</tr>
</tbody>
</table>

*Figures in () allow for transfers of scientific staff to outside funding.

In order to maintain the overall quality of the scientific staff, we must restore a better balance between research and service. As one step toward this goal, CTIO has already determined that it will not further reduce the size of its scientific staff, which has been reduced to only 12 people. Additional budget reductions in Chile will have to be found elsewhere in the program.

Over the next year we will reassess the size and role of the scientific staff. On the nighttime side, we will examine the relative sizes of the staff in Chile and Tucson, with the balance being determined by the level of functional responsibilities at the two sites.

Appendix 3 lists the members of the scientific staff, their recent publications, research plans for the coming year, and functional responsibilities. In addition to support of NOAO activities, many staff members are deriving external support to enable their contributions to outside projects. For example, Steve Ridgway is being supported half time by the CHARA interferometry project, for which he serves as project scientist; Fred Gillett is the acting (international) Gemini project scientist this year, and next year will serve as the first Gemini fellow, deriving half his support from the Gemini project and half from NOAO; Mike Belton, Roger Lynds, and Tod Lauer all derive one third or more of their salary support from NASA; and Helmut Abt is supported half time by the Astrophysical Journal. We normally have at least one Hubble fellow in residence; Ata Sarajedini is the Hubble fellow currently in Tucson.
Two new tenure-track appointments to the NSO scientific staff will strengthen both NSO's research and community support program in FY 1996. T. Rimmele joined NSO/Sac Peak in April 1995. As an experimental astrophysicist he will focus on the improvement of the image quality of the solar telescopes at Sac Peak and Kitt Peak. An astronomer appointment in Tucson, expected to be made in 1995, will fill the vacancy created by J. Brault's retirement. H. Lin joined the Sac Peak staff to work on the PSPT/RISE project. Two new postdocs will be recruited to fill the vacancies created by the departures of M. Penn and S. D'Silva in 1995. D'Silva will continue to work in residence in Tucson, but now as a postdoc funded by a grant from the Office of Naval Research, replacing R. Komm who recently joined the Solar Astronomy program at Caltech. Both observatory sites continue to profit from the presence of a number of partner agencies. These partners add to the vitality of the observatory not only by their own presence, but also by attracting short and long-term visitors and postdocs. The NASA program in Tucson is currently recruiting to fill a research associate level position and may have an astronomer position available to replace T. Duvall, who recently left to join the SOI/SoHO project at Stanford. A postdoc and a graduate student will be supported as part of the NASA funding of the SOI/MDI investigation onboard the SoHO spacecraft. S. Baliunas will be an AURA Visiting Professor at NSO during the year.

B. Budget
As a guideline for budget planning, the NSF has indicated that it expects to provide $28.69M to NOAO in FY 1996. Of this total, $2M is to be reserved for restructuring, and the operating budget is to be held at $26.69M. We have estimated the costs to maintain FY 1995 services in FY 1996. The following table indicates the increments to the FY 1995 operating budget, which was set at $27.0M.

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount (in $1000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY 1995 Operating Budget</td>
<td>27,000</td>
</tr>
<tr>
<td>Deferral of salary increase</td>
<td>(255)</td>
</tr>
<tr>
<td>Chilean payroll inflation</td>
<td>486</td>
</tr>
<tr>
<td>Increase in Overseas Allowance</td>
<td>100</td>
</tr>
<tr>
<td>RISE</td>
<td>215</td>
</tr>
<tr>
<td>Gillett return from Gemini</td>
<td>107</td>
</tr>
<tr>
<td>Solar-stellar program</td>
<td>48</td>
</tr>
<tr>
<td>Education Office</td>
<td>34</td>
</tr>
<tr>
<td>Restructuring of real-time programming group</td>
<td>35</td>
</tr>
<tr>
<td>Management fee FY 1995 increase</td>
<td>20</td>
</tr>
<tr>
<td>Subtotal</td>
<td>27,790</td>
</tr>
<tr>
<td>Decrease benefits rate to 28%</td>
<td>(274)</td>
</tr>
<tr>
<td>3% merit increase for US hires in October</td>
<td>525</td>
</tr>
<tr>
<td>3% non-payroll inflation</td>
<td>221</td>
</tr>
<tr>
<td>Management fee FY 1996 increase (use 2% of budget per HF)</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>28,322</td>
</tr>
<tr>
<td>Anticipated FY 1996 Base</td>
<td>26,690</td>
</tr>
<tr>
<td>Budget overage</td>
<td>1,632</td>
</tr>
</tbody>
</table>

Even if the program were funded at $28.3M in order to maintain current services, it is clear that the program is overextended. We are not maintaining the facilities adequately; as only one example, underground utilities continue to deteriorate at all sites. Outstanding safety problems, most notably the need at all sites for adequate fire alarm systems that can be remotely monitored and at CTIO for guard rails, are being addressed too slowly. Funding for capital investments, particularly in the instrument program, is inadequate. Deployment of adaptive optics at NSO still appears to be remote, and there is no adaptive optics program at the nighttime observatories. The instrumentation for Gemini is underfunded, and it
remains unclear who is going to make up the difference between the true cost and the amount budgeted by Gemini. The performance of the telescopes is not up to what is feasible even given their old technology. Administrative staff has been reduced to the point that we are not in full compliance with federal and other regulations in certain areas such as the ADA (Americans with Disabilities Act), and we are no longer able to meet deadlines for all of the reports, newsletters, and program plans that we are required to prepare.

Salaries have been frozen for the past year. Costs denominated in pesos are increasing at 10 percent per year, and we cannot legally freeze salaries in Chile as we can in the US. We are not contributing to a trust fund to cover future liabilities for health care costs for retirees. Every thorough external review of a particular aspect of observatory operation has concluded that that particular area of activity needs additional funding. No detailed review has recommended specific areas where reductions are consistent with maintaining an adequate or responsible program.

Like all government funded activities, we will have to make difficult choices, and those choices must be made in partnership with the users and the NSF. We are custodians of facilities that NSF has chosen to provide for the community, and the choice of what is to be operated is ultimately theirs.

The one optimistic budget-related event has been the commitment by the NSF to provide $3-4M toward restructuring. The goal is to replace or repair facilities in such a way that we permanently lower our operating costs. Given current projections of flat (not compensated for inflation) budgets for the next 6 years, such restructuring appears to offer the only opportunity for maintaining significant community access in the face of declining resources.

C. Restructuring

Nighttime Astronomy

In 1995, NSF provided funds of $26.67M for operation and an additional $2M for restructuring. The idea of the restructuring initiative is to make investments that will enable a permanent decrease in operating costs. At the time this award was made, the NSF indicated that it would provide the same level of funding in FY 1996. Approximately $1M of this restructuring money has been used to complete the deployment of GONG in FY 1995, thereby accelerating the start of operations by one year and saving $1.7M; to continue, at NSF's request, the RISE (Radiative Inputs from the Sun to the Earth) initiative; to cover severance costs; and to provide for an overnight increase in costs in Chile that resulted from an upward revaluation of the peso. If the NSF provides the level of support that they have committed to, then NOAO should have available about $3M for investment in new facilities and equipment with the goal of achieving lower operating costs.

There are two classes of investment that would achieve this goal. The first involves investments in a variety of improvements that would lower maintenance or utility costs. Examples include replacement of telescope control systems; engineering changes in the facilities at KPNO and CTIO to provide for common infrastructure, thereby making it possible to share instrumentation, software, detectors and controllers, etc.; addition of computer-controlled machining capability to increase the efficiency of the shops; installation of more energy efficient heating and cooling systems; and implementation of new software systems to increase office automation.

The second possibility is the construction of new telescopes that would permit the retirement of aging telescopes that are becoming increasingly costly to maintain. NOAO will give priority to this option, rather than to the types of investments outlined in the previous paragraph, provided there is strong scientific and financial justification. It is unlikely that there will be another chance to replace telescopes during the next several years. The other projects to achieve cost savings require more modest investment, and perhaps one such project can be carried out each year within the current budget.

The possibilities for building new telescopes are severely constrained by the available funding. A 4-m class telescope costs at least $15M, and with only $3M available for investment, it does not appear that NOAO could acquire a significant fraction of a new 4-m class telescope even in partnership with outside groups.
The money available also falls far short of what will be required to build a major new solar telescope that would allow consolidation of the NSO facilities on to a single site. Two other options appear feasible and are now being explored. The first involves building one 2-m class telescope at each of CTIO and KPNO and closing three of the smaller telescopes now operated at each site. It is likely that such a change would save about $500K in operating costs at each site. The solar option involves consolidating the synoptic observations now being made with several telescopes at both Kitt Peak and Sacramento Peak at a single new facility.

The scientific justification for 2-m telescopes designed to support optical imaging is strong. First, imaging surveys from 2-m class instruments cover the faint magnitude range suitable for spectroscopic follow-up with 8-m telescopes, as well as with multi-fiber and multi-slit spectroscopy with the 4-m telescopes and WIYN. A requirement for the 2-m class telescopes is that they be able to provide accurate astrometry suitable for determining accurate positions for fiber placement. Second, such a telescope is entirely adequate for a variety of important scientific problems, including those to study time variability. Such programs include searches for RR Lyrae stars in the distant halo, determination of Cepheid light curves, supernova monitoring, flare star searches, and monitoring of variability in cataclysmic variables and active galactic nuclei. Third, optical imaging telescopes support large specialized surveys. These projects include supernova discovery searches, stellar population studies for Galactic structure and abundance distributions, and systematic galaxy photometry. All of these programs are complementary in depth and filter choice to the basic data that will be provided by the Sloan Digital Sky survey in the north. The combination of aperture larger than the 1-m telescopes currently used for imaging, optical, and some queue scheduling could meet the majority of current demand for optical imaging data at moderate aperture.

The specific design option that we are evaluating has a field of view of at least 40 arcmin and optical quality comparable to that of the WIYN telescope (0.5 arcsec or better). The telescope would support a dedicated imager composed of a mosaic of CCD detectors. Full use of bright time could be made by running a fixed small fiber bundle from the telescope to existing high-dispersion spectrographs—the current bench spectrograph at CTIO and the coude spectrograph at KPNO. Both sites are investigating the use of a simple storage shelter as the enclosure. The operating configuration would be with the enclosure largely open through the use of either deployable windscreens or of a low-cost, thoroughly flushed “dome” structure. Telescope control and operations would be stationed remotely in an adjacent, existing structure.

After completion of these telescopes, CTIO would then close or privatize its smaller telescopes. The dividing point would be the 1.5-m, and its status will depend on the success of the SOAR consortium. Optical spectroscopy would be shifted to the 4-m, as would IR observing. SOAR would later support optical spectroscopy in small fields, while wide-field, fiber-coupled spectroscopy would continue at the 4-m. For a near-term deployment, the telescope would be sited on Cerro Tololo, with the possibility of a later move to Cerro Pachon.

KPNO would also close or privatize its smaller telescopes. Optical spectroscopy and infrared work would be shifted to the Mayall 4-m. Although it would be desirable on scientific grounds to continue to provide access to the current 2.1-m telescope, that facility has required so much ongoing maintenance attention that continued operation may be impossible given budget constraints.

A second issue that will have to be addressed as part of the restructuring at KPNO is the commissioning of new instruments. Major instruments for CTIO and Gemini, as well as for KPNO, will be built in Tucson and commissioned prior to shipping. Currently, commissioning takes place on the existing telescopes. On the new model, with KPNO operating only the WIYN, the Mayall, and the 2-m class imaging telescope, it will not be possible to take away large blocks of science time to commission instruments. Therefore, some type of simulator will have to be provided at either Kitt Peak or in Tucson.

NOAO has developed cost estimates for the 2-m class telescopes on the assumption that we serve as general contractor. These costs are now being verified by industry. At the same time, NOAO is exploring potential cost savings through partnering with industry in telescope production. NOAO's role would probably include developing the scientific specifications, writing the control software, and providing initial
commissioning support. The industrial partners' goal is the creation of a product line with a broader market in research institutions and universities. If NOAO can help to develop a cost effective 2-m class telescope with excellent scientific performance, then we would enable those in the university community who wish to pursue this kind of science at a more intensive level than is possible through the national observatories to build their own facilities. We also hope that if such telescopes can be obtained commercially at reasonable cost, the pressure on NOAO to continue the operation of telescopes of modest aperture will diminish.

The two years of restructuring support proposed by the NSF is probably enough to put two 2-m telescopes just within reach. If Foundation budget fluctuations force lower than full support for the second-year increment, CTIO will have priority for the single telescope. If it turns out that a sum of $3M would make the difference to the SOAR partnership, then this project has higher priority than either of the 2-m class telescopes.

The replacement of three telescopes with one will clearly reduce access by the community. The impact will be especially great for thesis students and Chilean astronomers. We will assess those impacts quantitatively as part of any proposal to go ahead with this initiative.

Solar Astronomy

The Sun varies on a wide range of time and spatial scales. NSO devotes a substantial effort to obtaining and distributing solar observations over a long time period. The essential characteristics of these sustained observations is long-term continuity.

The scientific goals of these long term observations are intimately connected to the quest to understand solar variability and activity. It is necessary to observe variations from the deep photosphere through the corona to disentangle causes and effects. Working outward, accurate measurements of the magnetic field are vital to understanding how activity is driven and energy is stored in the solar atmosphere. There is considerable current interest in studying magnetic helicity and also mass motions that sweep magnetic fields into their intricate patterns. Magnetic field measurements at present are quantitatively poor, do not give adequate results at the poles, and miss the inter-network fields, so that we may be missing vital clues to how the solar cycle works. The RISE instrument opens a new capability for accurate, photometric measurement of solar photospheric and chromospheric variability at modest spectral resolution. There is no need to duplicate this capability. However, there is a need to continue accurate measurements of spectrum line variability of the Sun as a star. While the study of flares and the corona has largely moved to space, space missions tend to be short-lived, inflexible, and prone to operational problems. Data bandwidth restrictions prevent many types of observations from space. Thus there is still a role for ground-based observations in the case of rapidly changing phenomena and/or a large amount of spatial and spectral detail over large extents.

With the advent of the new space initiatives YOHKOH, SoHO, and Solar B, solar synoptic observations take on a new importance. Such ground-based observations can link spacecraft measurements to phenomena observed at different layers in the solar atmosphere, identify the stages of the solar cycle and activity levels at which the space observations are made, and identify events or areas on the Sun worthy of detailed examination. At present, unfortunately, there are no funded space missions to observe the Sun after completion of the SoHO mission in 1998. At that point, ground-based data will be all that is available.

At present, over a dozen different programs are carried out at the two NSO sites with a large variety of instrumentation. With the revolutions in detector technology and data processing, modernization of many of NSO's long-term observing facilities is long overdue. The question that is currently being examined is whether many of the capabilities could be consolidated so that fewer facilities need to be operated.

Conflicting observational requirements make it difficult to consolidate all of the important current capabilities into a single new instrument. Three very different types of observations are now being made—of the corona and prominences above the limb; of the full disk at high cadence and moderate spectral resolution; and of the full-disk with high spectral resolution and moderate cadence.
At the present stage of planning for synoptic facilities, the coronal and high-cadence capabilities appear to be best achieved through upgrades of existing telescopes. The high spectral resolution capability appears to be best met with a new telescope.

Savings in operating budgets could be obtained through lower maintenance costs associated with new facilities and with greater automation. The savings have yet to be quantified, and the costs of construction have not been determined. The greatest savings in the NSO program would be achieved by concentrating all facilities as a single site. If, however, we ultimately conclude that three synoptic facilities, two of them new, plus a major new solar telescope are required to achieve this goal, then restructuring of NSO is likely to await preparation of a major proposal to the NSF. It appears doubtful at the present time that the limited amount of restructuring money can, apart from the investments already made in GONG and RISE, significantly lower operating costs at NSO.

III. NIGHTTIME PROGRAM

A. Major Projects

1. WIYN

The 3.5-m WIYN telescope, a collaboration among the University of Wisconsin, Indiana University, Yale University and NOAO, is nearing completion on Kitt Peak. The telescope is designed for optical imaging and multi-object spectroscopy with optical fibers, with a relatively fast focal ratio (about f/6.3) and a corrected field of view of a full degree (15 arcmin uncorrected). The WIYN Project has placed a high priority on achieving superb image quality with the telescope. The enclosure and mount are designed to minimize dome seeing through rapid ventilation and thermal control. The site (the southwest ridge of Kitt Peak) is known to provide excellent seeing. The primary mirror is designed with active mirror supports to maintain the superb figure. WIYN has demonstrated performance with a median seeing of 0.7 arcsec, and images better than 0.6 arcsec are achieved about 20 percent of the time.

One Nasmyth focus is equipped with a wide-field corrector and the Hydra fiber positioner for use with a bench-mounted spectrograph for multi-object fiber spectroscopy. The other Nasmyth focus is designated for a CCD imaging camera and other university instrumentation. Instrumentation for the WIYN telescope is being provided both by NOAO and by the universities. NOAO has provided the fiber positioner, the multi-object spectrograph, and a large format CCD for imaging. NOAO will maintain facility instrumentation provided with the telescope. The universities will be responsible for university instruments, which will not be generally available to the NOAO user community.

Time on the telescope will be shared among the members of the consortium according to the financial contributions of the four partners. Forty percent of the time will be allocated to NOAO for use by the national astronomical community through the peer-review process. NOAO's portion of the telescope time will be used in part for survey and synoptic programs, efficiently done with multi-object spectroscopy, and for wide-field imaging with good spatial resolution. Observations will be obtained primarily by the Observatory staff through queue scheduling and service observing, rather than by individual astronomers assigned nights on the telescope. The telescope will provide the dedicated resources needed for studies of distant clusters of galaxies, selected samples of stars in nearby galaxies and in star clusters, and the physical environments of galactic nebulae. This new facility will therefore allow NOAO's community to pursue larger programs than are often considered feasible on Kitt Peak's other telescopes due to over-subscription. The telescope will also provide ground-based support for space astronomy.

The majority of the construction work on WIYN was completed in FY 1994, and most of the effort in FY 1995 has gone to commissioning the telescope. Science observing will begin in summer 1995, but some commissioning activities will continue into second quarter, FY 1996. The major work will include:
• Completion of WIYN Imager Commissioning (June 1995)
• Completion of Telescope Commissioning (January 1996)
• Completion of Hydra Fiber Positioner Commissioning (July 1995)
• Start of Science Observing (July 1995)
• Completion of the WIYN Instrument Adapter Commissioning (January 1996)

2. SOAR

NOAO, along with the University of North Carolina at Chapel Hill (UNC) and the Brazilian CNPq, representing the Brazilian government, is planning for the collaborative construction and operation of a 4-meter class telescope to be located on Cerro Pachon. This effort will begin with the formation of the SOAR Consortium. (SOAR stands for the Southern Observatory for Astrophysical Research.) It is intended that the SOAR telescope will be operated by CTIO on behalf of the Consortium.

Brazil and the UNC are each seeking to provide 50% of the capital construction costs for the entire telescope, enclosure, and first suite of instruments. Current rough estimates place each party’s goal at 10 million dollars (US). The intent is that CTIO/NOAO provide operations for the SOAR Telescope until such time as all three parties agree that the CTIO contribution has matched 50% of the initial combined contributions of Brazil and UNC. An MOU describing each partner’s proposed commitments has been signed, but a formal agreement has not yet been drafted.

The first of the two primary goals for the SOAR Telescope is to achieve optimal image quality. The system performance goal, including the optics, pixellation, guiding, tracking, wind, and enclosure effects, but not including seeing, is 0.25 arcsec FWHM.

The second primary goal for the SOAR Telescope will be the capability to change quickly from one "permanently" mounted instrument to another; this capability will be exploited through queue scheduling. (By "permanent", we mean here for periods of one to several years.) The intent will be to offer new types of observing, including the ability to observe targets of opportunity, to do coordinated observing with other telescopes, both ground-based and space-based, and to enable long-term synoptic programs.

The telescope will have an altitude-azimuth mount and two Nasmyth ports. The rotating tertiary mirror will provide quick access to either port. One Nasmyth port will be dedicated to near-infrared wavelengths, 1 to 2.5 microns. The second Nasmyth port will be dedicated to the optical regime, from .33 to 1 micron.

The SOAR telescope will complement the current 4-meter telescope at CTIO. Where the latter emphasizes field of view, SOAR will, as stated, emphasize image quality. Consistent with this, there will be opportunities for Brazil and UNC to negotiate time trades with CTIO to gain access to instruments not part of the permanent suite on SOAR. Similarly, CTIO may negotiate for extra time on SOAR in exchange for time on the current 4-meter.

CTIO/NOAO will begin by developing detailed estimates for the operating costs; part of this effort will draw on experience gained during FY 1996 with the new service observing program on the 0.9-m telescope.

B. Joint Nighttime Instrumentation Program

Overview

FY 1996 will mark the first full year of integrated operation for the NOAO Instrument Projects Group (IPG). The scientific oversight and technical management for instrumentation development for CTIO and KPNO was unified in 1995, according to the philosophy outlined in that year’s Program Plan. The scientific staffs of the two Observatory divisions have defined a long-term goal for balanced capabilities at the two sites. This goal takes into account the strengths of the Gemini telescopes and provides complementary and supporting instrumentation for optical and near-infrared imaging and spectroscopy.
The new capabilities are based on the gains to be realized through the large-format detector arrays for optical and infrared. This program plan, then, defines the means of getting 20% of the way to completing the five-year plan.

The scientific oversight of the priorities and progress of the IPG resides in IPAC, the Instrumentation Program Advisory Committee. The committee consists of Taft Armandroff, Optical/UV Program Scientist; Ian Gatley, IR Program Scientist; Jack Baldwin and Jay Elias from CTIO; Dave De Young from KPNO; Todd Boroson from the USGP; and Richard Green, NOAO Deputy Director and Chair. IPAC meets monthly and sets the scientific priorities of the projects in queue for the allocation of resources by the engineering managers.

The IPG within ETS was restructured in April 1995, to reflect the newly integrated program. The new organization eliminated the boundaries between the former Optical/UV and Infrared technical teams. The real-time software group for instrumentation control is now directly associated with the hardware group. This unified structure was motivated by the reduction in size of the engineering and technical group over the last several years and by the desire to reduce the time from design approval to commissioning of major instruments to two years. Both the mechanical designer and instrument maker groups were reorganized to work on an integrated and prioritized project queue.

The new structure includes a relatively strict model for the approval and allocation of resources for new instrument projects. A new development project is led by a project scientist and project engineer. Design engineers with the requisite skills, including software, form a project team to develop the instrument concept. This matrix group stays together at least through the Preliminary Design Review, which provides the gate for approval of allocation of resources for detailed design. The critical design review then clears a project for fabrication, assembly, and commissioning. IPAC benefits from community expertise in convening non-advocate external review panels for these occasions. Such a major review was held for the multicolor, near-IR imager and spectrograph, GRASP, during March of 1995.

The first major projects to be completed through the new system will be the high-dispersion, near-IR spectrograph, Phoenix, and the large-format mosaic CCD imager. Other projects planned for resource allocation in FY 1996 include wide-field correctors to accommodate the Mosaic imager on Kitt Peak telescopes, initial work on the GRASP imager/spectrograph, and major work on the (externally supported) Gemini Near-Infrared Spectrograph, for which NOAO won the national competition in 1995. The Cryogenic Optical Bench will be upgraded to a 1024 square format ALADDIN detector and deployed at CTIO as the first scientific application of the new InSb arrays. Design work will proceed on a clone of the Hydra fiber positioner for CTIO, and concept investigations will continue on a high-throughput optical spectrograph and a fiber-fed high-dispersion spectrograph. NOAO will continue active involvement in consortia to produce large-format optical CCDs and near-IR InSb arrays. Closely related to the successful implementation of new detectors is the development of controllers adequate to handle the large data volume to produce images in a format useful for astronomical analysis. Both the ARCON CCD controller project and controllers for the new ALADDIN InSb arrays will receive major effort in FY 1996.

For reasons of efficiency, the resources needed to support KPNO instrument upgrades and maintenance are included in the joint nighttime instrumentation program. This organizational unity makes it easier to assign the best qualified personnel to various tasks. The KPNO-specific projects are described in the KPNO section of this plan.
## NOAO FY 1996 INSTRUMENTATION PROJECTS

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**Description of individual major projects**

**Phoenix**: This high-resolution near-infrared spectrograph has resolution $R = 100,000$ for a $0.5" \times 30"$ slit on the 4-meter telescopes. The detector will be a $1024 \times 512$ ALADDIN array. Because of its compatible approach to design, cooling, and cold dichroic for optical guiding, the Gemini Project has chosen Phoenix as a desirable loaner instrument. The mechanical fabrication should be complete by the end of FY 1995. Assembly and test will occupy the first quarter of FY 1996; telescope testing is planned for early calendar 1996, and user availability by the fall of 1996. Phoenix will be shared among KPNO, CTIO, and the Gemini telescopes.
Mosaic: This is a large-format CCD imaging system, with a single dewar containing a mosaic of 4K × 2K
CCDs producing an 8000-pixel-square format, which covers almost a degree at the prime focus of the 4-m
telescopes. The system consists of the dewar and associated ARCON controller electronics, a filter
transport for large-format filters, and a data system. FY 1996 will see fabrication and assembly of
mechanical parts, completion of the ARCON hardware and software for the parallel operation of the 8
CCDs, and the completion of a wide-field corrector for the Kitt Peak 4-m telescope to accommodate the
wide-angle format and back-focal distance. Assuming that suitable CCDs are manufactured and processed,
the imager will be commissioned on the Kitt Peak 0.9-m during the summer of 1996, and on the 4-meter
after the installation of the corrector. The imager will be shared between CTIO and KPNO, and is a
candidate instrument for the new wide-field 2-m class telescopes.

GRASP: The 4-color near-IR imager/spectrograph (R = 2000) is based on the successful SQIID heritage.
The input beam is split with cooled dichroics into 4 channels feeding ALADDIN detectors, simultaneously
covering the J-L bands. The format covers a 5-arcmin field of view with 0.3 arcsec/pixel. A Preliminary
Design Review by a non-advocate committee with strong external membership was held in March. The
committee made many useful suggestions about prioritization of modes and possible simplifications. A
Delta-PDR is planned for August, after which the design will be worked out in detail. Depending on the
availability of resources, deployment is planned for Kitt Peak in 1998. GRASP will become the workhorse
infrared instrument for KPNO and will reside at the 4-meter. In addition to being used for spectroscopy and
multicolor imaging, it may be used for the diffraction-limited imaging (DLIRM); at 4 microns that will be
implemented in FY 1996 through COB and rapid hardware-based shift-and-add electronics; this project will
then be interrupted as COB is retrofitted with a 1024-square ALADDIN array and deployed at CTIO.

Gemini IRS: This is a Gemini facility instrument produced with support from the International Gemini
Project. The current concept calls for a long-slit spectrograph (R = 2000-8000) with a reflecting collimator,
a choice of dispersions, and two cameras, one with 0.05 arcsec/pixel and one with 0.15 arcsec/pixel
projected onto ALADDIN 1024-square arrays. The schedule for FY 1996 calls for a Conceptual Design
Review in the first quarter and concerted work on the Preliminary Design following that. Delivery to the
site is planned for FY 1999. NOAO plans to produce a near clone of this instrument to be shared between
CTIO and Gemini South. Work on the Gemini IRS will require training new, temporary technical staff, and
will delay engineering work on some instruments for the existing sites as experienced staff are diverted to
the Gemini work.

Hydra Clone: The CTIO Users Committee cited this as the highest priority new instrument for CTIO. The
multi-fiber robot positioner would be a near-clone of the version used at the R-C focus of the KPNO
4-meter before it was converted to use at the WIYN telescope. Modifications include fibers of different
diameter to optimize for extended objects (galaxies) and stellar objects in good seeing and new motor
controllers that will increase the speed and replace obsolete hardware in the older version. Optimum image
quality at the 4-m may require a new wide-field corrector for the R-C implementation.

ALADDIN Arrays, Controllers, and COB Upgrade: NOAO, USNO Flagstaff, and Hughes Santa Barbara
Research Corporation have formed a partnership to develop 1024 × 1024 InSb arrays for astronomical
research. By the end of calendar 1995, the ALADDIN Project will have produced about 12 attempts at
hybridization. As of this writing, negotiations are underway for NOAO to manage a production run of
arrays for the Gemini Project. After we have a good estimate of yield, we intend to form other such
arrangements. In exchange for foundry run management and characterization expertise, NOAO would
receive some arrays for use in future instrumentation. Critical to the successful operation of the arrays are
capable controllers with adequate bandwidth, multiplexing, image format reconstruction, and compatibility
with existing NOAO controller operation. Resources will be devoted to development of such a controller
during FY 1996. The interests of the Gemini Project and of potential commercial suppliers will be taken
into account in evaluating the development strategy. The first deployment for scientific use will be in the
Cryogenic Optical Bench, which will be retrofitted with a 1024 × 1024 array and associated controller, then
shipped to CTIO at the end of FY 1996. The scale of 0.1 arcsec/pixel will be suitable for exploiting the
near-infrared delivered image quality with the CTIO tip/tilt secondary system. This instrument can do
spectroscopy with a resolution of a few hundred, but we expect it to be used primarily as an imager after the clone of the Gemini North IRS is completed and sent to CTIO.

**High-throughput and fiber-fed spectrographs:** These concepts will continue to undergo scientific definition and preliminary technical study during the fiscal year. The definition of the scientific instrument complement for the SOAR telescope will be a major factor in setting the specifications of the low-dispersion spectrograph.

## C. USGP

### 1. Organization and Staffing

The US Gemini Program (USGP) is the focus for US activities in support of the international Gemini Project (IGP). The purpose of the USGP is to facilitate the scientific participation of the US astronomy community in the Gemini Project. The office addresses this goal by establishing two-way communication with the community on technical and scientific issues, providing oversight and advice to the IGP, advocating and representing US interests in Gemini, and overseeing on behalf of the IGP the efforts of US institutions providing subsystems, such as instruments, to Gemini.

The staffing of the USGP continues to evolve. M. Trueblood became Project Engineer for the USGP in FY 1995; he was formerly with the GONG Project. F. Gillett, Associate US Gemini Project Scientist, moved temporarily to the IGP as interim Gemini Project Scientist. On 1 December 1995, he will become the first Gemini fellow and will derive half of his support from the IGP and half from NOAO. In this capacity, he will continue to oversee the program to optimize the IR performance of the Gemini telescopes. In addition to the staff formally assigned to it, the USGP draws extensively on the scientific, engineering, and administrative staff of NOAO.

The USGP supports scientists serving on the (international) Gemini Science Committee (GSC) and on the US Science Advisory Committee, which helps the USGP develop a US position on issues with scientific implications. The GSC has established working groups to provide scientific oversight of instrument design and fabrication. The USGP supports US participation in these committees in areas of optical instrumentation, infrared instrumentation, and adaptive optics and acquisition and guiding. In addition, an international working group on scientific operations for Gemini has recently been established, chaired by the US Gemini Project Scientist. The USGP also supports participation by the US community in this group. The USGP will continue its outreach efforts with displays and presentations at national meetings and colloquia at astronomy departments throughout the US.

The USGP has developed a program to identify key technologies and interests of the US community that can be applied to the Gemini Telescopes. In FY 1995 the USGP organized two workshops. The purpose of the first of these was to focus the attention of the US adaptive optics community on the second generation Gemini adaptive optics system. This group of around 15 researchers and vendors found the workshop to be a productive forum and plans to meet again in FY 1996 to define a development program aimed at producing a high-throughput adaptive optics system employing laser beacons for Gemini. A second workshop in which the USGP played an organizing role was an international meeting on innovative observing modes. The USGP plans to initiate new activities of this type each year, with a national instrumentation coordination workshop a likely candidate for FY 1996.

### 2. Instrument Acquisition Plan

The dominant activity within the USGP is the procurement and management of the Gemini instruments that have been allocated to the US. Within the initial instrumentation complement, five work packages fall in this category. These include a near-IR imager (assigned to the University of Hawaii), a near-IR spectrograph (negotiations in progress with NOAO), a mid-IR imager, CCDs for the optical spectrographs, and near-IR arrays and controllers for the near-IR instruments. The USGP has the task of organizing and managing these procurements in a way that encourages wide community involvement and guarantees the
delivery of instruments to Gemini which meet the requirements of the project and the partner countries. Furthermore, these instruments must be delivered for a fixed price.

The general form of the process for selecting builders for the instruments includes an open review of proposals by a committee with wide community representation. The exact nature of this review varies with the requirements for each item. In the case of the mid-IR imager, the procurement of which will be initiated in FY 1996, the selection will consist of an open competition conducted by NOAO, which does not plan to submit a proposal for this instrument.

The management and oversight of the instrument building efforts varies from case to case. For the near-IR imager, the assignment to the University of Hawaii is based on direct negotiations with NSF. The USGP's role in managing this work is not clear. In all other cases, the USGP has responsibility for delivery of the completed instruments. The USGP arranges for progress reporting and appropriate design reviews. In the cases in which the work is being done within the NOAO instrumentation program, the USGP has representation on the committee that provides scientific oversight to that program. This will be the case for the near-IR spectrograph and the near-IR arrays. The CCDs represent yet another different case. They are being procured by an international consortium organized and coordinated by the USGP. Testing will be distributed among the consortium members, with the USGP responsible for reporting directly to the Gemini Project.

3. **CTIO Interactions with Gemini**

Support of the construction phase of Gemini South is CTIO’s highest priority. Funds for this activity are provided exclusively through the international Gemini Project. More than half the site construction work on Cerro Pachon is expected to be complete by the end of FY 1996.

Engineers and technicians from CTIO will start planning work with engineers designated by CONICYT, Chile, for the production of CCD array controllers (Arcons) for Gemini, as part of one of the Chilean workpackages. The plan for this work must be accepted by the IGP in FY 1996 and work initiated immediately thereafter.

Jay Elias will transfer from CTIO to Tucson to head the NOAO effort to build the Gemini infrared spectrometer, which is largely based on an original CTIO design. This project will continue to draw heavily on scientific support from CTIO.

There are plans to build a similar spectrometer for CTIO, which will also be made available to Gemini South.

**D. Telescope Operations and User Support**

1. **Changes in User Service**

**KPNO**

**A. WIYN Operations**

During the third quarter of FY 1995, KPNO will begin science observing with the new 3.5-m WIYN telescope on Kitt Peak. For the fall 1995 semester, we received 45 proposals for WIYN programs, and an additional 19 proposals for the WIYN "2-hour queue" program. The WIYN telescope is scheduled in a manner different from that used for the other KPNO telescopes. A staff observer will obtain the data from the WIYN telescope using queue scheduling and distribute it to investigators. Where feasible, we will support eavesdropping by investigators to enlist their support in evaluating data quality.
The two-hour queue program will provide small amounts of data (up to two hours) to investigators without the need for peer review. Proposals will be reviewed internally for technical feasibility and appropriateness, and data will be obtained as time permits. The rationale for this program is to provide the opportunity for exploratory observations and short investigations. Such programs are often carried out on traditional observing runs as part of larger, approved programs, and we wish to maintain these opportunities.

Initially, NOAO will receive approximately 8 nights per month on the WIYN telescope because one week per month will be devoted to engineering work to achieve and maintain the high performance standards set for the telescope. We anticipate the level of engineering time will drop to about 2 nights per month by the end of FY 1996. At that time, NOAO should be able to schedule approximately 11 nights per month.

B. New KPNO Operations

The FY 1995 budget for KPNO operations represents a 9% cut in level of effort compared to FY 1994. During the period 1987-1994, level funding had already reduced KPNO’s resources some 29% as inflation eroded the base budget. In spite of cuts in operations, major new instrumentation has arrived on Kitt Peak (Hydra, SQIID, COB, 2048 x 2048 CCDs, etc.), bringing increasing complexity and raising support requirements. During FY 1995, a major new facility, the WIYN telescope, is coming on line and starting science operations.

In past years KPNO has struggled to minimize the impact of budget cuts on our users. Telescopes are now operated with a “leaner and meaner” staff while training has been postponed; facility maintenance has been deferred in the hope of better budgets in future years; the balance of the engineering effort has shifted from projects and upgrades to telescope maintenance, endangering the program of telescope improvements to achieve better image quality; the scientific staff has absorbed a heavier and heavier burden of visitor support at the cost of new programs within the observatory. As one lean year follows another, the situation becomes increasingly serious.

At the end of FY 1995, we will implement many changes to operations on Kitt Peak to allow us to shift resources to focus on the larger telescopes, to improve training, and to invest in modernization so that we can continue to provide access while lowering our operating costs.

Our highest priority for operations in FY 1995 is the new 3.5-m WIYN telescope; KPNO will receive a 40% share of the observing time on WIYN. This year we will assume responsibility for WIYN operations and begin to carry out scientific programs for the community through queue scheduling. Both the Hydra Multi-Object Spectrograph and the WIYN CCD Imager will be available for observations.

Our second priority will be continued operation of the Mayall 4-m telescope. Increased block scheduling and further restriction of the number of instruments offered will be necessary to reduce instrument changes. During dark time, the prime focus CCD imager and either the R-C Spectrograph or the Cryogenic Camera will be available. Only one instrument will be mounted at Cassegrain during each bright run. The selection of instruments offered during each half lunation will be determined by those proposals of highest scientific rank based on TAC review. The remaining time during each bright or dark run will be allocated to other programs approved by the TAC; time that cannot be scheduled in this manner will be allocated to the KPNO staff to carry out service observing for the community. Opportunities for service observations will be announced in the Newsletter and over the World Wide Web.

Additional changes will take place at KPNO’s small telescopes, the 2.1-m, the 0.9-m, the Coude Feed, and the Burrell Schmidt telescopes.

Instrument changes on the 2.1-m will be limited to no more than one per month; instrumentation available on the 2.1-m telescope will be limited to GoldCam and a selection of IR instruments. Note that this restriction will blur the distinction between bright and dark time. Consistent with this change, all of the 2.1-m proposals will be handled by a single TAC.
We will provide “appropriate” support for observing starts on small telescopes. That is, we will schedule support personnel in a way that takes into account the experience of the observer. Inexperienced observers will be asked to come one day early to gain experience by watching the previously scheduled observer. All observers will be expected to come fully prepared and to be familiar with the manuals. Technical assistance will be available during the day to install filters or gratings and to provide safety briefings.

Dedicated telescope operators will no longer be available at the 2.1-m telescope starting with the fall 1995 semester. Observatory staff will be available at the beginning and end of the night to open and stow the telescope. The 2.1-m operator will also serve as the roving assistant for the small telescopes. Therefore, 2.1-m observers must be prepared to operate the telescope themselves.

Nighttime technical staff will be reduced; technical problems which cannot be resolved easily by the staff available at night will be addressed the following day, if possible. Priority for technical assistance will be given to WIYN, the 4-m, and the small telescopes by aperture.

We believe these changes are in the spirit of the recommendations of both the OIR Panel and the KPNO Users Committee. At the current budget level, the alternative to these changes is to close one or more additional small telescopes.

C. DLIRIM Opportunity
We will conduct a special observing program during the fall 1995 and spring 1996 semesters using COB/DLIRIM on the 4-m telescope for high resolution imaging at 3.3-4.1 μm. Observations will be obtained by KPNO staff in a service observing, queue-scheduled mode, in such a manner as to obtain as much data as possible for all approved programs. To provide an opportunity to see this unique capability in action, visiting observers will be welcome to participate during the observing sessions.

The DLIRIM configuration provides 0.1 arcsec/pixel and a 25 arcsec field of view. It critically samples the Airy disc in the L and L' bands (3.3-4.1 μm) and slightly undersamples at K. In an experiment conducted last fall, high speed data acquisition followed by shift and add post-processing gave images at L' with diffraction limited cores and highly uniform PSF over this field. Due to the high thermal background of the sky longward of 3 μm, very short integrations remain background limited. There is no loss of sensitivity in this mode at these wavelengths.

A large part of the spatial resolution advantage is retained at K in the high-speed mode, but the data are no longer background limited, so a severe penalty is paid in sensitivity. The PSF is also more sensitive to atmospheric conditions and more likely to vary across the field of view. For these reasons, we are emphasizing programs at 3.3-4.1 μm in this opportunity. For other programs, the 2.1-m telescope offers larger field (50 arcsec) while retaining some advantage of higher resolution (0.2 arcsec/pixel, 0.6-0.8 arcsec FWHM images at K).

D. 1.3-m Closure
During FY 1995 we were forced to close the 1.3-m telescope on Kitt Peak. The telescope had been in operation for decades. It was originally built as a “remote observing” telescope, and later became heavily used for infrared observations and for IR array development. New infrared instrumentation now underway, including the Phoenix high resolution spectrometer and the GRASP multi-color grating spectrometer, will not be usable on the 1.3-m because of size and weight restrictions. While the 1.3-m telescope has been a highly productive facility for many years, the scientific capabilities it offers are now largely duplicated on the 2.1-m and 4-m telescopes.

During the spring 1995 semester, the 1.3-m telescope was scheduled to complete two graduate theses already underway and to complete two ongoing programs using photoelectric photometry. The telescope will also be used occasionally for testing new IR arrays. Other highly ranked proposals approved by the TAC for the 1.3-m telescope were moved to the 2.1-m, and some 2.1-m proposals were moved to the 4-m telescope.
E. Instrument Changes

During the spring 1995 semester we implemented several changes to the instrumentation offered on Kitt Peak telescopes. These changes include the retirement of the following instruments and capabilities: photographic imaging at the 4-m prime focus and at the Burrell Schmidt, the 4-m Fourier Transform Spectrometer, the Simultaneous Quad-color Infrared Imaging Device (SQIID), the 2.1-m Fiber Optic Echelle, photoelectric photometry, and the 0.9-m white spectrograph. We are making every effort to assist those astronomers impacted most heavily by these changes to complete their programs.

The instruments listed below will be available for visitor use on KPNO telescopes during the August 1995 - January 1996 observing semester.

4-m Telescope:  
R-C Spectrograph + CCD (T2KB)  
Echelle + UVFast, Red Long, or Blue Long Camera + CCD (T2KB)  
PF Camera + direct CCD (T2KB)  
IR Cryogenic Spectrometer (CRSP)  
Cryogenic Optical Bench (COB)  
IR Imager (IRIM)  
CryoCam (with 800 x 1200 Loral chip)

WIYN Telescope:  
Hydra + Bench Spectrograph (T2KC)  
CCD Imager (S2KB)

2.1-m Telescope:  
GoldCam CCD Spectrometer (F3KA)  
Cryogenic Optical Bench (COB)  
IR Cryogenic Spectrometer (CRSP)  
IR Imager (IRIM)

Coudé Feed:  
Coudé Spectrograph + Camera (5 or 6) + CCD (F3KB)  
NICMASS Array (Shared Risk)

0.9-m Telescope:  
CCD Direct Camera + CCD (T2KA)  
CCD Photometer (CCDPHOT) (T5HA)

Burrell Schmidt:  
Direct or Objective Prism + CCD (S2KA)

During FY 1996 we will continue to support the University of Massachusetts “NICMASS” infrared array for observing programs on the Coudé Feed telescope. We will also assist in the commissioning of two new instruments: Phoenix (a high-dispersion, IR spectrometer) and the NOAO Mosaic Imager. The Phoenix spectrometer should become available to users late in FY 1996.

F. Remote Observing

For some time KPNO has upon special request informally supported alternative observing modes. Beginning with fall 1995 semester, we will formally offer the following non-traditional services to scheduled programs using CCDs at the 4-meter, 2-meter, and 0.9-meter.

- Automatic FTP data transfer to a computer at your institution

  After each exposure each image is passed to a queue, which automatically transfers it to a home observer’s computer using FTP. This process operates in the background and will not affect observing efficiency.

- Remote observing station
The KPNO observing environment will be duplicated as far as possible on a computer at a home observer's institution. At present we are only able to support Sun SparcStations running SunOS (not Solaris) and IRAF. The remote window environment will include the ICE data acquisition window, IRAF data reduction window, and an Ximtool quick look image display.

Home observers will be responsible for providing the video conferencing hardware and software, including some or all of the following: microphone, speakers or headphones, Sun VideoPix board, TV camera, PictureWindow software. All long-distance telephone charges during the run between investigators on site and at the home institutions remain the responsibility of the observers, but the network audio link should make the phone unnecessary.

G. Save-The-Bits

Save-The-Bits is KPNO's low cost data archiving program that allows us to capture and store data from CCDs and IR arrays operated on telescopes supported by KPNO. This program has accumulated some 0.66 terabytes of data (approximately 400,000 images) since it began in July 1993. The archive is used to restore lost observers' data, for engineering applications, and to support long-term monitoring programs by investigators who rely on scheduled observers to collect small amounts of data.

During FY 1996 we anticipate that Save-The-Bits will continue to be adopted by other observatories. Planned upgrades include the addition of digital signatures to assure the integrity of the data, "postage-stamp" quick-look images for on-line access, and a simple on-line database for the header catalog to improve the accessibility of the data. We also are planning for long-term tape maintenance to avoid data loss.

H. Graduate and Undergraduate Education

KPNO has for many years provided opportunities for graduate students to learn the trade of observational astronomy through access to telescopes. The participation by graduate students in observing runs on Kitt Peak has become an important part of the training of new observational astronomers: KPNO supports thesis observations for dozens of graduate students from more than 20 institutions each year. Since only about 100 Ph.D. degrees are granted in all fields of astronomy each year in the US, KPNO is thus supporting a large fraction of all theses in optical and IR astronomy.

Most thesis observations taken at KPNO are carried out on our small telescopes, and we are concerned that under the new operations plan, thesis students' hands-on access to telescopes will decrease. To address this concern, we encourage students to plan extended visits to Kitt Peak to participate in and assist with observatory related service. Thesis students who wish to take advantage of this opportunity should contact the KPNO Director's Office. We can support travel expenses and room and board on the mountain for a limited number of students each semester who wish to gain experience in hands-on observing with optical telescopes.

The advantages for graduate students participating in this program are not only to gain observing experience but also to learn about instrumentation and to meet astronomers outside their own institutions.

With funding obtained from the NSF, we have recently instituted a program to support undergraduate visits to Kitt Peak with scheduled observers as part of our educational outreach effort.

CTIO

A. Service Observing at the CTIO 0.9-m Telescope

We hope to operate the CTIO 0.9-m telescope, and possibly also the Curtis Schmidt, in a service observing mode. Astronomers will still be assigned specific observing periods, but they normally will eavesdrop from their home institutions rather than travel to CTIO. In this small-scale experiment, CTIO will attempt to
identify enough direct savings (from not having to support the in-Chile expenses of visiting astronomers) to pay for the extra cost of providing observing and data-handling personnel. We believe that this will improve the scientific productivity and overall cost-effectiveness of the CTIO 0.9-m telescope and will allow CTIO gradually to phase into a queue observing program. This will let us gain experience with the new observing modes, which will be used at telescopes such as Gemini and SOAR.

CTIO is also exploring ways to set up a program to have US graduate students in residence for 6-12 months, during which they would participate on the data-taking end of the service/queue observing programs.

As part of this gradual experimental phasing over to service and queue-scheduled observing at CTIO, data taking began on the MACHO project at the 0.9-m on 1st September 1994; CTIO has provided this service on every night since then. The relevant contracts between the University of California (Berkeley)/NSF/CTIO are expected to be renewed twice - effective for one year each time, beginning 1st February 1995 and 1st February 1996. The income from this project has been used primarily to hire a service observer and contract staff to work on upgrades of the (small) telescopes involved in this program.

2. Telescope Upgrades

KPNO

In determining what telescope upgrades would be considered this year, we have taken into consideration the impact of the full scale operation of the WIYN telescope and the expected restructuring of the observatory over the next four years. Our goals are to improve image quality and to reduce costs through consolidation of programs and a reduction of engineering support at the small telescopes. The majority of the work will be carried out at the 4-m telescope.

During the year, we will continue our efforts at the 4-m telescope to make needed seeing improvements. We will complete a program begun FY 1995 to reduce heat generated by electronics in the Cassegrain cage. A major source of heat is the CAMAC/MUX system used for control of instrumentation. While we do not have the resources to replace the CAMAC/MUX at this time, power dissipation in the Cassegrain cage will be reduced to the 400-500 watt range. This heat source is directly below the primary mirror and is a significant source of seeing degradation. We expect to begin actively cooling the primary mirror in FY 1995, which should remove the heat produced by the electronics.

Other work to be carried out at the 4-m telescope includes the completion of the control system for programmed cooling of the floor, primary mirror, and telescope oil. The goal is to remove heat from the enclosure, the telescope structure, and the primary mirror to improve the image quality delivered by the telescope. Software to manage the interface hardware to TCS also needs to be written. This is a key project for the 4-m and is being given high priority. The upper floors of the building have been cooled for years but have been controlled manually. Manual cooling for the telescope oil was implemented in FY 1994, and manual cooling for the mirror is being implemented in FY 1995. Based both on models of seeing induced by a warm primary mirror and on the success at other observatories that have implemented similar measures, we expect to see a measurable improvement in seeing at the 4-m telescope. We hope to achieve sub-arcsecond median seeing.

The final step in our program to improve image quality delivered by the 4-m telescope will be to ventilate the telescope chamber. Studies are underway by David DeYoung using numerical models to understand how this can be accomplished most effectively. These studies should be completed in FY 1996, and we will begin engineering design for ventilation.

The CCD Mosaic Imager, currently under construction, will be tested at the 0.9-m telescope in FY 1996 and will become an operational instrument at the 4-m telescope in FY 1997. Due to the size and weight of this instrument, major modifications to the 4-m prime focus cage will be necessary. Replacement of the prime
focus pedestal may also be necessary to support the weight of the new camera; studies are underway to
evaluate the limitations of the present mechanical system.

At least three telescope control systems are in use on KPNO-supported telescopes. At present staffing
levels, it is difficult to support this wide variety of electronics and software systems. While the 4-m, 2.1-m,
and Coude Feed telescope control systems are similar, they operate with different versions of the underlying
commercial software. In FY 1996 we will consolidate existing source code for the telescope control
software (TCS) at these three telescopes. We will also evaluate the possibility of adopting and
implementing Gemini Project standards for telescope control.

Beginning with the fall 1995, observing semester, a dedicated telescope operator will no longer be available
at the 2.1-m telescope. Several improvements are planned to simplify the observing environment for users.
The old 1970s image dissector scanner, which is used to generate a guide signal for the telescope, will give
way to a state-of-the-art TV acquisition and guiding camera. This will make the telescope easier for the
observers to use and more efficient to operate. New software may also be installed to minimized the
occurrence of user errors.

We anticipate that the 0.9-m telescope, used for wide-field imaging, will remain in operation until it can be
replaced with a telescope of greater aperture. Work to date to improve image quality at this telescope has
included ventilation of the dome, replacement of the f/8 secondary mirror support, ventilation of the
primary mirror, and removal of electronics from the observing floor. These improvements have led to a
significant decrease in the seeing, which is now limited by the pixel size on the detector. To achieve better
image quality, we will replace the f/13 secondary mirror supports in FY 1996, so that observers can obtain
better sampling on the Tektronix 2048 x 2048 CCD in use at the 0.9-m. Users should then realize the good
images now delivered by this telescope.

CTIO
CTIO's future is dominated by the impending arrival of the southern Gemini telescope. Our planning
assumption continues to be that a large fraction of CTIO ETS personnel will inevitably be drawn in to help
support the Gemini commissioning phase starting in 1998 or 1999. Unless more resources are made
available to CTIO, we have only the next 2-3 years to get our existing telescopes and instruments into the
condition they will have to remain in until the middle of the next decade. Given this prospect, we must
work to a well-defined order of priority.

Given current budget predictions, the only existing telescopes that have a very high probability of still
operating on Cerro Tololo at the end of this decade are the 4-m and 1.5-m. Our near-term program
therefore must continue to give first priority to the imaging performance and general maintainability of the
4-m telescope, including the installation of a tip-tilt secondary mirror.

During early FY 1996, we will start to use the new f/14 focus of the 4-m telescope, and by the end of the
year we hope to have an operational tip-tilt system at that focus. This will open up a new range of scientific
investigations, particularly in the JHK passbands, which in the southern hemisphere can be carried out only
at CTIO.

We also expect to make significant improvements in image quality at the 1.5-m telescope and to move
towards providing a smaller, but better-performing, complement of instruments operating at one fixed focus
at that telescope.

A. F/14 Tip-Tilt Implementation

One of CTIO's top-priority FY 1995 projects is the installation of a new f/14 secondary mirror on the 4-m
telescope. One goal is to make CTIO IR instrumentation compatible with the KPNO 4-m (f/15) and Gemini
(f/16). But the new secondary is also being installed with piezo-electric actuators in place to make it "tip-

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tilt capability in the southern hemisphere. This is the logical extension of the program to improve the imaging capability of the telescope. The emphasis is on the near IR (JHK), where tip-tilt achieves the greatest proportional gains in image quality for a 4-m telescope with good seeing.

The actual tip-tilt implementation consists of adding a guider box at the Cassegrain focus, which will use a dichroic or beam-splitter to feed light from a guide star through re-imaging optics to a fast CCD camera. The fast CCD camera, which will work at about 100 Hz, will be an upgraded version of our existing CCD-TV acquisition cameras, using a commercial high-speed video board for the crucial centroiding calculations.

The guider box will have a remotely controlled x-y stage for the guide camera. The project includes software effort to make the system user friendly for visiting astronomers.

This project also includes the conversion of the existing IRS infrared spectrometer from f/30 to f/14 so that it can be used with the tip-tilt system.

B. 4-M Control System Improvements

The other area, besides image quality, where the 4-m telescope obviously needs basic improvements and upgrading to its infrastructure is in its control systems. Although the control software and the computer in which it runs are modern, almost everything else dates from when the telescope was commissioned 20 years ago. Not only is the performance well below today's standards, but it is no longer possible to get spare parts for basic elements such as encoders and drive servos.

In FY 1995 we started a three-year upgrade program, which will culminate in duplicating the recent upgrades made to the KPNO 4-m drives. During FY 1996 we will replace the relay logic controls for the telescope with a modern programmable logic controller. This is strictly aimed at improving the maintainability of the telescope.

We will also proceed into the fabrication of boards needed to convert to a new servo system that duplicates the one recently installed on the Mayall telescope. Fabrication of the new servo electronics systems will continue into FY 1997. During the crucial stage of tuning the servos, we will get direct assistance from the engineers who carried out this work at KPNO.

C. 1.5-M Telescope Upgrades

The 1.5-m telescope presently is used with 3 different secondary mirrors, each with their own problems, and a wide variety of instruments. Its imaging performance, and therefore its scientific productivity, is limited by both optical and thermal problems. Our goals are to get the optics working properly with a single, fixed f/13.5 secondary and a restricted complement of instruments, and to make major improvements to the thermal environment. The upgraded telescope initially would continue to be used with the optical and IR direct imagers and the optical low-resolution and Fabry-Perot spectrometers. We would expect to shift some of these observational roles over to a new 2.5-m-class telescope in the future. This will keep the 1.5-m telescope competitive for another 5+ years. In FY 1996 the major effort will go into installing large ventilation louvers into the dome walls (following the example of the KPNO 0.9-m), improving the removal of waste heat from the console and computer rooms, providing a corrector for the f/13.5 focus, and converting the spectrograph from the 1-m telescope to work at f/13.5. The latter will include the completion of a new spectrograph camera, built as a joint project with STScI, that will give good performance with large-format CCDs.
3. Instrument Improvements

KPNO

A. New Camera for the 2.1-m Goldcam Spectrograph

The 2.1-m Goldcam spectrograph is a popular and productive instrument, especially since the installation of a 1K x 3K Loral CCD as the detector. The instrument is capable of achieving low and moderate spectral resolution on point sources as well as extended sources with good efficiency. The original camera was not designed, however, to produce good images over the wide-field that can be obtained with a large format CCD. Fabrication is underway in FY 1996 on a new camera that can take full advantage of the format of the CCD. The camera should be installed on the spectrograph for testing in January 1996, and available to users in the spring 1996, semester. An important consideration is good image quality over a wide wavelength band for use with low-resolution gratings.

B. Correctors for Mosaic at the 4-M and 0.9-M Telescopes

In order both to utilize the full field of the 8K x 8K mosaic imager and to improve delivered image quality at the 4-m prime focus, a new corrector and atmospheric dispersion corrector are required. A design study has taken place over the last two years. The design is now finalized, and we plan to order glass and place a polishing contract before the end of FY 1995. The work in FY 1996 will involve primarily supervision of that contract, mechanical design work and fabrication for support of the corrector/ADC, and installation. A new corrector is also required at the 0.9-m for the mosaic imager; it is currently under construction and should be installed and tested early in FY 1996.

C. Detector upgrades

We will continue to upgrade the CCDs in use at KPNO telescopes as improved detectors become available. In FY 1996, we anticipate receipt of a 1K x 3K Loral CCD to be used with the R-C and echelle spectrographs at the 4-m telescope. When the 4K x 4K pixel “mini-mosaic” of Loral CCDs with 15-micron pixels is complete, it will be installed at the WIYN telescope for use in the WIYN imager.

KPNO will also assist the NOAO Instrumentation Program in the development of Aladdin IR arrays and array controllers through telescope testing and deployment. One path may be the detector upgrade in the SQuID IR imager. If SQuID is equipped with large InSb arrays and made available again on Kitt Peak, it could help to fill the one year gap between the departure of the Cryogenic Optical Bench to CTIO and the arrival of GRASP on Kitt Peak.

D. DLIRIM Implementation

The Diffraction Limited InfraRed Imager (DLIRIM) will go into service at the end of FY 1995, and we expect to continue development work on the shift-and-add technique for obtaining diffraction-limited images at a wavelength of 3 microns on the 4-m telescope. We are exploring the feasibility of incorporating the same capability into the “GRASP” IR grating spectrometer/imager when it goes into service on Kitt Peak.

E. Phoenix IR Spectrometer

The high spectral resolution IR spectrometer Phoenix will enter commissioning on Kitt Peak in FY 1996. We expect significant involvement of KPNO staff and engineering resources to commission the instrument successfully and achieve user status.

F. Adaptive Optics at the WIYN Telescope

The WIYN telescope is KPNO’s premier facility for high-resolution optical imaging. A low-order adaptive optics system is desirable at WIYN in order to achieve site-limited seeing more often; this is done by eliminating telescope shake due to wind and serve control limitations, and by minimizing guide errors and focus variations. In addition, such a system can improve delivered image quality beyond site seeing by
removing low order aberration terms. NOAO is working with the WIYN universities in order to specify and develop a low-order adaptive optics system for WIYN.

CTIO

A. Arcon CCD Controllers
Currently there are seven Arcon systems in use at CTIO and one at KPNO/WIYN. All use several electronics boards, which are interim versions. During FY 1996 we expect to complete the development of the final versions of the last three boards and to move into a phase of large-scale production. CTIO's short-term needs for these controllers have been met, but ~10 more need to be built to meet NOAO's longer term needs (5 systems for the NOAO Mosaic Imager, 3 more for KPNO, and 3 more for CTIO). Another 8-10 systems are needed by the Gemini telescope project. The manpower planned for FY 1996 includes CTIO electronics engineers who will carry out mostly supervisory and development tasks, a contract electronics engineer dedicated to production and testing activities, and electronics technicians to carry out the in-house portions of the fabrication. Additional manpower will be required to fabricate the Arcons for Gemini. A detailed scheduling and costing exercise for the full Arcon production run is currently under way, after which a contract can be negotiated with Gemini and a final overall schedule determined.

B. Spectrograph Motor Controllers
The R-C (low-dispersion) spectrograph on the CTIO 4-m has a number of remotely controlled functions that are presently run with 20-year-old stepping motors and encoders controlled over a Camac link. We are systematically changing all such hardware at CTIO over to a new generation of Smart Motor Controllers, which use off-the-shelf Standard Bus cards and chassis embedded in custom-made protective boxes with high-quality connectors. During FY 1996, we will convert the CTIO R-C spectrograph over to this new system. A moderate amount of mechanical effort will be required to produce suitable mounts for the modern servo motor units. This project will allow us to retire the Camac crate from the 4-m Cassegrain cage. We will also put the slit mechanism of the echelle spectrograph under remote control. We are modernizing the CTIO R-C spectrograph because we do not anticipate having the resources to replace it for at least another decade.

C. Hydra Camera
We will build a new camera for the existing Argus bench spectrograph at CTIO as the first step in replacing the Argus multi-fiber spectrograph with a more modern instrument (Hydra), which will be built by the NOAO central instrumentation group. The optics for this camera will be bought during FY 1995. The camera will be designed around a SITE 2048 x 2048 CCD. It will initially share an existing CCD with other 4-m and 1.5-m applications, and will be usable with the existing Argus system. We need the camera at this time because we do not have a backup for the Loral 3K x 1K CCD (used in a different camera), which is at present our only detector for Argus.

D. Implement CCD
We plan to bring up one additional CCD on an Arcon controller during FY 1996. This ideally would be a SITE 2048 x 2048 dedicated to the Hydra Spectrograph camera described above, but we do not have sufficient funding for that in our base instrumentation plan.

E. Projects Continuing from FY 1995
Several projects initiated in FY 1995 will continue in FY 1996. These include the fabrication, installation/testing, and documentation work for the f/14 secondary mirror project for the CTIO 4-m, design and construction of dewars needed for a new camera being built in collaboration with STScI for the 1.5-m telescope, several small electronics projects, and the conversion of the 1.5-m telescope control system to the VxWorks operating system.
## Summary Of CTIO/ETS Project Resources Planning

Columns headed ME, MD, MF are Mechanical Engineering, Design, and Fabrication estimates; OE is Optical Engineer; EE, ED, and EF are Electronics Engineering, Drafting and Fabrication; CS is Computer Software; all in man-months. $K Column lists non-payroll expenses in units of $1000.

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*Contract Hires.* This line deducts from the CTIO manpower requirements the work that we anticipate will be furnished by contract hires. We expect to have on temporary contracts 1 mechanical engineer and 1 machinist (paid for by the MACHO consortium), and 1 electronics engineer and 2 electronics technicians (paid for by CTIO). The cost to CTIO of these personnel ($45K) is shown in the $K column.

### 4. Issues

#### Joint Users’ Committee

To respond both to the recommendations of our individual Users’ Committees and to the recommendations of the AURA/OAC Workshop, the existing KPNO and CTIO Users’ Committees will be combined into a new Joint CTIO/KPNO Users’ Committee.

The Committee will be comprised of twelve members, six appointed by the CTIO Director and six by the KPNO Director, following consultation among the two Directors and the NOAO Director. Each group of six will serve as a Subcommittee to advise the corresponding Director about his or her Observatory and programs. The Chair of the Joint Committee will alternate between the Chairs of the CTIO and the KPNO Subcommittees. The Joint Committee will also have an opportunity to report directly to the NOAO Director annually and will provide formal input to the NOAO Director concerning the NOAO Instrumentation Program. In the longer term, the Joint Committee may also serve as the Users’ Committee for the US Gemini Program.

The charge of the new Joint Users’ Committee is as follows:

"The Joint CTIO/KPNO Users’ Committee is appointed in consultation by the CTIO, KPNO, and NOAO Directors to advise them jointly and separately on issues of concern to our users and to the broader astronomical community."

"The tasks of the Committee include, but are not limited to:

- advising CTIO and KPNO on the needs of the community, both short and long term;
- helping to evaluate how well CTIO and KPNO are meeting those needs;"
• advising on ways to improve existing services and programs at CTIO and KPNO;

• suggesting new services and programs needed by the community;

• reviewing plans for service and program changes to meet changing community needs and budgetary constraints;

• advising on new instrumentation and the deployment of instruments and scientific capabilities north and south and on the plans and priorities of the NOAO Instrumentation Program;

• advising on policies and process for the allocation of telescope time at CTIO and KPNO;

• advising on CTIO and KPNO operations and policies;

• advising on the evolution of telescopes and facilities to provide a good balance north and south.

Electronic Forum
The Joint CTIO/KPNO Users' Committee, in collaboration with the Directors of NOAO, CTIO, and KPNO, will initiate an electronic forum to improve the exchange of information between NOAO and the US optical/infrared community. The goals of this program are to facilitate communication regarding proposed changes within NOAO that will affect the user community and to encourage community input to the decision process. We want to provide a mechanism for NOAO to inform the community in a timely manner about issues regarding operations or policy and to fold in community input before final decisions must be made. This electronic forum is meant to complement the existing NOAO Newsletter.

Disposition of Small Telescopes After Closure
As KPNO and CTIO facilities are modernized and replaced, older smaller telescopes will be closed. These telescopes are still productive facilities and could offer scientific value to other institutions prepared to operate them. During FY 1996 we will develop and, if appropriate, implement a plan in consultation with the Joint CTIO/KPNO Users' Committee, AURA, and the NSF to offer these facilities to the community.

Joint Telescope Time Proposals
During FY 1993, both KPNO and CTIO implemented a new mechanism for the electronic submission of proposals for telescope time (including figures), following the approach of LaTeX templates developed by the American Astronomical Society for electronic submission of journal manuscripts and meeting abstracts. This procedure has worked successfully and simplified the processing of proposal forms. The forms and electronic processing of proposals are similar between the two observatories. In FY 1996, we plan to standardize the proposal forms for KPNO and CTIO and to consolidate the maintenance and support of the electronic submission of proposals. Users will obtain proposals from a single source via the World Wide Web at NOAO and will use a common form for proposals both at KPNO and CTIO. Once this step is taken, we will move to a common e-mail address for submitting proposals, and the proposals for KPNO and CTIO will be logged and distributed automatically to the proper sites for further processing. The consolidation of the proposal submission process for CTIO and KPNO will allow us to incorporate easily proposals for telescope time on Gemini and other facilities for which NOAO may provide peer review.

Replacement of ALPS
The database for proposals for telescope time at KPNO is maintained via software that was written locally in the early 1980s. This software is difficult to maintain and to modify, and it does not meet our current needs. NOAO has adopted standardized software for personal computers used in our offices, and we need to transfer the functionality of the present proposal system to the new software standards. Planning for this change will occur in FY 1995, and we hope to implement it in FY 1996.
Electronic Office

For the last 5 years, KPNO has been gradually incorporating new procedures to accommodate the more than 500 visitors we support to observe at Kitt Peak each year. These procedures include preparation of the telescope schedule, notification of observers, advance preparation for observing runs, support during mountain and downtown visits, and follow-up evaluation of observers' visits, as well as summaries and reports of KPNO operations. With the standardized office software, we hope to consolidate these activities to improve user support, reduce processing effort, and reduce the use of paper in the office.

E. Facilities Maintenance

KPNO

During FY 1996, we will continue to direct resources toward further reducing our maintenance and operating costs. Where it is cost effective, old hardware will be replaced with new, energy-efficient equipment. Our intent, over the next four years, is to modernize a down-sized infrastructure, while making it both more manageable and less costly to operate.

Summary

1. Water/sewer/telephone lines 30,000
2. Dormitory 1 upgrades 50,000
3. General building repairs 60,000
4. Water catchment repairs 20,000
5. Energy management improvements 48,000

Total FY 1996 funds 208,000

We are exploring the feasibility of upgrading the telephone link between Tucson and Kitt Peak. We are currently restricted to a single T-1 line. Estimated cost is $300K, and funds have not yet been identified.

1. Water and Sewer Lines

The sewer and water lines have also been in place for over thirty years. To date, we have not sustained any major failures. However, we intend to take a proactive approach in dealing with these lines rather than wait for a major failure. This is particularly important with the water lines since KPNO relies entirely on captured water for its domestic and fire protection use. Starting in FY 1996, these lines will be inspected and replaced as needed. At the same time, we will also use this opportunity to inspect our sewer lines and implement the improvements to our septic systems, as recommended in a consultant's study completed in FY 1994.

2. Dormitory 1 Upgrades

Dormitory 1, our primary nighttime sleeping facility, was constructed in 1960. With the exception of a five-room addition in the early 70s, this structure has not been upgraded since. We intend to do modest improvements to the entire dormitory, in particular the heating system, during the summer months. At the same time, we will retrofit one of the rooms so it is in compliance with the latest ADA rules for the handicapped.

3. Building Repairs

With over 130,000 s.f. of building space on Kitt Peak, it is necessary to have an on-going program of general building repairs. We will continue a program of repairing, painting and roofing all facilities on a five-to-seven year rotational basis.
4. Water Catchment Repairs
The two water catchment basins, which serve as the heart of our water harvesting capability, had their largest cracks repaired several years ago but are still in need of further sealing. In dry years, the loss of water, prior to processing, is a problem.

5. Energy Management Improvements
During FY 1994, the KPNO electric bill increased roughly 18%, due to rate hikes passed by the utility. The cost of our electric service went from one of the lowest in the state to one of the highest. Additional increases are expected in the future. The only way we can control and reduce our electric consumption is to implement an energy management program. As part of this new program, our intent is to not only reduce our electric costs, but to reduce our maintenance effort through the replacement of aged equipment. The 4-m telescope is the largest single user of power on Kitt Peak and we will concentrate our effort there in FY 1996. Items targeted for replacement include all fluorescent light fixtures, the rotary uninterruptable power source (RUPS), our main building refrigeration unit, and several air compressors. All this equipment has a payback time of approximately seven years or less.

Tucson-Kitt Peak Voice/Data Communications Upgrade
The voice/data communications link between Tucson and Kitt Peak will soon reach maximum capacity. Our remote observing program, scheduled to start in the fall 1995 semester, will significantly compound the problem. The present telephone rate structure makes it impossible to add additional leased bandwidth. To correct this problem, it was our intention to install our own microwave communications link between Tucson and Kitt Peak. However, in discussion with the telephone service provider, it was suggested that we defer the decision to implement the microwave equipment and review with them the possibility of utilizing fiber-optic cable instead. Of the two options, the fiber-optic method is vastly superior due to its low maintenance cost, long lifetime, and almost limitless bandwidth. We are now in the process of exploring this option. Preliminary cost figures indicate the fiber link may be competitive with the microwave link. As a fallback position, we will install the microwave equipment should it be necessary. In both cases, our goal is to upgrade significantly our communications, including the integration of the Tucson/Kitt Peak telephone switches, and do so with a payback period of five years or less. At the same time we are upgrading our telecommunications hardware/software, it is our intent to correct problems with buried-wire telephone lines. These wires have been in place for over thirty years and have exceeded their expected lifetime. The demand for new telephone extensions by tenants, coupled with line failures and the installation of the mountain-wide fire alarm system, has severely taxed some legs of the cable plant. As a result, in some areas of the mountain we are operating without any spare line capability.

CTIO
The highest priority of the Bahcall committee for ground-based research was to strengthen the research infrastructure at universities and at the national observatories. Specifically, the committee recommended that the National Science Foundation “increase the operations and maintenance budgets of the national observatories to an adequate and stable fraction of their capital cost, thereby repairing the damage caused by a decade of deferred maintenance.”

Unfortunately, this recommendation has not been implemented, and deferred maintenance remains a critical issue at CTIO. The CTIO plan for infrastructure improvements follows.
Summary

1. Fire prevention system - 4-m telescope 40,000*
2. Vehicle fleet renovation 90,000
3. Water system, Tololo (pipeline) 25,000
4. Telescope 4-m repainting 20,000
5. Power House 25,000
6. Main access road to Tololo 300,000
7. Water system, La Serena (filter) 10,000
8. Standby power, La Serena 55,000

Total funds required $565,000
FY 1996 funds available $28,000

*Preliminary estimate

1. Fire prevention system for 4-m telescope
A freak fire occured in the 4-m building earlier in 1995, which, if not detected in time, could have produced serious damage to the facility. It occured in an area out of sight of normal operations personnel yet not covered by fire detection devices. Our top infrastructure priority in FY 1996 is to improve significantly the level of fire protection at the 4-m. A preliminary cost estimate to cover just a few key areas is $40,000. This level of cost will require us to spread installation costs over two financial years unless new funds are made available. In FY 1996, it is expected that about $25-28K will be spent on this system.

2. Fleet renovation
Funds for fleet renovation have typically been cut every time a fiscal crisis arises; this financially inefficient policy merely adds to maintenance costs in subsequent years. During FY 1995, in spite of the difficulties with the budget, a start has been made towards replacing the oldest vehicles in the fleet. We are replacing the aging, larger passenger carryalls with smaller, more fuel-efficient models.

A light truck is necessary for our Santiago Operations. At present we depend heavily on outsourcing local transport services in Santiago. We estimate that the costs of the truck to be purchased as our top maintenance priority in FY 1996 will be recovered in approximately four years, including operations and maintenance. Moving cargo (one small truckload) from the airport to the CTIO office in Santiago, for example, is expensive when using outside resources. At present we have a minimum of two weekly air cargo receiving operations, apart from the usual pick-up of supplies and materials from vendors, commissary orders, construction material, and incidental hauls of ocean cargo from Valparaiso.

3. Tololo water system
The San Carlos water line—CTIO's only water supply—has been in continuous operation for over 20 years and is nearing the end of its normally-expected 25-year useful life. We must plan a gradual early replacement of those sections of pipe that are worn by use or by pitting due to the problems caused by iron-eating bacteria (innocuous to human health) that badly affected the line during the first few years of use. This problem has been dealt with so far by plugging the pipe or removing small stretches where soldering would not be possible because of the extent of the damage.

We have purchased pipe tubing and estimate that $25 K for manpower will be required to complete this replacement work.

4. 4-m telescope repainting
We must repaint the dome and building every five years. Delaying this kind of maintenance activity only leads to higher costs later.
5. Cerro Tololo power house
During the past 4 years, CTIO has been carrying out a plan to upgrade the Tololo Power House. The next phase of work involves replacement of obsolete switching and control gear that has been in use for well over 25 years.

6. Cerro Tololo road improvement
The greatest safety hazard in our entire operation continues to be the possibility of accidents on the access road to Tololo. We have again this year had near misses; in one case a car driven by a tourist with five family members rolled over on a narrow stretch of the road and stopped just short of falling down into a deep gulch. Miraculously, no one was badly hurt.

In recent years we have installed 483 linear meters of guard rails in sectors of the greatest potential danger. In order to continue offering greater protection to people using the road, we have estimated that a further 10,200 m of guard rail are needed, at a cost of US $27.50/linear meter ($44,155 per mile, total $300 K).

CTIO remains committed to steady improvement in overall operational safety through careful application of available funds to areas of greatest hazard.

7. La Serena water system
$10 K are necessary to purchase and install a new filtering system for the Compound well. We have detected impurities in excess of the 250 particles/cc guidelines set by the Chilean national health authorities.

8. Stand-by power generator for La Serena headquarters
The present power consumption requirements for our operations in La Serena are in the range of 120 KW, greatly exceeding the maximum capacity of our present 50 KW unit.

IV. SOLAR

A. Major Projects

1. Global Oscillation Network Group (GONG)
The Global Oscillation Network Group (GONG) is an international project created to conduct a detailed study of the internal structure and dynamics of the closest star by measuring resonating waves that penetrate throughout the solar interior. To overcome the limitations of current observations imposed by the day-night cycle at a single observatory, GONG has developed a six-station network of extremely sensitive and stable solar velocity mappers located around the Earth to obtain nearly continuous observations of the “five-minute” pressure oscillations. To accomplish its objectives, GONG has also established a distributed data reduction and analysis system to facilitate the coordinated analysis of these data. The primary analysis is being carried out by six scientific teams, each focusing on a few specific categories of problems. Membership in these teams is open to all qualified researchers.

The production of the stations has been completed, their deployment is underway, and the last station should be installed in September 1995. While some additional development remains to be done, the instruments are performing well. The data reduction pipeline and data distribution systems are routinely processing and distributing prototype data to the project staff and community users. All of the required functions are available, and the system is capable of performing at cadence.

The program is entering its observing phase, and operation of the network and the servicing of the field systems will be a major challenge. There are a number of important, though relatively minor, additional functions of the field systems that were set aside in order to expedite the initial deployments. These fall mainly in the area of increasing the degree of instrument automation in order to decrease the support load and enhance reliability.
Instrument software development will continue to improve the control systems and provide additional self-diagnostic capabilities. Similarly, engineering data-analysis software will be developed to facilitate the review and analysis of the functioning of the remote instruments, including fault diagnosis and long-term trend analysis. The site survey will continue for one more year to enable a full year of overlap between the decadal archive and the (different) insolation detectors used in the field stations.

The instrument group will conduct a study to determine the feasibility of upgrading the current nominal 256 x 256 detector to a 1024 x 1024 format. Such an enhancement should be possible without changing the existing optical and telescope control systems. It would provide significantly enhanced helioseismic resolution in the near-surface regions that are the home of the intense magnetic fields that seem to cause much of the more dramatic aspects of solar activity, extend all aspects of "local helioseismology" dramatically, as well as enabling many non-helioseismic, diachronic solar measurements. Similarly, a study will be done to establish the impact of sustaining the network in operation for an 11-year period.

The data management group will reduce data at cadence and distribute it to the community. Refinement of the processing software will continue, as will support of community access to the data. The group will study the data processing impact of the proposed detector upgrade as a part of the engineering study.

The science teams will be supported in a series of workshops to stimulate and facilitate rapid review and analysis of network data. This effort is primarily to accentuate and coordinate the science, but it also will promote rapid feedback from the community about the character of the data itself, which will be helpful in shaping service, processing, and development strategies. The project will organize and coordinate "First Data" presentations, symposia, and publications with the science teams.

Recent accomplishments include:

- Completion of field instrument production
- Preparation of the sites to receive the stations
- Deployment of the Spanish and Australian sites
- Demonstration of successful data merging from remote sites
- Commissioning of the Data Storage and Distribution System

Specific FY 1996 tasks will include the following:

- Operate the network and coordinate activities with the host sites
- Develop software to facilitate engineering analysis of remote instrument functions
- Continue routine operation of the prototype instrument
- Continue operating site-survey instruments at the sites for one more year
- Commence routine preventative and emergency service of the field stations
- Continue development work on certain deferred functions of the current system
- Do a feasibility study regarding upgrading the detectors to 1024 x 1024
- Reduce network data and deliver it to the community
- Continue the development of data reduction and distribution software
- Facilitate science team research efforts
- Coordinate “First Results” publications and presentations
- Examine the scientific efficacy of an extended observing run

GONG Long-Range Milestones:

- **May 1995**: Begin three-site network operations
- **September 1995**: Begin six-site network operations
- **July 1996**: Complete extended run and detector upgrade study
- **September 1996**: Extend or Cease network operations
- **September 1999**: Extend or Complete initial data reduction

The anticipated long-term funding requirements in inflated dollars (3% model) for extended operations of an upgraded GONG network are as follows:

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Note, however, that the current program plan provides funds only for operation of the existing GONG network.

**Budget**

The GONG project will complete the deployment of the network field stations in September 1995. The shift to full-scale operations and data reductions/distribution has already begun, and it will be the dominant activity by then.

Sustaining a quick-response, expert maintenance capability is essential to the mission of the project to provide essentially uninterrupted data. As with any new system, it is anticipated that during the first, commissioning year of operation, there will be a somewhat higher risk of anomalies, perhaps requiring a higher measure of technical support than in the years immediately following. Consequently, during this first year of full network operations, the operations instrument technical staff will be maintained at a higher level than may be necessary later. When not otherwise engaged, this group will be completing a number of tasks relating primarily to broadening the degree of automation with a view to improving reliability and reducing long-term support costs.

With the advice and consent of the GONG Scientific Advisory Committee, the project would like to study the feasibility of extending the observing run from three years to an 11-year solar cycle. The project also wishes to examine the feasibility of upgrading the detectors on some or all of the instruments to 1024 x 1024 on a timescale of three years, to catch the rising slope to the next solar maximum. In both cases, it is desirable to ascertain the feasibility, cost, and scientific merit before FY 1997. In addition to first-year technical support of the field instruments, this will require sustaining the instrument staff near its current level and making some modest non-payroll outlays, at least for FY 1996, until the two matters are resolved. This level of activity cannot, however, be funded within the budget projected for NOAO.

From a scientific point of view, it appears likely that both of these supplements to the baseline project plan can produce very significant payoffs in our knowledge of the Sun, and at a relatively small cost compared to the overall investment in the program. If funding is not available to pursue these studies, it will become increasingly difficult, and certainly much more expensive, to add either of them back in later years. If the
funding is inadequate to assure prompt servicing of the network and good turnaround on data reduction and distribution, the integrity of the baseline program will be jeopardized as well.

2. The RISE/PSPT Program at NOAO

The origin of the solar cycle has been a key astrophysical problem for many years. It received wider recognition with the recent suggestion that solar-cycle changes in luminosity may have a measurable influence on terrestrial conditions. A growing expectation that rapid progress can be made against this problem is fueled by: 1) sensitive space observations of total solar irradiance changes, 2) new helioseismic inferences of subphotospheric solar properties, and 3) high dynamic range numerical simulations that allow the “multi-scale” complexity of the cycle problem to be explored. While this is good news, the bad news is that spatially resolved (full-disk) solar observations with the differential (spatial) photometric accuracy of the space-based photometry do not exist. Such data are needed, both as an outer boundary condition for interpreting helioseismic changes and to interpret the measurable solar luminosity changes in the context of physical models for the variability mechanism.

The Precision Solar Photometric Telescope project will develop and operate a small network of specialized instruments for obtaining high-spatial resolution and high photometric accuracy solar surface photometry. These data will be obtained with a nearly continuous temporal resolution of about one hour and with spatial resolution only limited by the 15-cm telescope aperture. Based on the GONG site survey data, the PSPT network can expect to achieve occasional uninterrupted observing periods of half a solar rotation period (13 days) using a three-site network.

To realize diffraction-limited resolution, the instrument uses a fast tilt mirror atmospheric correction system in combination with digital frame selection hardware. The optical design of the instrument minimizes the optical complexity and scattered light in the image plane. The 2K × 2K CCD camera electronics are being developed by a commercial vendor to provide an 8 Mpix/s readout with approximately 30 electrons read noise. We will be using a CCD manufactured by Thomson, Inc. The coated, deep well, detector will be used at four wavelengths between Ca II K at 393 nm and approximately 700 nm.

This project is tightly constrained by its budget and by pressure to deploy the instruments as soon as possible. Two key personnel are supported by the NSF grant while the project scientist is supported by the NSO. Our development philosophy has been to depend on commercial vendors to a high degree and to cultivate partnerships with other astronomical institutions with similar scientific interest. Since these instruments will produce data with a broad range of applications, the PSPT project has several potential scientific and fiscal collaborations. To date, we have initiated a partnership with two other institutions (an Italian group and the High Altitude Observatory). The Spanish astronomers at the IAC have also expressed an interest in a partnership to operate a PSPT at Tenerife.

Several PSPT milestones have been achieved during the last year:

- The optical components have been designed, ordered, and received. The objective has been tested in breadboard experiments.

- The 1K × 1K prototype camera has been interfaced to a PC and DSP control system. It has been extensively tested and used for several experiments.

- Fast co-ad experiments with the prototype camera have demonstrated the utility of using scintillation to do frame selection (papers in press and submitted).

- Two piezo (a bimorph and stack) and a magnetostrictive (MS) fast mirror have been tested. The magnetostrictive system has been selected, ordered and received.

- The electronic design for the MS mirror has been completed and PC prototype boards are being designed.
• The scintillation monitor circuit has been designed and PC boards have been ordered and received. A GONG site survey tracker will be used with the new data acquisition system for scintillation measurements at several GONG sites.

• The equatorial mount has been designed. A prototype mount has been extensively tested.

• The mechanical shutter has been tested and selected.

• Barr, Inc., Ca K filters have been selected and tested.

• Solid body models of the telescope mechanical structure have been completed. The overall mechanical housing drawings are completed.

• Software for operating the PC/DSP was ported to C, while reliability improvements were made.

• The data acquisition system has been designed.

• The prototype housing and dome has been constructed at NSO/SP.

• A research associate was hired to start 1 January 1995. Total paid project personnel now number two.

• The prototype CCD camera has been tested (its design serves as the basis for the new Kiepenheuer Institute CCD camera).

• A contract for the 2K x 2K CCD camera system has been initiated with Xedar Corporation. To minimize expense, NSO will allow Xedar to use our camera software in exchange for financial consideration toward future camera sales.

• An MOU between Observatorio Astronomico di Roma (astronomers Fofi and Caccin are principals) is being signed. This agreement stipulates that the OAR will pay for the hardware cost of the first instrument, which will go to Italy.

• A letter from the IAC (Roca Cortes and Vazquez) was received expressing interest in the RISE experiment and encouraging deployment at Izana.

• Informal discussion with the High Altitude Observatory has indicated that a mutually beneficial arrangement for a PSPT instrument at Mauna Loa should be possible.

Plans for the next year:

Our budget for the next fiscal year is estimated at $430K. Current payroll is $11K per month ($132K/year). Non-payroll costs are dependent on additional funding, but estimates based on deployment of 2 PSPTs this year run to $306K. The cost per instrument breaks down as follows:

36
Instrument control $14,000
2K x 2K CCD camera 58,000
CCD and data control 25,000
Mechanical housing and mount 9,000
Optics and coatings 6,000
Filters 12,000
Miscellaneous 4,000
Data storage and networking 10,000
Site preparation (estimate) 15,000

PSPT1 total $153,000

The site preparation cost is difficult to estimate at this time and expenses may vary because of this. We tentatively expect to place instruments at Mauna Loa, Tenerife, and Learmonth. The working prototype, which is being funded by the OAR, will also have site expenses paid by the OAR and has a budget at NSO of $125,000.

Several milestones will be met during the next year:

- Test data from the prototype instrument will be available during May 1995
- The 2K x 2K camera will be received and tested by July 1995.
- The first complete instrument package will be completed for the Italian PSPT by September 1995.

B. Instrumentation

I. General

<table>
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<th>NSO/Sacramento Peak FY 1996 Projects</th>
<th>Priority</th>
<th>Payroll ($K)</th>
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<td>Adaptive Optics</td>
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<td>Correlation Tracker</td>
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<td>CCD Camera</td>
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NSO/Tucson FY 1996 Projects

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<td>Helium 1083 nm Video Filtergraph</td>
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<td>KPVT TCS Upgrade</td>
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<td>Spectromagnetograph Interface</td>
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<tr>
<td>FTS A/D Upgrade</td>
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<td>Total</td>
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Subject to the acceptance of the related proposal by NSF, NSO will undertake in FY 1996 and in the beginning of FY 1997 a feasibility study of the Coronagraph and Low Emissivity Astronomical Reflector (CLEAR) concept. This low-scattered-light telescope is currently planned to be used for both solar and nighttime studies requiring low scattered light and emissivity at all wavelengths and full wavelength coverage from 0.3 to 35 μm. This study will involve both an engineering effort under the direction of Larry Barr (formerly at NOAO) with the participation of the University of Washington, Telescope Engineering Group, and a science team chaired by J. Kuhn to refine in parallel with the engineering study the science objectives and requirements of the telescope. J. Beckers will be the Principal Investigator for this study.

2. Sacramento Peak

Adaptive Optics

Solar astronomers regard sub-arcsecond observations of solar phenomena as a cornerstone of the effort to understand fundamental physical processes on the Sun. The interaction of surface convection with magnetic fields, the buildup and release of flare energy, and the emergence and decay of sunspots are but a few examples of phenomena that must occur on a small scale (≤ 150 km). Videos recorded in July 1991, using the Lockheed (LPARL) 19-segment mirror, demonstrated that solar adaptive optics works, at least with a sunspot as a target. Since that success, this Adaptive Optics system has been returned to Lockheed where it has been used for other investigations unrelated to the Sun. Recently, S. Acton (LPARL) has upgraded the system and taken it to La Palma for about nine months. If he obtains the expected excellent results, this should provide a fresh impetus for funding for NSO's own system, which would become a permanent part of the Vacuum Tower Telescope, available to all investigators.

NSO’s approach, developed by R. Dunn, stresses four areas not currently available in the Lockheed system. The first is the development of a wavefront sensor that can derive the slope of the wavefront and hence a correction signal from images of the solar granulation that occurs all over the Sun, thus freeing the observing target from one that must include a sunspot in the field. The second improvement is in the digital wavefront reconstructor, which adapts the techniques used in DOD programs that reconstruct the wavefront from the slopes. This approach appears to be far more flexible than the analog system as used in the LPARL 19-segment mirror system. This type of reconstructor supports the third objective of the NSO approach, a 61-actuator adaptive mirror that has a continuous faceplate, which enables wavefront reconstruction unbroken by the sharp edges and corners of a segmented mirror. Finally the Adaptive Optics system must be integrated with the focal plane instrumentation of the VTT, which includes three spectrographs, a Universal Birefringent Filter and a Fabry-Perot filter system, a Correlation Tracker, and field monitoring and scanning hardware.

All the adaptive optics hardware components are now in hand, including the liquid crystal wavefront sensing items, the adaptive mirror face plate and its Queensgate actuators, the wavefront reconstructor processors and the opto-mechanical system that will feed the VTT instruments. In the beginning of FY 1996, Dunn expects to have corrected a pre-load loss problem, which developed in the actuators, and to have finished the final assembly and programming of the digital reconstructor. The remainder of FY 1996 will be spent in the
commissioning of the liquid crystal wavefront sensor. Integration and test of the full adaptive optics system is expected in FY 1997.

The adaptive optics program was initially supported by a combination of NSF and Air Force (Phillips Laboratory) funding. Due to budget cuts, the Air Force has not been able to contribute directly to the project for the last few years. At the present time only a small staff is available for this project: three NSO FTEs including the PI (R. Dunn). The program has purchased all the major hardware components required to complete a prototype in three years. A non-payroll budget of $15K/year from NSO instrumentation funds will be used for part-time shop personnel and to purchase miscellaneous hardware.

In April 1995, T. Rimmele joined the NSO/SP staff to work on the adaptive optics project. He will emphasize collaboration with university departments and government laboratories that are developing adaptive optics systems. He will concentrate on the development and implementation of wavefront sensing techniques, a key component of the solar adaptive optics system currently being developed by NSO.

As already mentioned, this system will incorporate a wavefront sensor, based on liquid crystal display technology, that will be largely insensitive to slowly varying aberrations, such as those in the optical system at the VTT. A slow, low-order wavefront corrector, based on a Shack-Hartmann wavefront sensor, will be implemented at the VTT/SP in order to correct these optical aberrations, which are mainly introduced by the entrance window (“Active Optics”). Wavefront data taken at the tower show that the Strehl ratio can be increased by a factor of 4-5. As a first step, the new correlation tracker hardware will be used to implement such a low order correction.

In addition, wavefront sensing techniques have applications well beyond adaptive optics systems. For example, the knowledge of the instantaneous wavefront allows for reconstruction of images and narrowband filtergrams using methods similar to Speckle Polarimetry, which recently has been successfully demonstrated to be capable of resolving individual flux tubes.

Milestones:

**FY 1995**  Install thermal control of entrance window and monitor its performance. Bench tests in order to compare performance of Hartmann-Schack wavefront sensor and LCD wavefront sensor.

**FY 1996**  Finish design of low order corrector. Implement and test system.

Solar Image Tracker (Mark II Correlation Tracker)

About two years ago, the NSO copy of the correlation tracker that was developed jointly during the 1980s with the Kiepenheuer Institut für Sonnenphysik (KIS) in Freiburg, Germany, quit working because of a hardware failure. This correlation tracker was based on custom-built hardware components that are obsolete and irreplaceable. A second copy had been built for KIS for use at the German VTT at the Canary Islands. Since KIS is currently completing a Mark II correlation tracker in collaboration with the Instituto de Astrofisica de Canarias, KIS has loaned its copy of the original tracker to the NSO on a temporary basis. This unit is frequently used at the VTT/SP, effectively without spares or backup. This high risk situation has also led to efforts at NSO/SP to develop its own Mark II tracker.

Rimmele made a study to compare different tracking algorithms. In particular, he compared the performance of the “absolute difference algorithm” and the “FFT cross correlation algorithm” via computer simulation using data taken at the VTT/SP under different and varying seeing conditions. The simulations clearly show a performance advantage for the FFT cross correlation algorithm in conditions where the image contrast is low. The ability to track low-contrast images is important to a user-friendly system. It also bears on possible use of a tracker in a Shack-Hartmann wavefront sensor. Based on the results of the simulation studies, it was decided to design and build a Mark II correlation tracker system by implementing the FFT cross correlation algorithm. The initial design has been completed and is based purely on commercially available hardware components. Therefore the system should be easily maintainable and can be cloned for use at other NSO sites.
Milestones:

FY 1995  System design and purchase of all components (completed). Write low level software, hardware-drivers etc., perform bench tests of basic functions. Engineering run at VTT (expect to be completed by the end of FY 1995).

FY 1996  Complete user interface and commission the finished system (early FY 1996).

**CCD Camera**

This is part of an ongoing effort by the Observatory to continue to provide state-of-the-art detectors for use by the community. Initially, NSO and KIS will develop a fast data acquisition system utilizing a Thomson 1024 × 1024 chip for use at Sac Peak and KIS. Rimmele is the principal investigator in this project; Stauffer is the engineer. Many existing instruments that are only film-based will need to have CCD capabilities added. New instruments using CCD technology will be integrated into the existing system architecture. The general advance of this technology also requires that we look continuously at new detector designs and implement them when appropriate. In particular, we need to provide users with larger array formats (2048) or mosaics of chips.

Milestones:

FY 1996  Completion of first two NSO/KIS 1024 × 1024, 6 frames/second CCD data systems. One of these will stay at NSO/SP.

FY 1997  Completion of second NSO/KIS camera.

3. **Kitt Peak**

**Near Infrared Magnetograph, NIM-2**

The major goal of the infrared program during FY 1996 will be the fabrication and initial testing of NIM-2, an imaging vector magnetograph based on a piezoelectrically-tuned, servo-stabilized Fabry-Perot etalon from Queensgate Instruments.

The existing Near Infrared Magnetograph (NIM) is a unique instrument developed to map the true magnetic field strength in the deep solar photosphere using the McMath-Pierce Telescope, the 13.7-m vertical spectrograph, and a 256 × 256 InSb array camera from Amber Engineering. Two Zeeman-sensitive Fe I lines near 1565 μm are observed. Initially using the same infrared camera and data system, NIM-2 will complement rather than replace NIM: the existing instrument will excel in spectral resolution and, therefore, magnetic discrimination, while NIM-2 will have better time resolution and geometric stability (because the field of view is imaged simultaneously rather than built up by scanning). A longer-term goal is to replace the Amber system with a camera based on an array from the NOAO/USAF Aladdin collaboration. The NIM-2 project is partially supported by a grant from NASA.

NIM-2 was delayed during FY 1995 by technical considerations that emerged from the preliminary design review and consultation with other users of the Queensgate etalons, leading to a revised optical design.
Milestones:

FY 1996  Begin fabrication; first light for engineering tests.

FY 1997  Complete fabrication and software; commission Amber-based system.

FY 1998  Migrate to Aladdin-based camera.

**Helium 10830 Å Video Filtergraph**

The He I line at 10830 Å is an important diagnostic of the upper solar chromosphere and an effective proxy for coronal holes, low-density regions of the corona often associated with high-speed solar wind streams. Full-disk spectroheliograms in this line have been acquired daily for many years at the KPVT. Although heavily used, the spectroheliograms are not ideal for studying short-term solar activity because they are built up by scanning the image and are taken slowly. The He 10830 Video Filtergraph, a rapid-cadence imager with an active-region field of view, will address this scientific need for the next solar maximum. Mechanical fabrication of the filter is complete.

Milestones:

FY 1996  Bring to full operational status and use to support observations from the SoHO (Solar and Heliospheric Observatory) spacecraft.

**Kitt Peak Vacuum Telescope Control Upgrade**

This project, first proposed in 1990, will upgrade the 20-year-old control and guiding systems of the KPVT. Maintenance of these systems is becoming difficult; many of the spare components are no longer available. The guider no longer functions properly in some operational modes and performs poorly through light clouds.

A design study for the control upgrade has been completed. The existing limb guiders will be replaced with a CCD camera; the limb-guider translation stage will be replaced. Control of the Littrow spectrograph grating, shutters, lens focus, as well as the telescope control console and handpaddles, will be handled by a layer of distributed processors coordinated by a Sun workstation, which will also host the user interface.

Another aspect of the KPVT upgrade is image-motion and polarization compensation. A recent comparative study of solar magnetographs has shown clearly that image jitter at the KPVT (from mechanical vibration as well as seeing) both degrades individual observations and introduces uncertainty into the overall calibration of the magnetograph. The concept for the image motion compensator is to servo the #4 folding mirror with the high-frequency error signal from the output of a 2-d CCD guider. The polarization compensator is envisioned as a low-frequency device using a stack of liquid crystal plates to zero the polarization in a reference beam sent in reverse through the telescope. The motion and polarization compensation phase of the KPVT upgrade is partially supported by NASA and is one aspect of the wider Image Quality Improvement project described below.

Milestones:

FY 1996  Complete the fabrication and installation of the upgraded mechanical drive assemblies on the #1 mirror. Complete the fabrication and installation of the mechanical components of the image-motion compensation phase of the project. Complete the design and fabrication of the image-motion compensation electronics. Complete the design of the guider control electronics and software.

FY 1997  Complete the installation and testing of the image-motion compensation electronics. Complete the installation and testing of the guider control electronics and software.
Image Quality Improvement at the McMath-Pierce Telescope Complex

This project seeks, first, to measure the seeing external to the telescopes and to identify the amount and sources of internal image degradation. This "seeing budget" will form the basis for improving the quality of the images, with a particular view toward optimizing the McMath-Pierce for infrared observations.

The site seeing will be measured with a scintillation monitor (Seykora meter) atop the McMath-Pierce, where the wind will also be recorded. The internal seeing will be mapped with an array of microthermal sensors and a Seykora meter in the telescope tunnel. Temperature sensors located on the heliostat and image-forming mirrors will monitor the effects of mirror seeing. An image-motion sensor (Brandt meter) will measure the final image quality.

Another aspect of the image quality improvement will be to incorporate a fast guider, a copy of the Mark II Correlation Tracker currently under development at NSO/SP.

The hardware for this project, including the data-logging system, has been procured and tested. Installation of the sensors is nearly complete. Two Seykora meters and the Brandt meter have been tested and cross-calibrated. The figure qualities of the main heliostat and concave mirror have been measured; problems with the mechanical support of the heliostat have been isolated.

Milestones:


FY 1997 Implement highest-priority improvements dictated by seeing budget. Incorporate NSO Mark II Correlation Tracker.

C. Telescope Operations and User Support

Sacramento Peak

Tests of the aberrations of the entrance window of the Vacuum Tower Telescope (VTT) have shown that their variations are due primarily to insufficient cooling of the window. The problem will be addressed in FY 1996.

The slip rings of the VTT are worn and have caused interruptions of observations. They will be replaced in FY 1996.

An improved version of a correlation tracker is being built for the VTT. This device will allow highly precise tracking of a small field of view by locking on to images of solar granulation.

A CCD data acquisition system, employing 1024 × 1024 CCDs, is being developed in collaboration with the Kiepenheuer Institute. Once a prototype is built it can be replicated for use at NSO.

Because of the reduction in observing staff at the Evans Facility, NSO scientists will be required to carry out their observing proposals without operator support. Visitors will receive observing support only during weekdays in FY 1996. The observers at the VTT and Evans facility have been merged into a single pool to better serve users of both sites. As an exception to the 5-day operation, synoptic coronal scans will be taken daily.
**Kitt Peak**

An especially critical, long-term operation and maintenance issue facing NOAO/NSO/Kitt Peak is the aging Telescope Control Systems (TCS) at the McMath-Pierce and Vacuum Telescopes on Kitt Peak. The current 20-year-old control systems are increasingly difficult to maintain, resulting in increased downtime. The replacement of these systems with modern, lower maintenance hardware and software is a high priority. It is anticipated that the design phase for the Kitt Peak Vacuum Telescope TCS upgrade will be finalized in FY 1995, and that implementation of the three phases of the upgrade could be completed in FY 1996-97. It is hoped that the TCS at the McMath-Pierce can be upgraded beginning in FY 1996, but adequate funding is not currently available.

**D. Facilities Maintenance**

**NSO/Sacramento Peak**

During FY 1994 and FY 1995, we began the replacement of furnaces in the relocatables, completed the final phase of the fire alarm installation, replaced a Bridgeport mill in the shops and updated the sewage plant permit.

Much of our effort in FY 1995 has gone towards renovating the Cloudcroft Telescope Facility and installing the NASA 3-meter Liquid Mirror Telescope (LMT). This facility, which NSO acquired about 12 years ago from the USAF, was in extremely poor condition. NASA has provided funding for the complete renovation of the facility including dome painting, roof replacement, heating system restoration, interior repairs, and many other items required to bring the facility up to date. The LMT will be operational in FY 1995.

Available funding will limit the maintenance activities that will be undertaken in FY 1996. Many of these items have been carried forward from previous years. Items which are in need of attention are power line replacement, painting of all housing, re-roofing of relocatables, underground storage tank upgrades, completion of pavement replacement, water/gas pipeline replacement, and Americans with Disabilities Act (ADA) upgrades.

During FY 1995, additional funding was acquired for the Sunspot Education Center. We received an additional grant from the Federal Highway Administration’s Intermodal Surface Transportation Enhancement Act for $495,818. Our total budget for the project is now $1,521,000. Delays in the project brought about by the need for additional NEPA biological assessments have pushed the schedule back by about one year. This time has been used to raise more money and further the planning. Final design should be complete by May 1995 with construction beginning upon approval of the NEPA decision. Completion is expected in FY 1996.

**V. EDUCATION/OUTREACH**

**Research Experience for Undergraduates**

The Research Experiences for Undergraduates Program (REU) was established by the National Science Foundation (NSF) to attract students to careers in science and engineering by providing opportunities for undergraduates to participate in scientific research experiences. NOAO plans to provide funding for eleven summer research assistant positions assigned to Kitt Peak National Observatory (KPNO) and the National Solar Observatory (NSO), along with four undergraduate research assistant positions assigned to Cerro Tololo Inter-American Observatory (CTIO), from awards by the NSF for the 1996 NOAO REU Site programs. Program awards will cover salary and transportation expenses for the students.

The 1996 NOAO REU students will carry out collaborative research projects with scientists at NOAO research facilities on topics ranging from the nature and origin of solar and stellar activity to galaxies and cosmology. Students will be recruited for the program through the distribution of posters and applications to a broad spectrum of colleges and universities. Announcements will be sent to over 700 astronomy, physics, engineering, mathematics, and natural science departments throughout the United States and Puerto
Rico. In an effort to attract students from underrepresented areas, primarily women and minorities, NOAO will utilize specific mailing lists, including the Historically Black College List generated by the NSF and a list of American Indian Science and Engineering Society affiliates. Applications for REU positions will follow a review process beginning with a graded assessment of all candidates by a designated staff member based on quality of references, application content, and relevancy to NOAO projects. The evaluation will then be distributed to REU project advisors for individual selection of candidates. Staff members will be encouraged to consider strongly the background of each student in conjunction with their overall application grade and specific interest and aptitude for a project area. Staff members wishing to participate in the NOAO REU program submit proposals to division program coordinators. Selection is based on the scientific merit of the proposals and on their effectiveness in providing a wide range of research experiences for the participating students.

In Tucson, at the facilities of Kitt Peak National Observatory, REU students will be involved in a broad range of research topics including stars and stellar systems, galaxies, and cosmologies. At the National Solar Observatory in Tucson, REU students will participate in a complementary program of the study of dynamo processes as they occur in the solar interior and solar-type stars. REU students at the National Solar Observatory on Sacramento Peak will join in an integrated research effort designed to develop models of the processes that lead to the build-up and release of energy in solar active regions. REU students at Cerro Tololo Inter-American Observatory in La Serena, Chile, will participate in independent research activities that are characteristic of the NOAO REU programs at KPNO and NSO, but with additional emphasis on observational techniques and direct observational experience.

NOAO tries to select REU projects where significant progress can be made during the summer and from which a publication is likely to result. A small sample of REU project proposals by NOAO scientific staff follows:

- Analysis and modeling of an accretion disk in NGC 6251.
- Reduction and analysis of data acquired in the CTIO Supernovae survey.
- Crowded-field photometry on CCD images of the Galactic globular cluster NGC 7089 (M2).
- Determination of the mean metallicity and detailed abundance distributions in evolved stars in open clusters used as tracers of the chemical composition of the Galactic disk.
- Comparative analysis of correlation tracing algorithms under various seeing conditions.
- Photometric observations of the Sun in Calcium-K.

The REU students have an unparalleled opportunity to participate in original research with the NOAO scientific staff along with access to state-of-the-art instrumentation and extensive library collections for astrophysical research. Students and staff participate together in weekly scientific meetings and scheduled lectures, tours of various observatory sites and facilities, and weekend social events. Student Research Presentation sessions are held at each site to allow students the opportunity to give brief talks to NOAO scientific staff members on topics related to their research projects. To encourage students to present papers and posters based on their REU experience at scientific meetings and conferences, NOAO will retain a portion of the REU awards for travel assistance to such events after the close of the program.

While the NOAO REU students may work principally on one research project in close collaboration with a scientific staff member, the total program of lectures, observatory visits, and mutual interactions among the students and staff within the professional and social environment provided by NOAO will, in fact, serve to expose the REU student to not just one topic, but to many facets of modern astronomical research.
**K-12 Educational Outreach**

Effective in mid-March of 1995, a half-time position of Education Officer was established, to develop and obtain funding for a K-12 Educational Outreach program for NOAO. Our overall educational outreach plan includes direct classroom involvement, support of educational technology, and, if funding permits, a series of summer workshops for teachers which include observing time on Kitt Peak.

Our current direct classroom involvement is funded by a NASA IDEA Grant, awarded for a proposal titled "Active Learning Exercises in Planetary and Solar Astronomy for K-3 students." Working with elementary teachers since spring of 1995, we have planned, developed, and presented lessons to students involving basic concepts in planetary and solar astronomy. Four planetary astronomers have participated in classrooms this spring, and four solar astronomers will continue the project in FY 1996.

In FY 1996, the extensive computer facilities of NOAO will be increasingly used as an electronic home base for the astronomy and science education community. Through the World Wide Web of the Internet, we will disseminate information and science education materials. We will begin in May of 1995 to work with the North Carolina Museum of Life and Science to distribute their series of Survival Guides for Sharing Science for Children, funded in part by the NSF. The leadership role of NOAO in electronically disseminating science education materials will be discussed at the June 1995 Astronomy Education Symposium at the ASP meeting in College Park, MD.

**VI. TUCSON SUPPORT FACILITIES**

**Central Facilities and Operations (CFO)**

<table>
<thead>
<tr>
<th>Central Facilities Maintenance and Improvement Projects</th>
<th>Labor (man-months)</th>
<th>Non-Payroll ($K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Support of fiber optic or microwave communications</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>2. Energy management</td>
<td>8</td>
<td>60</td>
</tr>
<tr>
<td>3. Electro-magnetic field modifications</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4. ADA compliance modifications</td>
<td>Contract</td>
<td>3</td>
</tr>
<tr>
<td>5. CAS and computer room fire/security</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>6. Building power modifications</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>7. Re-coat main parking lot</td>
<td>Contract</td>
<td>5</td>
</tr>
<tr>
<td>8. Replace exterior doors</td>
<td>Contract</td>
<td>4</td>
</tr>
<tr>
<td>9. Replace shuttle vehicles</td>
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<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>119</td>
</tr>
</tbody>
</table>

Central Facilities Operations (CFO) is responsible for providing all of the basic facility support services required for the operation of the NOAO Tucson headquarters buildings. In addition, CFO provides limited architectural and civil engineering support to KPNO and NSO/Sac Peak.

There are a number of FY 1995 improvement projects underway that will carryover into FY 1996. The two key projects we will concentrate on are the KPNO telecommunications upgrade and the headquarters energy management program.
With regard to the telecommunications upgrade, CFO will assist KPNO in the negotiations and implementation of one of two options. Increased bandwidth between NOAO Tucson and KPNO will be accomplished through the purchase of a microwave system or the installation of fiber-optic cable.

The NOAO Tucson headquarters building HVAC is now under computer control, but some major work remains before the maximum savings can be achieved. There will continue to be small energy improvements made in future years, but the savings will be small in comparison to what has been accomplished. If we had not previously invested in an energy management program, our electric costs alone would currently be in the range of $300K/year. As a result of our energy program, for FY 1995 our electric costs will be roughly $240K. In FY 1996, we believe it is possible to reduce our costs to slightly under $200K, where they are expected to remain. We hope that additional, small energy improvements in the future will be able to cancel the effect of further rate increases.

In FY 1995, interference on a computer monitor was traced to a moderately high electromagnetic field emanating from an office floor. Further investigation revealed that similar levels prevailed in several other offices. The full extent of this problem remains to be determined. It is possible that corrective action may require the rerouting of portions of our electrical wiring. Current estimates are that this project will be completed in FY 1996.

Each year we attempt to make improvements to the NOAO Tucson headquarters building with regard to ADA compliance. In FY 1995, we are modifying two of the rest rooms in the main building. In FY 1996, it is our intent to improve handicapped access at the northwest entrance. The present entrance is not ADA compliant.

The Central Administrative Services (CAS) building is totally without fire or security monitoring, with the exception of our guard service. We purchased hardware in FY 1994-FY 1995 which will allow us to tie that building into the headquarters building alarm system. We will install this equipment in FY 1996. In addition, we will replace the antiquated alarm system in the headquarters computer room.

We will use the new energy management system for the programmed starting of heavy duty electrical equipment following power failures. This will allow us in FY 1996 to eliminate the old over/under voltage protection system, which periodically plunges NOAO Tucson into total darkness for excessive periods of time.

In addition to the carryover projects, in FY 1996 we intend to re-coat the main asphalt parking lot, replace several worn out exterior doors, replace several shuttle vehicles, repaint the exterior of the CAS building, review the status of aging plumbing, do general building maintenance, and provide as-needed support to KPNO and NSO/Sac Peak.

Central Administrative Services (CAS)
CAS provides accounting, procurement, human resource administration, and other business services to NOAO, Gemini, WIYN, and the AURA Corporate Office. In FY 1994, CAS initiated a process that will gradually but substantially reduce the cost of its operations over a five-year period. Key to this goal is replacement of administrative computers with modern, more efficient hardware along with the purchase of off-the-shelf software that contains easy-to-maintain accounting, procurement, human resources, and networking programs. Transition to the new software will begin FY 1995 and continue into FY 1996. Savings from the new systems will begin in FY 1997 and grow as additional processes come on line and staff members become proficient in their use. Changes in policies and practices should produce additional cost reductions. Total savings depends on a number of external factors, but a pre-inflation FY 2001 budget that is 25 percent below the CAS base FY 1995 budget is within reach.

VII. IRAF
IRAF is an Image Reduction and Analysis Facility that is developed and distributed by NOAO. Early FY 1995 usage is estimated at 3000 astronomers at over 1200 sites in 24 countries on 7 continents. A
significant increase in the number of users is expected toward the end of FY 1995 as a consequence of (1) the release of PC-based versions of IRAF, and (2) the introduction of easier-to-use graphical interfaces for complex reduction and analysis packages. Consequently, FY 1996 support loads can be expected to rise in order to accommodate new users.

IRAF is a highly portable software system for astronomical data acquisition, reduction, and analysis. It provides tools for general image processing, graphics, and visualization of small or large data sets, plus specialized data reduction capabilities for astronomical data including all NOAO instruments. Usage of IRAF grows as new applications become available, including those for the NASA astrophysics community (e.g. HST, AXAF, EUVE), and as the cost of computers drops. IRAF is one of NOAO's most scientifically productive "facilities," having a role in at least 7% of all astronomical papers.

During FY 1996, IRAF development will continue with major effort going toward:

- Opening IRAF to provide access to IRAF internal facilities through
  - alternative language interfaces (C, FORTRAN)
  - direct access to standard data formats (FITS, TIFF)
  - access to IRAF tasks from host level scripts
  - distributed applications, network access to IRAF

- Enhanced graphical user interfaces for science applications
  - SPECTOOL for highly interactive spectroscopic analysis
  - XGPHOT for highly interactive digital photometry
  - General image display and graphics, visualization

- New science applications/upgrades
  - Astrometry package
  - Support for CCD mosaics
  - Error vector support
  - Pixel mask support

- Data archive support
  - New database server
  - Network access to archival data
  - Web-based and custom GUI user interfaces

- Support for Gemini and NOAO observing
  - Quick look and observing tools
  - Data reduction from the Gemini instruments

In addition, support for users around the world will continue to occupy about 40% of the IRAF group's effort.
VIII. Central Computer Services (CCS)

NOAO - Tucson

The computer facilities in the Tucson office complex serve several general needs for NOAO-Tucson: data reduction and analysis for the scientific staff and visitors, general computing for all staff members, infrastructure for dedicated computers and for PCs and workstations on staff members' desks, administrative computing, and IRAF development and support. Our distributed computing strategy for Tucson implements a combination of central, shared facilities (provided and maintained by Central Computer Services—CCS) and a variety of desk top facilities including workstations, PCs, and X-terminals (provided and maintained by the individual Observatories or Departments). Computing systems are networked together and linked to the computers on Kitt Peak and to the world-wide Internet.

The central facilities maintained by CCS must provide an environment for reduction and analysis of data taken at Kitt Peak by visitors and staff members. As the scientific workstation revolution of the past decade has proceeded and powerful computers have appeared on almost every scientist's desk, it is no surprise that fewer visitors and staff members utilize the CCS hardware facilities. Nevertheless, a significant number still reduce and analyze their data, especially the largest and most challenging datasets, in Tucson (see Appendix 4). Moreover, with the planned arrival of new instruments such as the 8K × 8K CCD Mosaic Imager and the 1K × 1K IR arrays on Kitt Peak in the next two years, data handling needs will again outstrip individual workstation capabilities, and CCS needs to keep up by upgrading the central facilities devoted to data reduction and analysis. Thus the machine Ursa will be upgraded during FY 1995 and FY 1996 to increase cpu speed, main memory capacity, and disk capacity at a cost of $60K.

An academic and scientific institution such as NOAO-Tucson must provide a set of computing services to its staff such as e-mail, document processing, scientific plotting packages, and so on. These needs are met by providing sufficient servers and the necessary infrastructure to connect these servers to several hundred terminals, X-terminals, PCs, and workstations on the staff members' desk tops. Upgrading the infrastructure is ongoing as more computers are attached to the network, as more scientists and engineers need access to the computer facilities from their home computers, and as servers need to be updated and upgraded to handle the load of more and faster systems utilizing their services. Infrastructure upgrades cost $30K in both FY 1995 and FY 1996.

Pursuant to a directive from the NOAO Director and monitored by an ongoing working group, all future administrative software development at NOAO-Tucson will use PC hardware running Windows and the Microsoft Office software suite (Word, Excel, PowerPoint, and Access). Databases that can and should be shared "read-only" will be placed in a public location on the network. More complicated databases (such as successors to the ALPS system used for telescope scheduling and the CHAOS system used for NOAO accounting) will still be developed in the context of Office, but may use more capable database programs than Access "in the back end."

Converting all the existing administrative software into this environment may be prohibitive in cost; however, all new systems, as well as older systems that are being substantially updated, will conform to the new requirement.

KPNO - Kitt Peak

Computers on Kitt Peak serve three broad but overlapping functions: real-time control of the telescopes and instrumentation, data taking (including data reduction and initial analysis), and support for observing and operations of the Observatory. Continuing replacement and upgrading of these computers are driven by three factors: obsolescence, which implies high maintenance costs and lack of functionality (for example, the telescope control system at the 0.9-m telescope is over 15 years old); new technology and improved techniques (for example, the 8K × 8K Mosaic Imager being developed by the NOAO Instrumentation...
Group will result in nightly data sets of the order of 30 GB); and changes in standards and approaches (for example, the gradual adoption of Gemini software and standards at KPNO).

At the 4-m telescope, new instrumentation and new standards are converging to mandate a major revamping of the computer systems. KPNO is committed to evolving the overall control environment to one compatible with the Gemini Observatory Control System (OCS). New instrumentation currently under development for the 4-m, such as GRASP and the Mosaic Imager, is being built under the assumption of an OCS-compatible environment. Utilizing the OCS at the KPNO 4-m has several implications: the interface between OCS and the telescope/instrument control systems will be through EPICS (Experimental Physics and Industrial Control System); our existing data collection, archiving, reduction and analysis system (IRAF) must be adapted to use the OCS interfaces; and a “back end” database system must be created to store observing programs and other relevant data. Furthermore, the arrival of the Mosaic Imager at the 4-m in October 1996, with 8K x 8K images will drive an upgrade of the computers devoted to data reduction and analysis.

During the latter part of FY 1995 and into FY 1996, our intention is to develop an OCS-compatible environment at the 4-m to run in parallel with the existing environment. Thus we plan the following computer acquisitions at the 4-m for the remainder of FY 1995 and into FY 1996. In FY 1995, we will add a cpu card to the existing telescope control VME crates to be used as an EPICS system ($4K). In FY 1996, we will purchase a fast, multi-cpu Sun Workstation, which will support the development of the OCS software (including an operating system transition to Solaris 2.x) and eventually become the main data-taking and reduction machine as the new instrumentation comes on line ($35K). In addition, another Sun will be purchased to run the actual OCS software and to become the home for the “back end” database ($8K). Also in FY 1996, the network interconnecting the Suns at the 4-m will be changed from Ethernet (10 Mbps) to Fast Ethernet (100 Mbps) and a high-capacity digital tape drive (either the new “super” Exabyte or Digital Linear Tape—each capable of 20-30 GB per cartridge) will be deployed. These latter two projects will cost a total of $20K but should substantially increase the data flow between computers (currently a bottleneck in the existing operations) and allow storage of very large datasets on a modest number of tape cartridges.

At the WIYN, KPNO is investigating layering portions of the OCS onto the existing software to facilitate queue and service observing. The design of the OCS is optimized for scheduling and completing scientific programs and not just for scheduling observations of individual objects. Thus in FY 1996, a cpu card will be purchased for use as an EPICS system ($4K). The suite of KPNO-supported instrumentation at the WIYN will not be significantly changed during FY 1996 and no other computer upgrades will be required for that reason.

At the 2.1-m, the 0.9-m, the Coude Feed, and the Burrell Schmidt telescopes, computer changes during FY 1995-1996 will be minimal. No new instrumentation is scheduled for these telescopes that will require new computer facilities, and the existing computer facilities are adequate for the instrumentation currently deployed. Any possible future upgrades are on hold until the future of the “small” telescopes at KPNO is determined. In a similar vein, the obsolescent Telescope Control System (TCS) at the 0.9-m telescope will remain as-is through FY 1996. However, minor changes in the TCS at the 2.1-m telescope in early FY 1996 will be made to accommodate observing without Telescope Operators.

The administrative facilities on Kitt Peak (supporting both KPNO and NSO) include computer facilities for staff and visitors who do not have other access to communications facilities to link them to the mountain network and to NOAO-Tucson. During FY 1995, an old Sun serving as a staff and visitor support machine will be replaced with a much more supportable Sun recycled from elsewhere in the Observatory. This new Sun will be equipped with nine-track, Exabyte, and DAT tape drives to serve as a media-conversion machine. Also, two ancient Suns serving as X-terminals in the Administration building will be replaced by mountain standard X-terminals ($7K). There is a good possibility that the communications link between Tucson and Kitt Peak will be upgraded to a fiber connection or a 2 x T1 microwave link; communications
An initiative that will take place late in FY 1995 and into FY 1996 is the development of two observing techniques that fall under the category of remote observing over the Internet: automatic FTP transfer of data to home institutions and an "eavesdropping" mode whereby a scientist can monitor the data acquisition process from a remote location. A modest investment in video and audio hardware for the KPNO Suns ($7K) will be required for the eavesdropping system.

CTIO - La Serena

The computer facilities in the La Serena offices consist of three main parts.

A group of four “public” computers, two SPARCStation 10-41's, and two older VME-bus Suns, are located in the main computer room. These machines are used for data reduction by visiting astronomers. They also act as central servers providing software, a substantial body of disk storage, and peripherals such as nine-track, Exabyte and DAT tape drives, and printers for the network of scientific and engineering workstations. In addition these machines provide facilities for general computing and for network access for administrative and other non-scientific staff.

A total of 24 workstations are located on the desks of individual staff members. All members of the scientific staff now have individual workstations, which they use for data reduction and general scientific computing. These machines have some local disk storage, supplemented by shared access to larger amounts of scratch space on the central servers. Most of these workstations also have individual DAT drives, while other peripherals are available as shared resources on the central servers. All members of the CTIO computer applications group, and some of the engineering staff, have desktop workstations used in performing their functions.

Finally, there are five laboratory machines: two used for Arcon development, one for support and maintenance of optical CCDs, one for support and maintenance of the IR detectors and instruments, and one for general electronics use.

All computer purchases at CTIO are made centrally. Most major acquisitions have been made using end-of-year moneys as only a small amount of money is explicitly budgeted for computer purchases. In recent years several members of the scientific staff have obtained outside funding (mainly HST grants), part of which has been, or will be, used to upgrade their desk top workstations. CTIO funding has been used to upgrade the remaining scientist workstations.

During FY 1996 we will upgrade the two main central servers by adding an additional 9 GB of disk space and a further 32 Mb of memory to each at a total cost of $8K. This is necessary to keep pace with the growing volume of data being delivered by IR and optical detectors. The two VME-bus machines in La Serena are now very old and are becoming obsolete. The cost of repair in the event of a major failure would greatly exceed the cost of their replacement by a much more capable machine. They are also, by modern standards, relatively power hungry, implying higher operational costs. As a second priority we plan to retire one of the two and replace it by a mid-level SPARCStation at a cost of about $4K. The second machine would be kept operating, using the retired machine as a source of spares, in order to retain the capability of reading and writing nine-track magnetic tapes, without investing in an expensive SCSI-bus-based tape transport. Another area of concern is that the workstations available to the programmers and engineers are old low-end machines, and this is beginning to limit productivity. Consequently we anticipate the need to upgrade or replace these machines (cost $4K/machine) as funding permits.

CTIO - Cerro Tololo

Data acquisition on Cerro Tololo is supported by a network of Sun computers located in the various domes.
At each of the 4.0-m, 1.5-m and 0.9-m telescopes, two machines are available. The main data acquisition computer (currently a SPARCStation 10-41) is directly connected to the optical CCD (Arcon) and IR (Wildfire) controllers and is used for the collection, reduction, and initial analysis of the data delivered by these devices. This machine has the bulk of the disk storage (typically 6-7 GB) and is equipped with both Exabyte and DAT tape drives. The secondary machines are older VME bus computers. They have a modest amount of local disk storage and also host nine-track magnetic tape transports. These machines are typically used for data reduction when more than one observer is present at the telescope. A single SPARCStation 10-41 is used at the Schmidt telescope for data acquisition with Arcon, while the 1-m telescope, now only used for single channel optical photometry, has a VME bus computer.

A further SPARCStation 10-41 fully equipped for data acquisition with Arcon is located in the Cerro Tololo electronics laboratory. This machine is used for test and maintenance work on the optical CCD systems and is also available as a hot spare for the other data acquisition computers.

An additional SPARCStation 10-30 and one low-end SPARCStation are used by the Cerro Tololo support staff for data reduction and general computing, while another low-end machine is available to visiting astronomers waiting between observing runs.

All these machines are connected to one another via a conventional Ethernet, to the USA by a satellite link, and to La Serena by a microwave link (see the communications discussion below). However, a policy decision has been taken that each of the data acquisition computers must be able to perform its basic role in stand-alone mode, so that a failure of one machine does not affect any of the others. Two computers owned by outside groups (the MACHO collaboration and the Universidad de Chile) are also located on Cerro Tololo and make use of the mountain Ethernet for network connectivity.

The mountain computer system as described above is viewed as being substantially complete in the sense that we do not anticipate the need to add further machines. However, the volume of data being generated each night has increased as detectors have become larger and read out times shorter. As a consequence the amount of disk space on the main acquisition computers is only marginally adequate. Therefore, during the remainder of FY 1995 and FY 1996 we will increase the amount of disk space and computer memory on each of these machines as funding permits. An expenditure of $4 K per machine will increase disk space by 9 GB and memory by 32 Mb.

The arrival at CTIO of the NOAO Mosaic will necessitate a major upgrade to the data acquisition environment and computers at the 4.0-m telescope. However, the Mosaic is not scheduled to come into service until October 1996 and is not expected to travel to CTIO until the second year of operation. We therefore plan to delay these purchases until FY 1997 so as to benefit from experience gained with the Mosaic at KPNO and from the inevitable changes in the computer market.

The VME-bus auxiliary Suns are now very old. The cost of repair in the event of a major failure would greatly exceed the cost of their replacement by a mid-level SPARCStation, which would also offer substantially improved performance. However, in the meantime they do serve a useful though not critical role, providing a second Sun screen in each dome and also access to nine-track magnetic tape drives. Given the present funding situation, our intention is simply to allow these machines to fade away. The auxiliary machine at the 4.0-m and possibly that at the 1.5-m would be replaced with a suitable SPARCStation (cost about $4K each) as and when they fail. New operating modes such as queue/service observing at the smaller telescopes will likely eliminate the need for an auxiliary machine in these locations. Given the declining use of nine-track tape, an adequate level of service would be retained if only one of these machines were kept running.

There are two rather different telescope control systems in use on Cerro Tololo.

The 4.0-m telescope is controlled by a VME-bus-based processor running software based on the VxWorks operating system. A major CTIO project for FY 1995-97 is to upgrade the drives of the 4.0-m telescope following experience gained at KPNO. This project also involves changes to the telescope control
computer and software. The 1.5-m computer is operated by a similar VME-bus processor but using an earlier version of the TCP program based on the VRTEX operating system. A project is under way to convert the 1.5-m system to VxWorks, making it compatible with the 4-m system to the maximum possible extent.

The 1-m and 0.9-m telescopes are operated by an aging and obsolete commercial TCS. These systems are a serious maintenance headache, and we would like to replace them with copies of the 4.0-m/1.5-m system. However, budgetary and manpower restrictions mean that this cannot occur until FY 1997 at the earliest.

CTIO Communications
The La Serena and Cerro Tololo installations are connected by a microwave link, which provides an E1 (2 Mbaud) connection between the mountain and the downtown headquarters. We have recently completed a project to replace the modems, which have been a constant cause of maintenance headaches, with a more reliable alternative. A satellite link, purchased and maintained using NASA funding, provides a direct 56 Kbaud link between Cerro Tololo and Internet in the US.

A 56 Kbaud satellite link was state of the art when it was installed in 1989 but is now showing its age and seems distressingly primitive. It is heavily used but is too slow for the demands that users put on it. As a result, observers are constantly asking for an improvement in its speed.

It will be necessary to upgrade this line’s performance in the near future. For the present, we are concentrating on trying to persuade NASA to pay for increasing the existing link’s velocity to 128 or 256 Kbaud, which is within the capability of the existing equipment.

By the Gemini era, a much greater increase in bandwidth will be required. This will probably be achieved by installing high speed ATM switches on Tololo, Pachon, and in the La Serena offices. An ATM system will hook naturally into the fiber links, which are now being installed within Chile and to the US. Communicating via fiber will increase the effective communication bandwidth to 155 Mbaud or higher and eliminate the lack of responsiveness caused by satellite delay. This will provide the high speed capability that will be required for true interactive remote observing for both Gemini and the Cerro Tololo facilities.

NSO/SP Computer Support
The computer facilities at NSO/SP are in four areas: Main Lab (ML), Evans Solar Facility (ESF), Hill Top (HT), and the Vacuum Tower Telescope (VTT). The HT, ESF, and VTT computer systems are mainly used for telescope control and data collection with limited data analysis. The ML facility is used for data reduction, analysis, and general computing by local staff and visitors.

Over the last five years, the NSO/SP computer budget has been reduced by 50%, from 5% to 2.5% of the overall site budget. Because of this, we are moving to a different computer/network architecture for the Main Lab, as described below.

NSO/SP Main Lab
The goal of our plan is to provide local staff and visitors the necessary computing power to perform their work, within our present budget, and to reduce system administration time. The plan is to:

1) Move our general-purpose computing environment from desktop workstations to cost-effective multiprocessor compute/disk servers and X-terminals.

2) Where possible, replace PCs with X-terminal/workstations.

3) Standardize on PC architecture and specific Window software where X-terminal/workstations are not possible.
4) Connect all PCs and X-terminal/workstations to our local network.

5) Purchase software that will allow centralized system administration of hardware and software.

There will be several compute/disk servers connected by a high-speed network. The X-terminals will be connected to the servers through an Ethernet switch. Each server will have 4 high-end CPUs, 512 MB memory, and 10-15 GB disk storage. The X-terminals will have a minimum of 12 MB memory.

During FY 1996 we expect to upgrade an aging Sun 4/670 to a Sun SS20 for $45K, including four 100 MHz CPUs, 512 MB of memory, and one 10 GB disk.

To complete the plan, we will need in future years to:

1) upgrade two SS10s to SS20s for $80K; the cpu boards and memory from the SS10s will be used to upgrade other SS10s at the VTT, ESF, and ML;

2) acquire three FDDI interface boards for the three SS20s ($10K);

3) acquire one FDDI interface board for an Artel Ethernet Switch ($10K); and

4) acquire ten X-terminals to replace our old SUN IPCs ($30K).

NSO/SP Telescope Computers

The telescope computer systems were upgraded several years ago. The systems now meet or exceed the requirements for a TCS. New camera systems based on fast-framing 1K × 1K CCDs are currently being developed. The camera systems will require significant expenditures for data acquisition computers in FY 1997 and beyond (about $25K per camera). The cameras systems will be the next major purchases.

The following enhancements to the current system will be made during FY 1996:

<table>
<thead>
<tr>
<th>Location</th>
<th>Requirement</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESF</td>
<td>2 display cards for data acquisition display</td>
<td>$4K</td>
</tr>
<tr>
<td></td>
<td>1 fast A/D card for data collection</td>
<td>$1.5K</td>
</tr>
<tr>
<td></td>
<td>1 X-terminal</td>
<td>$3K</td>
</tr>
<tr>
<td></td>
<td>1 disk drive for data collection (and spare)</td>
<td>$2K</td>
</tr>
<tr>
<td></td>
<td>1 Exabyte drive for quick look</td>
<td>$2.5K</td>
</tr>
<tr>
<td>VTT</td>
<td>1 display card for data acquisition</td>
<td>$2K</td>
</tr>
<tr>
<td></td>
<td>1 X-terminal</td>
<td>$3K</td>
</tr>
<tr>
<td></td>
<td>1 disk drive for data collection</td>
<td>$1K</td>
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<tr>
<td></td>
<td>1 Exabyte drive for quick look</td>
<td>$2.5K</td>
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</table>

NSO/Tucson

The NSO Tucson anonymous FTP archive places a heavy demand on support resources. The data products available to the community consist of the daily KPVT images, FTS atlas, and FTS data archives. During the previous year, FTP accesses exceeded 15,000 file acquisitions, while WWW interrogations for the KPVT web page exceeded 30,000 hits. The archive currently consists of 250 GB of data on nine-track, Exabytes, and CD-ROMs. There is a ongoing project to move all data to CD-ROM. To reduce the support needed to service these requests, NSO will purchase one CD-ROM jukebox for $20K in FY 1995 to place the archive data from the FTS, KPVT, and Sac Peak on-line. We plan eventually to have 600 CDs (360 GB) of data on-line, which will require the purchase of another jukebox and CD-ROM writer.
Administrative and support staff computers used at NSO/Tucson will continue to be Macintosh-based. The Macintosh platform is integrated into NSO operations, not only for administrative tasks but also for observing support on the mountain. LabView is being used for quick instrument development and in support of the image quality improvement project underway at the McMath-Pierce. We will support the standard Microsoft software suite adopted by NOAO (Word, Excel, PowerPoint, and Access), except for Access, which is not a cross-platform database. We have adopted FileMaker as our database of choice, because it is supported in both Windows and Mac environments. Since most of our Macs run soft windows, we can run the few applications, such as CHAOS, that are not Mac-based. We will install MAE (Apple's Macintosh Application Environment) on one or more Sun workstations. This will allow Sun users to run the same applications used by the administration and support staff.

We plan to purchase a laptop computer for $3K to be checked out by NSO staff during travel. We will also upgrade one or two of our current Mac systems to RISC PowerPC architecture to be used by the programming staff for development ($2-4K).

GONG and the Solar Oscillation Imaging project (SOI) will purchase additional disk space for five Sun workstations, about 4 GB per machine. SOI will purchase three Sparc 20s in anticipation of new hires. H. Jones (NASA/GSFC) plans to upgrade two workstations (Norma and Grus) to Sparc 20s and add 9 GB of additional disk space to Grus.

**NSO/Kitt Peak**

Computers at the NSO facilities on Kitt Peak meet similar, but highly individuated, requirements. The Telescope Control System (TCS) at the KPVT works on an auxiliary image whereas, at the McMath-Pierce, it controls the main image. The KPVT control system is designed for smooth image scanning, the McMath-Pierce for stationary operation. The McMath-Pierce is now being used for scanning at infrared wavelengths not available to the KPVT. Both telescopes are in need of upgrades. The project to upgrade away from a PDP-11/FORTH/CAMAC system at the KPVT is currently in the late planning stages with ETS. This upgrade would bring its TCS in line with upgraded systems on NOAO nighttime telescopes.

The grating control system for the McMath-Pierce main spectrograph is also a PDP-11 based system, still using nine-track tape. This is an area that needs timely attention because of the disappearance of nine-track capability; it is being addressed in the proposal to upgrade the McMath-Pierce TCP.

It is likely that the bulk of the computer purchases associated with the proposed TCS upgrades will be made in FY 1997 or beyond, depending on the progress of the associated mechanical work.

The FTS has undergone a major control system upgrade in the past few years. However, there are still parts of the lower-level hardware that need to be updated. One aspect that is being addressed is the 22-bit A/D converter. The A/D is well past its useful lifetime, and many of the components are no longer supportable. A PCI-bus based A/D converter, consisting of a Crystal Semiconductor 20-bit, dual-channel A/D sampling at 48 KHz, is being developed and will soon move into the testing phase. We will purchase a PC (with non-NSF funds) to run this new system.

The Stellar-Spectrograph is the application that most closely reflects the systems used at other sites on Kitt Peak. With the 800 x 800 TI-4 CCD, we anticipate no changes to Pacifico (the ICE Sun) used for stellar observations. However, the Cross-Dispersion system recently installed was designed with the 1K x 3K Ford chip as its detector. If the 1K x 3K system becomes available, we will implement a faster CCD controller based on the system used by WIYN.
IX. Budget

The budget tables are attached as Appendix 5. In accordance with NSF instructions, the operating budget has been held to $26.69M in FY 1996. Also in accord with discussions with the NSF, we show an additional contribution of $2M toward restructuring the observatory with the goal of lowering operating costs.

In order to hold the operating budget to $26.69M in the face of US inflation at 3 percent and Chilean inflation last year at 20 percent, we have been forced to continue to downsize the staff and to limit our offerings to the user community. The 1.3-m telescope on Kitt Peak was closed in April, 1995. The stellar synoptic program at the McMath-Pierce will be closed effective October 1. The position of Director of Kitt Peak Observatory will not be filled. The search for a director was unsuccessful, largely because of the uncertain prospects for the observatory. We have therefore elected not to fill the position pending a reorganization of the observatory in order to reduce administrative costs.

One key element in restructuring must be downsizing the staff. We have already offered an incentive retirement plan to the scientific staff, and six staff have accepted. We have laid off other staff. NSF restructuring funds have been used for the incentive retirement program and to fund severance costs. We have requested permission to offer an early retirement program to the non-scientific staff both in the US and in Chile. If that is approved, additional restructuring funds will be required to fund it. The amount required is unknown because we do not know how many staff will choose early retirement but is well within the total funds available for restructuring.

A second element of the restructuring plan is replacement of telescopes. We cannot continue to operate all the same telescopes with a smaller staff. We can either reduce the number of operating facilities, or we can replace aging telescopes, which require high maintenance, with new telescopes that offer better performance at lower cost. The WIYN clearly demonstrates the advantages of this strategy.

We are currently exploring three options: 1) Replacement of 3-4 smaller telescopes with a single new 2.4-m telescope optimized for optical imaging at each of CTIO and KPNO; 2) replacement of the existing solar telescopes used for synoptic observing with a single facility as a first step toward consolidating the solar program on a single site; 3) investing in the construction of SOAR with the goal of reducing our long term contribution to the operation budget. We are currently costing these projects, and a detailed plan for restructuring will be presented to the NSF in early fall. Each of these is a multi-million dollar project and the first two have payback periods in the range 5-7 years. It is likely that we can do one of them with the combination of funds remaining from this year's restructuring money plus the $2M that NSF has indicated will be available next year.
APPENDIX 2

NOAO Management

Sidney Wolff  Director, NOAO/Acting Director, KPNO*
Richard Green  Deputy Director, NOAO
Jacques Beckers  Associate Director, NOAO/Director NSO
Todd Boroson  Associate Director, NOAO/Director USGP
Malcolm Smith  Associate Director, NOAO/Director CTIO
John Leibacher  Project Director, GONG
Mark Phillips  Assistant Director, CTIO
Robert Barnes  Assistant to the Director, KPNO
Glen Blevins  Manager, Central Administrative Services
Larry Daggert  Manager, Engineering and Technical Services
John Dunlop  Manager, Central Facilities Operations
Yvette Estok  Manager, Public Information Office
Steve Grandi  Manager, Central Computer Services
Rex Hunter  Administrative Manager, NSO/Sacramento Peak
James Kennedy  Manager, GONG Project
James Tracy  Controller, Central Administrative Services

*Internal recruitment in progress for Assistant Director, KPNO
APPENDIX 3

Cerro Tololo Inter-American Observatory

Scientific Staff: Primary fields of interest and 1994 publications.

**Jack Baldwin** - Active galactic nuclei; quasars; H II regions.

In the coming year Jack Baldwin plans to complete a detailed study of the Seyfert 2 galaxy NGC 3393. This is based on extensive HST and ground-based data taken in collaboration with H. Netzer (Tel-Aviv U.), G. Ferland (U. of Kentucky), A. Cooke (Cambridge U., England), B. Wills (U. of Texas) and A. Wilson (STScI). Baldwin will also continue working with B. Wills, D. Wills, G. Ferland, H. Netzer and I. Browne (Manchester U.) on HST and ground-based spectroscopy of a large sample of QSOs, and with Ferland and others on a combined HST/ground-based study of the spectra of quasars with narrow emission lines showing evidence of outflowing gas.

Most of Baldwin’s time will continue to be spent on service activities; principally the 4-m upgrades program and serving as the chairman of Advisory Committee on Telescope Resources (ACTR).


**Olin Eggen** - Photometry and astrometry; dynamical evolution of the Galaxy.

Olin Eggen is examining a sample of 1400 A0/1 to F2 (log \( T_e \) = 3.96 to 3.82) stars with accurate photometric and astrometric data. The sample contains members of the Hyades, Sirius, and HR1614 superclusters, all of which show an appreciable age spread. Eggen aims to clarify the detailed nature of this spread of ages and some of the details of the evolution of blue stragglers and Am stars.

Eggen is also studying the nature of various members of the Pleiades supercluster, including pre-main-sequence stars and visual binaries with high orbital eccentricity. He wishes to test models for such binaries using masses derived from the cluster parallax.

Eggen serves as chair of the CTIO TAC and is the scientific supervisor of the library. He is also responsible for maintenance of the single-channel photometers.


Jay Elias - IR instrumentation; star formation; stellar mass loss; supernovae and novae.

During the coming year, Elias’s main research activity will be devoted to a study of mass loss in evolved stars in the Magellanic Clouds. The principle goal of the study is to quantify and understand the differences in mass-loss by evolved stars between the Large and Small Magellanic Clouds, and between the Clouds and the Galaxy. It is expected that these differences will primarily or entirely be due to differences in metal abundances among the three galaxies, which may manifest themselves as differing gas-to-dust ratios, mass-loss rates, and even as different evolutionary tracks. A major part of this work is identifying mass-losing stars in the Clouds, and understanding selection effects. Part of this involves comparison of existing surveys with one another. In addition, Elias has been granted time to do higher sensitivity IR survey work with the ISO satellite (when launched), and will spend time preparing for these observations.

A second project is an attempt to use existing IR and visible spectroscopic data to understand the processes that lead to dust formation in novae. Many, but not all, novae form dust in their ejecta; it appears that those that do form dust are the carbon-rich objects and that the dust formation is preceded by molecule formation. Much more work is needed, though, in examining the data in order to strengthen the evidence for this hypothesis. In addition, there is evidence that not all dust formed in novae is the same and that there may be corresponding differences in the prior spectral evolution.

Elias is one of the three staff members responsible for the CTIO IR program; this includes both construction and support of instruments. He also serves on the CTIO ACTR committee, is one of the two staff members on the NOAO IPAC committee, one of the two staff members on the CTIO TAC, and is responsible for all aspects of telescope scheduling. He participated in preparation of the NOAO proposal for construction of the Gemini IRS. He is also in charge of the CTIO section of the NOAO Newsletter.


Richard Elston - Galaxy formation and evolution.

At this time Elston is pursuing three primary programs. First, Elston and P. Eisenhardt (Jet Propulsion Lab.) have nearly completed their deep B,R,I,Z,j and K survey of 100 square arcminutes of sky to an unprecedented depth of K = 22. The hope is to use the J-K color to identify galaxies with z > 1.5. ISO time has also been allocated to study these objects at 5 μm to verify that they are distant galaxies.
Additionally, HST images will be obtained to study the morphologies of these distant normal field galaxies. Elston and G. Hill (U. of Texas) will obtain further spectra of UV Mg II and Fe emission to search for the depletion of Fe in high redshift quasars \((z > 4)\). Finally, Elston and Hill are pursuing an extensive program to determine the multi-variate luminosity function of galaxies. They are obtaining redshifts for 10,000 galaxies identified on deep CCD images and will measure the galaxy luminosity function as a function of both color and surface brightness. They will then use these luminosity functions to model faint galaxy counts without resorting to strange populations of galaxies.

Elston has been project scientist for the CTIO IRS, which was recently upgraded with a \(256 \times 256\) InSb array and a prismatic cross disperser. Elston is also mostly responsible for visitor support of this instrument. He has also been active in the testing of the new CTIO IR camera, CIRIM, and in providing visitor support for this instrument. Elston has written the operating manuals for both the IRS and CIRIM. Additionally, Elston is the project scientist for the CTIO f/14 tip-tilt secondary, which should come on line in 1996. Finally, Elston has played a significant part in the development of the conceptual design and scientific definition of the second generation IR spectrometer that NOAO proposed to Gemini, both in writing the successful proposal to Gemini and in coordinating the work of others on this proposal.


**Brooke Gregory - Low temperature physics and infrared instrumentation.**

At the beginning of this fiscal year, FY 1995, we learned that the NOAO design for the Gemini IR Spectrometer had been selected to be built by the NOAO instrumentation group. That instrument will be produced initially for the Gemini 8-m telescope on Mauna Kea. NOAO will also produce a copy for Cerro Tololo, which will be shared with the Gemini 8-m on Cerro Pachon. The conceptual and optical designs for the instrument were developed by Jay Elias, Richard Elston and Brooke Gregory, who will all continue to be actively involved in this multi-year project. During FY 1995 and FY 1996, Brooke Gregory will be spending the majority of his project time refining the optical design and working with astronomers and mechanical engineers on tradeoffs between scientific performance and manufacturability.

Gregory will continue to be involved in the later phases of several other projects, among them the f/14 tip-tilt secondary for the 4-m telescope and the program to improve the imaging performance of the 4-m telescope. In particular, he plans to implement a scheme to apply micro-thermal air temperature measurements in the 4-m dome to aid in the diagnosis of dome-seeing effects.
In addition, Gregory serves the Observatory by acting as the Manager of the La Serena engineering group (ETS) responsible for instrumentation development and maintenance. In that capacity, he also serves as vice-chairman of the ACTR, which advises the CTIO Director on the allocation of technical resources among various development and maintenance projects.

Stephen Heathcote - Interstellar medium; planetary nebulae; Herbig-Haro objects; star formation; supernovae; polarization of active galactic nuclei.

During the forthcoming year, Heathcote will continue to concentrate his efforts on the analysis and interpretation of images and spectra of Herbig-Haro objects obtained with the Hubble Space Telescope. In collaboration with B. Reipurth (ESO), R. Schwartz (U. of Missouri), J. Bally (U. of Colorado), J. Morse (STScI), P. Hartigan (Rice U.), and J. Stone (U. of Maryland), Heathcote has obtained images of the two prototypical Herbig-Haro jets, HH 46/47 and HH 111, using HST and WFPC-2 during Cycle 4. Analysis and interpretation of the data for the first of these objects are now complete while that for the second is at an advanced stage. The HST images reveal a wealth of new details not detected from the ground and provide important insights into the physics of optical jets. In particular, they provide convincing evidence that source variability and entrainment play important roles in exciting the internal shocks within the jet. The same group has obtained HST time during Cycle 5 to make follow-up spectroscopic observations of the HH 46/47 jet. Heathcote was also PI on a successful Cycle 5 application, with B. Reipurth and A. Raga (UNAM), to obtain WFPC 2 images of the high-excitation Herbig-Haro objects HH 80/81. As a result of high shock velocities and only modest pre-shock densities, the post shock cooling zone in these objects should be resolvable with HST, offering the first opportunity to study directly the stratification of high- and low-excitation/ionization lines in Herbig-Haro shocks.

Heathcote is the instrument scientist for the 2D-Frutti photon counting detector and, jointly with R. Schommer, for CTIO optical spectrographs. He is also responsible for oversight of CTIO’s facilities for scientific computing and for supervision of the data reduction assistants in La Serena and on Cerro Tololo. During the past year Heathcote has been heavily involved in the software side of CTIO’s Arcon CCD controllers and has taken part in planning for the replication of Arcon controllers for Gemini. He is also project scientist and manager for a multi-year project to upgrade the drives and control system for the 4.0-m telescope. Heathcote continues to be a member of the Advisory Committee on Technical Resources at CTIO.


Thomas Ingerson - Optical astronomical instrumentation, automated electronic control systems and computer networking.

Ingerson will be on sabbatical leave for most of FY 1996. During his leave, he plans to study the problems and technology of high speed communications and computer networking, in particular as they relate to providing efficient and cost-effective facilities for astronomical queue scheduling and remote observing. He will spend his sabbatical leave at the Dominion Astrophysical Observatory, which is responsible for writing the Gemini Data Handling System, and Ingerson will be involved in this effort, with the goal of helping CTIO and NOAO make as smooth a transition as possible into the Gemini era.

Ingerson is an instrumental physicist who has been working in numerous projects involving instrumentation and instrument control. In the area of electronics, he has been the manager of the Arcon detector controller project. He is responsible for the design and implementation of a new generation of motor controllers, which are gradually replacing many of the antiquated systems in use at CTIO. He is the member of the scientific staff who oversees computer networking and inter-computer communication at CTIO. He originally designed Argus, CTIO’s multiple object spectrograph, and is currently assisting in the effort to specify a version of KPNO/WIYN’s multiple object spectrograph, “Hydra,” which will be built in Tucson and installed at CTIO, replacing Argus. During FY 1995, he is finishing the final characterization and certification of an Atmospheric Dispersion Compensating corrector for the CTIO 4-m and has recently designed and installed a new, high-resolution camera on the 1.5-m echelle spectrograph.

Mark Phillips - Supernovae; novae.

Mark Phillips will continue to concentrate his research effort during FY 1996 on supernovae. In collaboration with M. Hamuy, R. Schommer, N. Suntzeff (NCAO), J. Maza (U. of Chile), B. Schmidt (MSSSO), B. Leibundgut, J. Spyromilio (ESO), R. Kirshner, A. Riess (Harvard/CfA), and C. Smith (U. Michigan), Phillips will carry out a search for Type Ia supernovae at redshifts to z ~ 0.3-0.5 using the CTIO 4-m telescope. This program is the next step in the Calan/Tololo SN survey, where ~30 Type Ia supernovae were discovered and observed out to z ~ 0.1. The distant supernova discoveries will be followed up with CCD photometry and spectroscopy, both at CTIO and other observatories in both hemispheres. With the spectral classification and light curve shapes, the calibration of the absolute magnitudes of Type Ia supernovae obtained from the Calan/Tololo survey will be used to place stringent limits on the deceleration parameter, q0. A discovery rate of ~3 Type Ia supernovae per month is expected, which, in principle, should allow the value of q0 to be strongly constrained within only ~1-2 years of observation.

Phillips serves as the CTIO Assistant Director. In addition to heading up CTIO’s efforts to control light pollution in the IV Region of Chile, he helps out with the support of spectroscopy on the 4-m and 1.5-m telescopes and serves as the CTIO coordinator for the REU and Cerro Calan summer student programs. During FY 1996, Phillips will serve on the TAC and take on the responsibility for scheduling the telescopes.
Robert Schommer - Star clusters; Magellanic Clouds; distance scale; galaxy dynamics.

Schommer is working with two groups using cycle 5 HST observations of globular clusters in Local Group galaxies. With N. Suntzeff and A. Walker (CTIO), E. Olszewski (U. of Arizona), M. Mateo (U. of Michigan) and P. Hodge (U. of Washington), he plans to obtain deep color-magnitude diagrams (CMDs) of possible old globulars in the central regions of the LMC. With A. Saradejini and P. Harding (KPNO), and D. Geisler, he is studying CMDs of the red globular clusters in M33, to investigate their horizontal branch morphology and search for a possible second parameter in this old cluster system, analogous to the Milky Way halo clusters.

Schommer plans to observe ultra-luminous IRAS galaxies with the imaging Fabry-Perot on the CTIO 4-m, in collaboration with C. Mihos and J. Barnes (U. of California, Santa Cruz), and G. Bothun (U. of Oregon). They hope to determine the kinematics of these systems at high spatial resolution, to test models of the mergers of gas-rich galaxies. The 2D structure of the starburst winds from these systems will also be studied.

Schommer is part of two SN search programs. With M. Phillips (CTIO) et al. he is studying the luminosity function of SNe Ia in a sample of clusters of galaxies at low redshift (z = 0.05-0.08). With
Suntzeff et al., he will search for and measure SNe Ia at redshifts 0.3 to 0.5, in order to measure cosmological effects in the Hubble expansion.

Schommer’s regular CTIO service duties have included the following assignments: small telescope support; small telescope guiding and control systems jointly with S. Heathcote and, on the Schmidt telescope, with A. Walker; member, Advisory Committee on Technical Resources; seminar chair; CTIO contact for Gemini and SOAR projects; Cassegrain spectrograph support jointly with S. Heathcote; and visitor support for observing runs with the Rutgers/CTIO Imaging Fabry-Perot Spectrometer.


Malcolm Smith - Discovery and observational study of quasars and active galactic nuclei.

During the coming year, Malcolm Smith will continue his V, I, Z three-filter survey, recently started with the CTIO 4-m, in search of QSOs with z > 5. The technique is based on the large difference in continuum flux at these redshifts between the region longward of the Lyman-alpha emission line and the region shortward of this line. For QSOs with 5 < z < 6, selection by V-I color is ideal, with the I band centered at about 7900Å and the V band at about 5700Å. V-I > 4 is the primary selection criterion for this redshift range. Most of the high-latitude CCD fields do not contain stellar objects as red as this, and such objects are likely to be interesting in their own right. For 6 < z < 7. V-Z color is an optimum discriminator, and cannot readily be obtained by photographic means; work will be done during the year to quantify the effect on photometry of the fringing that is observed in the z frames.

Once the 2048 x 2048 chip is available on the Schmidt with suitable 4-inch filters, a survey with a field of 1 sq. degree per frame will be initiated. Follow-up spectroscopic work will use the 4-m and later the Gemini telescope.

Nicholas Suntzeff - Stellar populations; stellar abundances; supernovae; Galactic structure; Magellanic Clouds.

Suntzeff is collaborating with A. Klemola (U. of California, Santa Cruz), E. Olszewski (Steward Obs.), R. Schommer (CTIO), and E. Hardy (Laval U.) on various projects designed to study the overall kinematics and stellar evolutionary history of the Large Magellanic Cloud (LMC). With Hardy and Schommer, he has obtained data with the Argus multi-fiber echelle system on virtually all known carbon
stars in the LMC, in order to map out in greater detail than ever before the kinematics of the intermediate
age population in the LMC. They will be able to determine the rotation of the LMC out to at least 8
degrees from the LMC center and will study the nature of the disk rotation and bar perturbation, as well
as the distribution of dark matter. With the other collaborators, Suntzeff is studying selected regions in
the LMC primarily to isolate the oldest population of stars. One of the most curious aspects of the LMC
is that it evidently formed its initial population of stars in a rotating spheroid, in distinction to the barely
rotating halo of the Milky Way. This conclusion is based on observations of only 13 old clusters and, in
order to make any more progress, individual field stars must be used. This project was begun on a field
of stars near NGC 2257 that has been selected by color and lack of proper motion. Out of 200 stars
surveyed, about 100 are LMC members; of those, about 30 are Population II stars. These data will allow
the measurement of the velocity dispersions and metallicities of field stars, which will be used to model
the formation and evolution of the LMC.

Suntzeff will continue his work with M. Phillips and M. Hamuy (CTIO), and J. Maza (U. de Chile) on
the evolution of supernovae. These projects involve the gathering of basic photometric and spectroscopic
data on supernovae. The Calan/Tololo survey is a program aimed at discovering SNe out to z = 0.15.
Suntzeff has been concentrating on the photometric measurement of local, bright supernovae, which
will be templates for the more distant supernovae discovered by the Calan/Tololo survey. These observations
are fundamental in understanding both the physics of supernova explosions and the utility of SNe as
possible standards candles to be used in distance scale measurements. This group, along with J. Elias
(CTIO), will also continue to gather data on SN1987A.

With T. Kinman (KPNO) and R. Kraft (U. of California, Santa Cruz), Suntzeff will continue a program
aimed at determining the metallicity and kinematics of the Galactic halo. They will observe RR Lyrae
and blue horizontal branch stars in the Galactic halo to measure the velocity ellipsoid. In a related
project, Suntzeff is collaborating with R. Ibata (U. of British Columbia), G. Gilmore (Cambridge U.), R.
Wyse (Johns Hopkins U.), and M. Irwin (Royal Greenwich Obs.) on a kinematic and metallicity study of
the Sgr dwarf galaxy. The Sgr dwarf, which was discovered last year, is evidently being tidally disrupted
by the Galaxy. The team will obtain high- and low-resolution Argus data at CTIO and low-resolution
data with the fiber system at the AAO.

Finally, Suntzeff is involved in a number of HST projects. He is member of the Supernova Intensive
Survey (SINS) along with M. Phillips, with R. Kirshner (Harvard U.) as PI. He is working on the Tucana
dwarf galaxy project to produce a color-magnitude diagram of this distant dwarf spheroidal galaxy
dSph). P. Seitzer (U. of Michigan) is PI and A. Walker is also a member of the team. Suntzeff is PI on
an HST project to study the age and metallicity of the globular cluster population in the LMC; other
collaborating investigators are Schommer and Walker. He is also a member of the project to study the
globular clusters of the Fornax dSph (R. Zinn, Yale PI).

Suntzeff will continue to serve as a member of the Advisory Committee on Technical Resources for
CTIO. He has provided technical assistance to the Gemini project relating to the meteorological and
astronomical characteristics of Cerros Pachon and Tololo, based on the results of the Cerro Pachon Site
Survey. Suntzeff is in charge of the CTIO Photo Lab, and is the instrument scientist for the bench-
mounted echelle on the 1.5-m telescope and the Argus multi-fiber system on the 4-m telescope. He will
be on sabbatical at Dominion Astrophysical Observatory during half of this Fiscal Year.

1992bc and SN 1992bo: Evidence of Intrinsic Differences of Type Ia Supernova Luminosities”


**Alistair Walker** - CCD photometry instrumentation; stellar evolution; distance scale.

With H. Smith and N. Silberman (Michigan State), A. Walker will complete the analysis of CCD photometry of a one-degree square field in the Small Magellanic Cloud, obtained with the Curtis Schmidt telescope. This field contains many short-period Cepheids, and the program is aimed particularly at defining the structure of the faint end of the Cepheid Period-Luminosity relation in the HR diagram.

With the anticipated completion of the observations in 1995, analysis of high precision B, V and I photometry for the evolved stars in a number of galactic globular clusters will be undertaken. Some specific problems that the observations will be able to address are: the accurate placement of the RR Lyraes in the HR diagram for comparison with evolutionary tracks and with positions of instability strip edges and mode boundaries; and comparisons of RR Lyrae light curves with theoretical light curves obtained from hydrodynamic models.

Photometry and high dispersion abundances are being obtained for several southern clusters that contain Cepheid variables. The abundances have been assumed solar. However, the derived distances to
Cepheids are very sensitive to abundances. The observational aspects of this work, which is a collaboration with B. Carney and A. Fry (U. of North Carolina), are nearing completion.

A search in galactic bulge fields (photometry, spectroscopy) for hot evolved stars will commence in 1995, with the goal of identifying the origin of the copious UV flux in old, metal-rich populations in other galaxies. This is a collaboration with D. Terndrup (Ohio State U.), R. Peterson (U. of California, San Diego), and E. Sadler (Anglo Australian Obs.).

Completion is expected of a photometric investigation into the stellar populations present in the local group dwarf elliptical galaxy, Tucana, from ground-based and HST observations (P. Seitzer, U. of Michigan).

Both ground-based and HST photometry for a sample of possibly very old LMC clusters will be analyzed. These clusters are in the bar of the LMC and are extremely crowded; their great age is suggested from either integrated photometry or from their low abundances. Whether or not they are old, the data will help in deciphering the LMC age-metallicity behavior and is relevant to the formation history of galaxies in general. This is a collaboration led by N. Suntzeff.

A. Walker continued to coordinate the CCD program, supervise the operation of the CCD laboratory, and be responsible for direct imaging operations on all CTIO telescopes. With R. Schommer, he is responsible for the Schmidt telescope. He served as CTIO project scientist for the NOAO Mosaic project (8192 x 8192 CCD mosaic for the 4-m telescope), as manager for the continuing upgrades at the Schmidt telescope, and also managed a number of other minor projects relating to CCDs and imaging.

A. Walker served as project scientist for the Arcon CCD controller project. This project made much progress in FY 1994, with installations onto two Tek 2048 CCDs (one for WIYN), and preparation work for three more installations. He has continued as a member of the ACTR (Advisory Committee for Technical Resources).

With R. Schommer, A. Walker has shared CTIO representation on the US Gemini Science Advisory Committee and was a member of the Gemini Science Committee for its 1994 October meeting.


APPENDIX 3

Kitt Peak National Observatory

Scientific Staff: Primary fields of interest and 1994 publications.

**Helmut Abt** - Stellar rotation, stellar classification, binary frequencies, astro-sociological studies.

Helmut A. Abt plans the following research during 1995-1996: (1) Completion of the study (with Daryl Wilmarth) of the binary frequencies and characteristics for the Coma and Praesepe open clusters. Previous work on younger clusters showed that the characteristics of binaries can be explained entirely in terms of capture processes, rather than by fission. (2) Completion of the study (with Christopher J. Corbally) of 250 possible Trapezium systems. A published analysis of one-quarter of those systems showed that most were not physical systems, but the remaining real Trapezium systems had an upper age of $10^7$ yr, which is consistent with the expected dynamical lifetimes of such unstable systems. (3) Completion of a study of rapidly-rotating A stars, which often have Ti II shell lines in the near ultraviolet. No stars with moderate or sharp lines show those shell lines, so the circumstellar material is in disks. The disks develop and disappear on long time scales. Abt and collaborators have studied this behavior over several years to get estimates of the time scales of their appearance and disappearance.

Abt’s service to KPNO in recent years has been minimal because he works for KPNO only half-time and is paid by the Astrophysical Journal for the other half-time. Because the Journal has grown so much — a 450-page journal is published every week — this has left little time for other services. However, Abt has served other organizations, e.g. IAU Nominating Committee, President of IAU Commission 26, member of several NASA committees, President of the Van Biesbroeck Award Committee, Chair of the AIP Publications Board, member of the Publications Board of Scientometrics, setting up the Y.-C. Cheng Annual Award for astronomers in China, etc.


**Taft Armandroff** - Stellar populations in the Galaxy and nearby galaxies, globular clusters; dwarf spheroidal galaxies.

Armandroff is studying the dwarf spheroidal (dSph) companion galaxies to M31. WFPC2 images of one such galaxy, And I, are being analyzed in order to construct a color-magnitude diagram that will reveal for the first time the morphology of the horizontal branch (HB) in this system. The dSph companions to the Galaxy show a large diversity of HB types, and many show redder HBs than would be expected from their generally low metal abundances. This trend of red HBs despite low abundances, seen in both Galactic dSphs and in some outer Galactic halo globular clusters, is often taken as an indication that these objects formed later than the inner Galactic halo. It is therefore of considerable interest to see if the And I, II and III dSph galaxies, which are in the outer halo of M31, show this same effect. Subsidiary results that will follow from this project include comparisons of HB and giant-branch-tip distances and estimates of internal abundance dispersions free from the complications caused by AGB contamination on the upper giant branch.
Armandroff serves as project scientist for the NOAO optical/UV instrumentation program. In this capacity, he coordinates all optical instrumentation development efforts and serves as a member of IPAC. The modification of Hydra and the Bench Spectrograph for optimal use at the WIYN telescope currently represents a major part of Armandroff's service effort. Armandroff participated in a group studying a Hydra clone for CTIO, and he led a group studying the need for, and parameters of, new high-efficiency low-to-moderate resolution optical spectrographs for the KPNO and CTIO 4-m telescopes. He serves as KPNO CCD Scientist and is a member of the team developing a Large Mosaic CCD Imager for KPNO and CTIO. He leads the effort to replace the camera in GoldCam with one of higher efficiency and wider field. In addition, Armandroff serves as a staff contact for Low-to-Moderate Resolution Spectroscopy and Multi-Fiber Spectroscopy. Finally, Armandroff served on the Gemini Optical Instruments Science Working Group.


**Samuel Barden - Spectroscopic instrumentation and binary stars.**

Barden will use the Hydra instrument to continue observations of selected stars in M71 and M13, in order to monitor their radial velocities. The goal of this project is to determine the binary frequency of the stellar samples. This information is required for theorists to understand the dynamical processes which halt core collapse within the centers of globular clusters. As binaries are discovered, follow-up observations are planned to determine the period and other orbital parameters in order to define the distribution of those parameters within this class of stellar population.

S. Barden is instrument scientist for the Hydra multi-fiber positioner. This instrument has been modified for permanent installation on the WIYN telescope and is currently undergoing commissioning. Barden will also be co-project scientist for a copy of Hydra for the CTIO 4 meter telescope. This project is expected to start in FY96 and has recently been approved for the preliminary design phase. Barden is telescope/instrument scientist for high resolution spectroscopy at KPNO. He is also currently the scientist in charge of the KPNO filter collection.

This spring, Barden will chair the first SPIE conference dedicated to the subject of "Fiber Optics in Astronomical Applications." Barden has served on two design reviews, one for the Sloan Digital Sky Survey fiber optic feed, the other for the SAO Hectospec fiber positioner for the upgraded MMT.

Michael Belton - Planetary astronomy.

M.J.S. Belton’s research focus for 1995-1996 will be on the global properties of cometary nuclei and asteroids and specific topics in the Jovian system. This includes a theoretical project with N. Samarasinha on the interpretation of the measured water production rates in comets (particularly P/Halley) in terms of the physical properties of cometary vents, an observational project on Chiron’s bound dust coma with K. Meech utilizing the Hubble Space Telescope, and a project on the origin of Jovian equatorial plumes with P. Sartoretti and R. Beebe also utilizing the HST. Belton and his colleagues were fortunate to acquire time in cycle 5 for both of these projects. All of these projects are mature and build on work accomplished in the past year. Belton will also continue his work with the Galileo project. The analysis of last year’s 243 Ida encounter and Shoemaker-Levy 9 impact data is in full swing and will have the earliest priority. A special issue of Icarus, containing 14 papers covering all aspects of this research, is in preparation. Belton’s SMACS (Small Missions to Asteroids and Comets) proposal to the “Discovery” Program, while not successful in 1995, is expected to provide the basis for an advanced technology “New Millennium” project. This will be evaluated in the coming year.

Belton’s service activities have primarily been outward into the community. He chairs the IRTF Management and Operations Working group and the NASA/Keck Review Team. He is an active member of the Editorial Advisory Board for Planetary and Space Science, the NASA Planetary Astronomy Management and Operations Group, IAU Commissions 15 and 16, the Steering Committee of the International Jupiter Watch, and the Advisory Council of the Small Bodies Node of the Planetary Data System. He has provided reviews of KPNO and NSO observing proposals and of proposals submitted to NASA and NSF. He has reviewed numerous papers for scientific journals and in 1994 earned the “Editor’s Letter of Commendation” from Icarus. Belton is also a Distinguished Visiting Scientist at the Jet Propulsion Laboratory.


Bruce Bohannan - Stellar spectroscopy, evolution of massive stars, astrophysical instrumentation and data reduction.

Bruce Bohannan's research centers on observational studies of the evolution of massive stars. Such stars, through their radiation, mass loss and supernovae explosions, are important to chemical element evolution of and kinetic energy input to their parent galaxies. Determination of the basic stellar properties -- temperature, gravity, mass, mass loss and surface element abundances—of luminous stars are crucial to understanding stellar evolution at masses where mass loss rates determine the path which a star follows from hydrogen to helium core-burning and then on to supernovae. Current investigations involve detailed analysis with P. Crowther (University College, London) of Of and WN-type stars with similar morphological characteristics and abundance studies of B supergiants in the Large Magellanic Cloud with E.L. Fitzpatrick (Princeton). The results of the detailed analysis of the extreme Of and morphologically related WN stars demonstrates that spectroscopic classification alone should not be used to define the evolutionary state of hot, massive stars and thus determine their contributions to the properties of their parent galaxies. B supergiants in the LMC exhibit a range of CNO abundances, an observation indicating that a significant fraction of these stars have evolved through the red supergiant stage and have returned to the blue supergiant region with core processed material now in their atmospheres, a result not consistent with all models of massive star evolution.

As Manager of Mountain Operations, Bruce Bohannan has supervisory responsibility for all KPNO mountain-based activities, including facilities, electronic and computer maintenance, instrument and observing support for astronomers using KPNO telescopes, and operation of the kitchen and dormitory. Personnel reporting to him also provide electronic and facilities maintenance for the National Solar Observatory site on Kitt Peak. He works with Tucson-based engineering personnel in telescope and instrument improvements—most often at the project management level—and he plays a key role in long-range planning. Major projects in the past year include thermal control of the 4-m primary mirror, a number of "re-engineering projects" to address the management and operation of NOAO as it adjust to level or declining budgets, and training of NOAO personnel to operate and maintain the WIYN telescope. Major activities for the coming year include continuing work on improving the optical performance of the 4-m telescope, coordination of work on the thermal control system of the 4-m dome, the upgrade of the 84-inch Telescope Control System for astronomer operation, and WIYN operations.

Todd Boroson - Quasar emission lines, quasar host galaxies and environments, stellar populations and galaxy evolution.

In 1995, Boroson will continue efforts begun in several areas. With Michael Corbin (NOAO), he will complete a study of HST archival spectra of quasars. This work is aimed at extending previous analyses of
the information contained in optical quasar emission lines to UV wavelengths, with the goal of understanding the relationships between the emission line properties and the physical processes which control them. The spectra have been extracted from the archive and the statistical analysis is just beginning. A second area of research is the continuation of surface photometry of edge-on disk galaxies in collaboration with Heather Morrison (CWRU), Paul Harding (U. of Arizona), and Penny Sackett (U. of Groningen). The initial stages of this research involved the discovery of a faint halo around the galaxy NGC 5907. The light distribution in this halo matched that expected for the dark matter required to account for the observed rotation curve. Efforts are under way to determine the color of the halo light and to search for similar components in other galaxies. Also, work will continue on the long-term program to identify a large number of faint low-luminosity emission-line galaxies. One hundred square degrees are being surveyed with an objective prism on the Burrell Schmidt in an attempt to define a complete sample that extends to quite low luminosity. This work is being undertaken in collaboration with John Salzer (Wesleyan U.), Trinh Thuan (U. of Virginia), and Valentin Lipovetsky (SAO, USSR).

Boroson's principal observatory service is in his role as US Gemini Project Scientist. Among the responsibilities of this position are a) the identification of areas of potential scientific and technical commonality between NOAO and Gemini, b) the facilitation of mutually beneficial work that NOAO can do for Gemini, and c) the procurement and management of the US-allocated Gemini instrumentation, some of which will be designed and fabricated within NOAO. In addition, he serves as a member of IPAC, the scientific oversight group for NOAO's instrumentation program, and as the project scientist for the Mosaic CCD imager. An additional role of the US Gemini Project Scientist is Associate Director of NOAO. Service in this role includes the development of an ongoing program for the US Gemini Program, one of the four divisions of NOAO. Finally, he has served as an NOAO representative in community-wide discussions of policy, including the OIR Panel and the AURA-NOAO workshop.


**Michael Corbin** - Quasars and active galaxies (observation and theory), starburst galaxies, quasar absorption lines, instrumentation development.

Corbin will spend the early part of this year completing the program in collaboration with T. Boroson of combining HST and IUE archival QSO spectra with ground-based spectra. The sample is complete, and they are beginning the statistical analysis and interpretation of the data. The resulting paper will be submitted to the Astrophysical Journal Supplement Series; papers dealing with individual objects in the sample in greater detail are anticipated. Observationally, Corbin and Boroson are pursuing a spectroscopic survey of bright, low-redshift, radio-loud QSOs using the facilities of KPNO and CTIO. The goal is to supplement the current spectral database of primarily radio-quiet objects and to determine in detail the differences in the emission line properties of the various QSO subclasses. Assuming successful observing runs, the analysis and papers resulting from this work should be completed by 1996. In addition, in collaboration with Boroson, Corbin will obtain and analyze data from a pilot program of imaging low-redshift QSOs under the WIYN "shared risk" program. Finally, Corbin will be pursuing a collaboration with J.W. Haller, a U. of A. physics doctoral student, involving a theoretical study of the QSO broad-line region. Specifically, they will present a fully relativistic treatment of the photon energies in an effort to reproduce effects Corbin has discovered in the observational data.
Corbin’s main contribution to observatory support has been participation in the OUV instrumentation oversight group. Specific areas that have been addressed have been the upgrade of the GoldCam spectrograph and an assessment of the value of this upgrade relative to upcoming observational programs. He has also served as Astronomer In Residence on the mountain on several occasions and plans to do so again in the coming months.


**Stephane Courteau - Cosmology, dust, dynamics of spiral galaxies.**

In 1995/96, Courteau and Broeils (Cornell) plan to complete a project to determine the distribution of mass in spiral galaxies. Using luminosity profiles and rotation curves from Courteau’s thesis to decompose the various mass components (gas, stars, non-baryonic), they will study the distribution of mass with radius and compare with models of galaxy formation that include baryonic infall to form a halo of dark matter. The latter will be pursued with colleagues at UCSC. Mass-to-light ratios will be compared with predictions from synthetic models of stellar evolution (collaboration with Stephane Charlot). Courteau and Faber (UCO/Lick) will pursue the calibration phase of a project to determine diagnostics for the study of mass distribution and chemical abundances of distant galaxies. This work is being conducted at the Lick 3-m telescope and the KPNO 4-m telescope.

Courteau and Holtzman (Lowell) are also involved in an observing program at NOAO and Lowell to study the extinction of light and dust properties in spiral galaxies. Multicolor optical and IR imaging, combined with radiation transfer and stellar population models, will provide first estimates of the amount of cold dust in spirals from a sample of ~400 galaxies. Recent investigations suggest that the mass of cold dust may have been underestimated by at least 900% in previous work and could form an important part of the “missing mass” in the halos of spiral galaxies. Another goal of this project is to determine more accurate corrections for dust extinction at all visual spectral bands, which is crucial for the measurement of galactic distances. Courteau has been invited to give a key review presentation on these topics at a “Dust and Morphology” conference in South Africa next January.

Courteau is also planning a comprehensive study of the dynamics of rich clusters in collaboration with several colleagues. The aim of this project is to map the radial velocity distribution of six rich Abell clusters and determine dynamical and kinematic information to provide greater knowledge of the formation history of structures in the universe.

Courteau contributes to mountain support as an imaging specialist at the 0.9-m and 2.1-m telescopes. The task involves reviewing observing proposals for direct imaging on these telescopes and helping new observers get started and maximize their scientific output. This contribution amounts to one or two nights of work per month. In collaboration with Tod Lauer (KPNO), he also intends to enable automatic information logging for most instruments at Kitt Peak. They have already installed this program for imaging and spectroscopy (GoldCam, Hydra, R-C spectrograph) and the project should be completed this year. Last year, Courteau produced a popular atlas of infrared UKIRT standards; plans call for a second edition with digitized imaging. He also plans to continue serving as public consultant for a local Middle School.
David Crawford - Young open clusters.

In the coming year, David L. Crawford will be continuing his studies of young open clusters. This work has applications to the calibration of the observed photometric indices of intrinsic colors, absolute magnitudes, and other parameters, as well as to studies of stellar structure and evolution. In the past year, analysis of the existing data for the clusters NGC 1502 and NGC 6611 has been finished. Work on IC 1805 and 1848 is continuing. All of these clusters contain young OB type stars and are ideal for investigations of accurate zero-age main sequences as well as for definitive studies of interstellar reddening effects on photometric systems and on the ratio of total-to-selective absorption. Results in the literature are often affected by systematic errors in the photometry and are hence far from conclusive. The present photometry should help sort out the issues. A summary paper on the calibrations and on a comparison of the young clusters will follow after the next cluster paper. Work also continues on synthetic photometry studies relative to standard photometric systems.

Crawford has continued his activity in support of the control of light pollution, both locally in the southern Arizona area, and nationally and internationally. He is a member of the Tucson/Pima County Outdoor Lighting Code Committee. A revised and upgraded outdoor lighting code was passed by both the city and the county in mid-1994. He is also active in several key committees in the national and international astronomy and lighting (IESNA and CIE) communities. These very time-consuming activities have been paying off with positive results, boding well for the long term future of dark skies at the observatories.

Crawford has been active in the technology transfer efforts at the observatory, both in general and in support of potential new generation small telescopes for the observatories and for the community, including a successful meeting on the topic held in Tucson early in 1994. Discussions continue with potential partners in industry.


Crawford, D. 1994, Revista Mexicana de Astronomia y Astrofisica, 29, 115, “Photometry as a Fundamental Tool, But Be Careful”


David De Young - Active galaxies, galaxy clusters, star formation, young stellar objects, turbulence, dynamos.

Research efforts in 1995 will be primarily centered on galaxies and clusters of galaxies. In collaboration with Colin Norman, an investigation on the effects of active central galaxies in cluster cooling flows is nearing completion. Injection of energy from such a galaxy into the flow may provide enough power to explain the observed emission line luminosities and may be a source of significant re-heating as well. A study of the evolution of galactic halos, and in particular a detailed investigation of the onset and evolution of thermal instabilities in the hot halo gas, is also being undertaken with C. Norman. This research will utilize a newly developed version of a very accurate numerical hydrodynamic code. In collaboration with T. Heckman, an extended study of mass loss from dwarf galaxies due to starburst activity is being initiated. The issue is one of possible re-collapse of an inflated ISM in the galaxy versus complete dispersal of the ISM. Realistic modeling of a two phase ISM with radiative cooling will be employed via numerical techniques. A subset of this research will be applied specifically to the Carina galaxy in collaboration with T. Smecker. Finally, research will continue on understanding the development and evolution of large scale structures in the turbulent boundary layers of jets. This has immediate application to the outflows from young stellar objects as well as to the transport of energy by, and evolution of, extragalactic jets.

A significant amount of time has been devoted to performing a series of calculations for the 8-m Gemini project. These entail numerical simulations of airflow through 8-m enclosures to address problems of turbulence and dome seeing, dynamic pressure and wind shake, and thermal flushing of the primary mirror surface. Such calculations supplement water tunnel tests because they can be carried out with the correct Reynolds number for the actual flows and because arbitrary wind speeds and directions can be simulated. Another set of such simulations calculated pressure fields over the surface of the primary mirror and cell assembly for a variety of wind directions and speeds. Simulation of airflow through the KPNO 4-m enclosure to study the effects of large vents will be undertaken this year. Other service activities include chairing the KPNO bright and dark time telescope Time Allocation Committees, supervision of the NOAO/Tucson library and chairing its oversight committee, chairing the KPNO Personnel Committee, membership on the NOAO IPAC committee, membership on the WIYN Board, membership on the WIYN SAC, membership on the KPNO postdoctoral selection committee, and participation in the NOAO 2000 meeting at SPO and the AURA workshop in Albuquerque.

Ian Gatley - Star Formation, the Galactic Center.

In the coming year, Ian Gatley plans to emphasize diffraction-limited 3 μm imaging at the KPNO 4-m telescope, using the real-time shift-and-add capability presently under construction for the Cryogenic Optical Bench (COB). The intent is to exploit the improved spatial resolution to study the inner regions of the galaxy NGC 1068 and to investigate the young stellar cluster in the core of the Orion Molecular Cloud OMC1.

Ian Gatley helped remodel the KPNO Visitor Center and organize an educational outreach program to exhibit children’s work. He took part in the NOAO 2000 exercise at Sac Peak, and attended the AURA Workshop on “The Future of NOAO.” He is the photo lab supervisor, a member of KPNO Bright TAC, and a member of IPAC. Gatley is part of the team that successfully proposed to construct the Gemini IR Spectrograph and is project scientist for several infrared projects, including COB Shift-and-Add, Grasp (with R. Joyce), and the Aladdin 1024 × 1024 InSb detector development.


Richard Green - Quasar energy distributions, emission and absorption lines; galaxy and quasar population evolution.

Richard Green is collaborating with Patrick Osmer (Ohio State U.), Patrick Hall, and Charles Liu (thesis students at Steward Obs.) to analyze a multi-color survey of about a square degree of sky at high galactic latitude complete to 23rd magnitude. Point-like objects that stand out from the stellar color locus provide a candidate list for a complete sample of high-redshift quasars and Seyfert galaxies that will be key probes of the evolution of the luminosity function. The galaxy counts as a function of color will be modeled to determine the evolution of star formation per unit mass as a function of cosmic time.

Green is a member of the Medium Deep Survey team working with the Hubble Space Telescope parallel imaging survey. Early studies have focused on the evolution of galaxy morphological properties as a function of redshift. Current work with Vicki Sarajedini (thesis student at Steward Obs.) concentrates on identifying faint active galactic nuclei as unresolved point sources in the high-resolution Wide Field Camera images. The result will be tracing the incidence of lower level nuclear activity out to redshifts of 0.5 to map the increase of non-thermal power with cosmic lookback time.

Green also collaborates with B. Jannuzi in determining the association of low-redshift Lyman alpha absorption clouds with the large-scale structure of galaxies. They are conducting an imaging and redshift survey to concentrate on the range $0.1 < z < 0.4$.


Kenneth Hinkle - High resolution infrared spectroscopy, especially applied to circumstellar and interstellar matter and variable stars.

In the next year Hinkle plans to continue a number of ongoing collaborations. Hinkle will be continuing Mira and semi-regular variable radial velocity studies for oxygen-rich stars in collaboration with Lebzelter and Hron (U. of Vienna) and for carbon-stars with Barnbaum (NRAO). Radial velocity as a function of phase for these stars sets a key constraint on the mode of pulsation. Determination of the mode of pulsation remains the outstanding issue in cool variable stars. In related work, with F. Fekel (Tennessee State) and R. Joyce (KPNO), Hinkle will be continuing radial velocity observations of symbiotic systems with NICMASS at the Coudé Feed. This is a multi-year project to determine orbits, using infrared spectra, for binary systems containing obscured or Mira primaries. Hinkle is also working on infrared radial velocity studies of RV Tau stars with Pollard (SAAO) and Wahlgren (GSFC). RV Tau stars have complex infrared spectra. A detailed understanding of the spectra should give insight into the atmospheric structure. Another goal is to confirm that the infrared pulsation period is half that measured in the visual. Wallace (NOAO) and Hinkle will continue their work on infrared spectral standards. Projects planned included an extension of the (now in press) infrared Arcturus atlas to overlap the visible Griffin Arcturus atlas, a catalog of low-resolution K-band spectra spanning the HR diagram, and a catalog of high-resolution K-band spectra of representative G, K and M supergiants, giants, and dwarfs. Hinkle will also be continuing his research with P. Bernath (U. of Waterloo) on circumstellar chemistry. Hinkle and Bernath are interested in long chain-carbon molecules and other symmetric molecules not detectable using microwave spectra. They plan to continue to search for the infrared spectral signatures of these molecules.

Hinkle’s principal service activity in FY 1996 will be the assembly, laboratory testing, telescope integration, and final system checkout of the high-resolution infrared spectrograph ‘Phoenix.’ Phoenix is a major observatory instrument that will provide high-resolution infrared spectroscopy capability using 1024 x 1024 InSb Aladdin arrays. It is intended to replace the 4-meter FTS and to be one of two infrared instruments offered at Kitt Peak in the next decade (the other instrument will be GRASP). The completion of the Phoenix spectrograph and the certification of this instrument as a user-ready facility are major goals of the NOAO instrumentation program in FY 1996. Hinkle is the Phoenix instrument scientist and has been the manager for the project. He will be in charge of the final testing and responsible for confirming that the instrument is user ready. Hinkle is also instrument scientist for the 4 meter FTS. While it is expected that this instrument will not be used in FY 1996, Hinkle is in charge of the archived spectra taken over the previous 17 years. With the greatly increased use of infrared spectroscopy resulting from infrared arrays, there has been considerable interest in the broad-band spectra of bright sources taken with the FTS. Hinkle supplies spectra to the community on request. Hinkle and R. Joyce will also continue as the instrument scientists for the NICMASS at the Coudé Feed project. This project, being carried out jointly with the University of Massachusetts (UM), uses the UM NICMOS array as a detector in the Coudé Feed. NICMASS works in the non-thermal 1-1.8 μm infrared. Hinkle and Joyce will be working to improve this system and to support visitors on this instrument.


George Jacoby - Planetary nebulae, the extragalactic distance scale, galaxy stellar dynamics and stellar populations.

George Jacoby’s primary area of research centers on the use of planetary nebulae as probes of galaxy properties. His most widely recognized effort is the use of planetary nebulae to derive distances to elliptical galaxies. The PN identified in those surveys are now being used to derive the kinematic properties of spiral and elliptical galaxy halos. Having dynamic test particles in the outer regions of galaxies provides a means of mapping the distribution of dark matter, if any, in galaxies. During the coming year, several Virgo galaxies will be surveyed from KPNO to enhance the test particle collection; several hundred are needed for a complete analysis of the three dimensional distribution of matter.

Observations at ESO, La Palma, and prior data taken at KPNO will be used to derive the chemical abundances of the PN, and by inference the progenitor stars, in nearby elliptical and spiral galaxies. PN emission-lines provide the best way to measure directly the abundances and their gradients in elliptical galaxies.

Both abundance and kinematic studies of the Galactic center will follow from observations made this year at ESO of a sample of new PN identified last year with the KPNO Burrell Schmidt. PN within 1 degree of the Galactic center were identified using a near-IR technique.

During 1994 Jacoby provided the following observatory service: telescope scientist for the 0.9-m; project scientist for (1) the IRAF project, (2) upgrading the 4-m prime focus corrector for the Mosaic, (3) low order adaptive optics development, (4) acquisition and guide cameras; and direct imaging capabilities scientist.


**Buell Jannuzi** - Active galaxies (unification schemes for active galaxies, BL Lacertae objects, radio galaxies, quasars, emission properties, variability, physical models, host galaxies and environments); evolution of the gaseous content of the universe (quasar absorption lines, relation of absorbers to galaxies and large scale structures, the Milky Way’s ISM); wide field, high throughput, low resolution spectroscopy and polarimetry instrumentation.

Jannuzi will continue the study of the degree and nature of association between low redshift Ly α systems and galaxies. Together with his collaborators, he will determine the fraction of the Ly α systems that can be directly associated with disks or halos of galaxies, as well as examine the clustering properties of Ly α clouds over the redshift range 0 to 1.6. The clustering properties of these systems have implications for their origin and their relationship to high redshift Ly α clouds. This work requires continuing observing programs that make use of the Hubble Space Telescope as well as many of the KPNO and CTIO telescopes. The gathering of the necessary data is still in progress. In addition to the project described above, Jannuzi will be continuing several projects which are focused on the study of the properties of active galactic nuclei (AGN). This work includes detailed studies of specific objects, determinations of the optical polarization properties of BL Lacertae objects and high-redshift radio galaxies, studies of the UV emission properties of quasars, and tests of unification schemes for radio galaxies and AGN.

Jannuzi serves as instrument scientist for Cryocam the R-C Spectrograph, and Goldcam. He also serves as a contact point for proposers and observers requiring the use of KPNO facilities to obtain low resolution optical spectroscopy for their scientific programs.


Richard Joyce - Late-type stars; mass loss; infrared detector and instrumentation development.

A long-term project to obtain infrared photometric monitoring and spectroscopy of heavily obscured late-type stars undergoing mass loss has been completed. The photometric aspect of the project will be submitted for publication shortly, although analysis of the spectroscopy may continue into the following year. A project to search for unusual molecular species in the 1.1-1.4 μm region of S stars (with K. Hinkle (NOAO) and D. Lambert (U. Texas)) netted spectra of 106 stars, the analysis of which will also continue into the next year. K. Hinkle, F. Fekel (Tem. St. U.), and Joyce are beginning a long-term experiment to determine orbits of symbiotic stars from their infrared spectra. These systems are interacting binaries in which one star is a cool giant and the other a hot main sequence star or white dwarf. Orbital determinations from optical spectra have been problematical, since these spectra are often dominated by the continuum from the energetic and irregular mass flows associated with the stellar interaction. The infrared spectrum, on the other hand, is almost completely that of the cool giant, and an unambiguous velocity determination of one of the stellar components is possible. They intend to use the Coudé Feed spectrograph and the University of Massachusetts NICMASS IR camera to observe the CO bands in the 1.6 μm region. The results would not only confirm that symbiotics are mass-transfer
binaries, but, given the constraints on the mass of a white dwarf secondary, could yield accurate masses for cool giants over a range of evolutionary stages.

As a Support Scientist, a significant fraction of Joyce's time is spent in providing observing support to visiting observers using the facility instruments CRSP and IRIM, as well as visitor IR instrumentation such as the 2MASS prototype camera and the NICMASS IR camera being offered as a shared-risk instrument at the Coudé Feed. This includes direct support such as checking out the instruments after installation and providing instruction to observers, and off-line support in providing advice to prospective observers and assistance with data reduction. Joyce is the capability scientist for infrared spectroscopy with CRSP and COB, as well as co-instrument scientist on the new major infrared instruments PHOENIX (a high-resolution IR spectrograph) and GRASP (the next-generation IR imaging spectrograph). He is also telescope scientist for the 1.3-m telescope on Kitt Peak. For a number of years he has assisted in the scheduling of the Kitt Peak telescopes and will probably assume this duty completely beginning fall 1995. Other service areas include serving on the Infrared Group, WIYN Remote Observing, and KPNO Safety Committees and being the editor for the KPNO section of the NOAO Newsletter.


**Thomas Kinman - Stellar populations, galactic structure.**

It has recently been shown (Kinman, Suntzeff and Kraft 1994) that the Galactic halo consists of two parts: the well-known spherical component and an additional flatter component that accounts for the majority of halo stars near the Sun. Kinman will continue to investigate the natures of these two components using blue horizontal branch stars and RR Lyrae stars as halo tracers. The flat component will be investigated by isolating samples of these stars in the nearest cubic kiloparsec. The chemical composition and rotation (v_sini) and color distribution of these stars will be determined from spectroscopy (with Harmer, Braggalia and Cacciari), IUE photometry (Cacciari) and filter photometry. The orbital characteristics will be studied with Allen. Correlations between the physical properties and their galactic orbital properties will be sought. Majewski has recently claimed that the spherical halo has prograde rotation. This will be investigated using radial velocity determinations (with Kraft and Suntzeff) and proper motions (with Hanson and Klemola) from new Lick astrometric data. The survey for blue horizontal branch stars will be continued in the South Galactic cap using CCD filter photometry.

Kinman's service to the Observatory includes: Construction of Transparency Monitor for Kitt Peak (with D. Tody, L. Davis and B. Schoening); Organization of Meeting, “High Resolution Spectroscopy for Very Large Telescopes” held in Tucson, 13-15 October 1994 and editing of the proceedings; Telescope Scientist for Burrell Schmidt; Instrument Scientist for Aperture Photometer and Photomultipliers; Library Committee (Mountain Library).

Tod Lauer - Cosmology, large-scale structure of Universe, distance scale, normal galaxies, stellar populations.

Lauer is currently involved with several programs of HST observations. He will soon complete a major work, conducted in collaboration with Faber and others, on the central structure of normal galaxies, as imaged with HST. This work is based on pre-fix observations. New imaging observations are being received, as well as high resolution spectra, and will be analyzed in the coming year. WFPC team observations of galaxies are also now coming in and will be analyzed in the coming year. Lauer's next major work with HST will be to analyze extremely deep pictures of NGC 3379, which for the first time reveal details of the stellar population of a giant elliptical galaxy. Completion of this work will be a major concern in the coming year. Other HST programs in the coming year include a GO program with Postman, Tonry and others to calibrate the Lauer-Postman BCG Hubble diagram by the SBF method to yield a far-field Hubble Constant. Lauer also plans to complete a program on the color-magnitude diagrams of M31 globular clusters, on which Ed Ajhar (a postdoc) is the lead.

Observations for Lauer's program with Postman on extending the Abell Cluster Reference Frame for measuring motion of the Local Group may be completed this year. The new frame is 60% deeper than their previous frame and will be used to test whether the large flow decreases on larger scales. Postman and Lauer also hope to begin analysis of their deep I-band imaging survey, which will be used as a point of departure for probing the cosmological evolution and formation of large-scale structure.

Lauer's service largely falls into the areas of supporting the staff scientific program and communication with NOAO's user community. He edits the NOAO Newsletter and is responsible for the Highlights section of the Newsletter, which is designed to communicate interesting work done with NOAO facilities. He chairs the postdoc selection committee, and also serves as the KPNO representative on the darktime telescope allocation committee. He jointly runs the NOAO/Steward colloquium program, as well as the informal NOAO Friday lunchtime talk program. In service to the Observatory, he is 2.1-m telescope scientist. Outside of his responsibilities to NOAO, he also chairs the Space Telescope Users Committee.


Roger Lynds - Cosmology.

Most of Roger Lynds’ research for the coming year will focus on image data from WFPC2 on the Hubble Space Telescope, especially data from the deep surveys. Special emphasis will be given to evidence bearing on the evolution of stellar subsystems of galaxies.

Lynds performs no service to the Observatory.


Phillip Massey - Massive star evolution, star-formation, Local Group galaxies.

In the coming year Massey plans to answer the question “Where do Wolf-Rayet stars come from?” Wolf-Rayet stars are known to be the evolved, He-burning descendants of massive stars (see Maeder and Conti 1994 Ann. Rev. Astron. Astrophys. for a recent review), but many questions remain. Do all WC stars go through a WN phase? Do all WN stars live long enough to become WC stars? These questions are equivalent to asking if all types of WR stars have the same mass progenitors. In recent work, Massey et al. (1995) have shown that the formation of massive stars in clusters is essentially instantaneous (< 2Myr), and hence the mass of the highest mass star on the main-sequence (i.e., the turn-off mass) gives a good measure of the initial mass of Wolf-Rayet stars in the same cluster. During the end of CY1995 Massey hopes to have obtained data on Magellanic Cloud OB associations that are known to contain WR stars. To see if there is any difference in massive star evolution with metallicity, he plans to obtain similar data on Galactic OB associations and in the nearby Sb galaxy M31.

Next year Massey will continue his duties as telescope scientist for the Kitt Peak 4-m Mayall telescope. These responsibilities include seeing that the telescope can be used as efficiently as possible for science and also entail doing occasional “starts” on the mountain for visitors, writing the notes for the weekly telescope scientists meetings, and acting as an advocate for visiting astronomers internally. He is also responsible for the WIYN Hydra assignment software, and will continue to interact with visitors and staff. He has recently begun commissioning of the WIYN Imager. Other on-going duties include (a) visitor support of issues having to do with astrometry; (b) looking after the optical imaging and spectroscopy user manuals; (c) looking after the electronic submission process for Kitt Peak observing time; (d) acting as a contact for low-to-medium resolution spectroscopy, multi-object spectroscopy, direct imaging, and crowded field photometry. In CY1996 Massey expects to be involved in the commissioning of both the wide-field mosaic CCD camera (4-m and 0.9-m), and the “Hydra Clone” at CTIO.


Michael Merrill - Star formation, stellar evolution, interstellar medium, circumstellar environment, photodissociation regions, interstellar/circumstellar dust, IR array technology.

Merrill’s current scientific research interests follow along two intimately intertwined threads, the stellar content within regions of star formation and the diffuse environment with which the stars interact. With Ian Gatley, Merrill will be examining the circumnebular environment of stars, using the Cryogenic Optical Bench and CRSP. For isolating diffuse emission from the stellar “contaminant,” spatial mapping by stepping the slit across the source and wide-field imaging employing frequency switching on and off emission lines are proving to be powerful discriminants. They will employ 2-μm hydrogen emission, both atomic and molecular, and 3.28-μm dust emission, as probes of the distributed energy content (in the form of exciting UV photons and mechanical shocks) of active regions of star formation, including NGC 2024 (a young cluster embedded in a dense cloud), S106, and the center of the galaxy, Sgr A. In NGC 2024, they intend to take deep broadband JHK images to complement existing broadband L’ and narrowband 3.4-μm and 4-μm images to enable them to separate unambiguously the effects of reddening from excess emission, which have plagued earlier attempts to ascertain the luminosity and intrinsic color for the embedded stars. The scientific goal is to construct an approximate H-R diagram and luminosity function for this presumably young cluster and (through modeling) ascertain its likely age. Long-slit K-band spectra of selected areas will be obtained to pursue the issues of excitation, gas density, and distribution using the observed molecular hydrogen line ratios and the Brackett γ and [Fe III] line strengths. When combined with existing Br α and 3.28-μm fluorescent dust images, the observations will provide a multi-component (molecular gas, ionized gas and dust) map of the interaction of this nascent cluster with its parent/remnant cloud, unprecedented in scope and detail. With P. Conti, M. Hansen and I. Gatley, Merrill will be classifying the very young, high-mass OB stars which are usually found buried in their birth clouds of dust and gas. By combining near-IR spectra with JHK colors to estimate temperatures and absolute magnitudes, H-R diagrams for these shrouded H II regions can be constructed. From this, the masses, ages and evolutionary states of massive and intermediate mass stars in these young regions can be studied. With George Jacoby and Ian Gatley, Merrill will be searching for planetary nebulae within the central regions of the galaxy using online-offline, narrow-bandpass Brackett γ emission as a discriminant.

As Instrument Scientist for SQIID, Merrill handled SQIID instrument setups, briefed new observers on operations, acquainted observers with expertise in optical/radio/X-ray/space astronomy with the observational and data reduction techniques necessary for productive IR observations, and trained KPNO Mountain staff on servicing and operating SQIID. He actively participated in the NOAO infrared detectors R&D efforts, focusing on the 1024 × 1024 ALADDIN array, and served as principal point of contact for questions concerning IR data reduction within IRAF. Using COB, SQIID and CRSP as stand-ins, Merrill prototyped observing and data reduction protocols for GRASP, the proposed KPNO four-channel infrared imager/spectrograph. He advised the Gemini team on site and IR related issues and helped draft the NOAO Proposal for the GEMINI Infrared Spectrograph. He refereed IR observing proposals for technical suitability for the KPNO TAC and papers for the ApJ, AJ and PASP, observing proposals for the AAT, the CHFT and UKIRT, and proposals for NSF and several private foundations. Merrill also enjoyed teaching astronomy to Middle School students and serving as astronomy coach for the Vail Middle School Science Odyssey team.
Catherine Pilachowski - Stellar evolution, stellar abundances, nucleosynthesis, stellar spectroscopy, spectrograph design, new generation telescopes.

Pilachowski and T. Armandroff (KPNO) will continue their survey of heavy element abundances in Population II giants. Their survey will determine barium and europium abundances in a sample of nearly 100 metal-poor giants to examine the relative contributions of the r- and s-processes of nucleosynthesis in the early phases of galactic chemical evolution. Pilachowski, C. Sneden (U. of Texas) and R. Kraft (U. of California, Santa Cruz) will continue a program to detect and measure sodium abundance variations in a large sample of globular cluster giants observed with the Hydra fiber positioner and multi-object spectrograph. Spectra of nearly 300 stars in M15 and M13 have been obtained. The analysis will help to resolve whether sodium enrichment occurs during the process of stellar evolution and how the globular clusters self-pollute during the formation and early evolution of the cluster.

In addition to serving as Interim Director of KPNO, Pilachowski is working specifically to solidify plans to replace or upgrade existing telescopes on Kitt Peak with new, modern, facilities. She is assisting with the development within the observatory of electronic documentation, information access, and outreach, including data archiving and remote observing. She is developing new programs within the context of KPNO to provide new observing opportunities to the community via service and queue observing, and new models of observatory operations. She continues to serve as a member of the WIYN Board of Directors and as Secretary to the WIYN Consortium. She also contributes to NOAO’s educational and public outreach activities through school visits, lectures, mentoring, and public events.

Ronald Probst - Infrared imaging instrumentation, star forming regions, low mass stars, high spatial resolution imaging.

While permanently attached to NOAO/KPNO, Probst will spend most of the coming year as a long term visitor to NOAO/CTIO in Chile. He will complete some projects on the stellar content of star forming regions, for which a variety of data have been obtained in the course of commissioning infrared cameras over the past several years. Some of these data have longer term and more general utility as well, and these will be gathered into a publicly accessible archive for access and use by the community. Probst is interested in the prospects for IR imaging at high angular resolution and devoted considerable effort in 1994 to a demonstration of this capability on the KPNO 4-m at 3-4 μm. While at CTIO, he will be involved in bringing similar capabilities on line at 1-2 μm. This program brings together adaptive optics capabilities separately developed at the two sites. Probst is interested in the application of this capability to infrared astrometry, a heretofore unexplored area. He shares research interests with several colleagues in the Department of Astronomy at the University of Chile and will be working with them in research and instructional/advisory activities. This is expected to strengthen further the cordial relationship NOAO has had with scientists in a host country.

As a Support Scientist, the bulk of Probst's activities have been devoted to service activities for the past eleven years. His visit to CTIO is largely a sabbatical for purposes of personal research. However, as Instrument Scientist for the Cryogenic Optical Bench, he will act in an informational and advisory capacity to ETS engineering staff as this instrument is reconfigured into a high spatial resolution mode for Fall 1995. He has been Optics Scientist, charged with maintaining optical collimation of telescopes on Kitt Peak. He will be training and advising his successor scientist (Chuck Claver) in this role. They are working jointly to confirm quantitatively the diagnostic results of wavefront curvature sensing by other means and to export the highly automated real time wavefront curvature analysis package used at WIYN to other sites via IRAF. Finally, Probst's activities at CTIO in developing a high spatial resolution capability will be a major service function during his time there.


Jones, T.J., ...Probst, R., ... and eight others 1994, AJ, 107, p.2120, “Near-infrared Survey of the OMC2 Region”

Stephen Ridgway - Stars and star formation; infrared imaging and spectroscopy.

Stephen Ridgway will continue his collaboration with the Center for High Angular Resolution Astronomy at Georgia State University, working on the design and construction of the CHARA
Interferometric Array (H.A. McAlister, PI). During FY 96, the major contracts will be let for telescopes and facilities. Ridgway will also use the new high resolution imaging mode of the Cryogenic Optical Bench at the 4-m telescope to determine the luminosity function for young stars in the Orion BN-KL star formation region.

Ridgway has continued his work on the development of high resolution infrared imaging at NOAO. This has included the development of the Diffraction Limited Infrared Imaging prototype (DLIRIM) and its initial operation, development of a plan for NOAO to obtain access to the Air Force Starfire Laser Adaptive Optics (AO) equipped telescope, and review of plans to equip KPNO telescopes with adaptive optics capability. He participated in the KPNO and NOAO 2000 planning process, especially in the areas of site testing, image quality and adaptive optics. He participated in the KPNO self-evaluation. He attended the IRAF Technical Working Group national meetings in 1994 as a representative of the NOAO scientific staff. He also worked with CTIO staff in planning seeing tests and the design of a mechanism for tilt correction with the secondary mirror of the CTIO 4-m telescope. Outside NOAO, Ridgway has participated in reviews of Gemini plans for adaptive optics and presented a paper at the AAS describing the Gemini AO plans. He worked with the Center for High Angular Resolution Astronomy at Georgia State University in preparation of their proposal to NSF to build an interferometric array of seven telescopes and has worked on several NASA committees (chairing one) in the planning of ground and space based instrumentation for solar system science and extra-solar planetary detection. He wrote an article on interferometry for the new edition of Astrophysical Quantities. He served as Ph.D. advisor to V. Foresto, who received his degree in 1994, and is now advising G. Perrin, who is working part time in Tucson on the Infrared Optical Telescope Array at Mt. Hopkins. In Tucson he consulted with H.M. Dyck (U. of Wyoming) and research associate J. Benson (CFA) on their work at IOTA. During a three month sabbatical at Meudon Observatory, he consulted with students Beuzit, Gendron, Zhao and DeMailly on their adaptive optics and interferometry related thesis projects.


Ata Sarajedini - Stellar populations, globular clusters, dwarf galaxies.

Sarajedini’s 1996 research program will be concerned with continuing work on understanding the formation history of globular clusters in the Local Group. The formation of the globular clusters is important in probing the formation of the galaxies themselves. The observational plan of attack consists of both ground-based observations from Kitt Peak, Cerro Tololo, and the European Southern Observatory, and spaced-based observations using the Hubble Space Telescope. He and his collaborators will derive age information for globular clusters in the Milky Way, M31, and M33 by constructing color-magnitude diagrams. By comparing the relative ages of clusters in each galaxy to each other and to clusters in the other Local Group galaxies, they will be able to place the formation of each galaxy on a
time line. In addition, they will look for differences in the ages as a function of the morphological type of the galaxy. There are also a number of smaller projects on which Sarajedini plans to work. These include the construction of the first photometrically complete luminosity function for blue straggler stars, the construction of a set of standard globular cluster giant branches in the Washington photometric system, and photometry of several poorly-studied open clusters.

Sarajedini’s service to the Observatory has come on two distinct fronts. First, he is the instrument scientist for the CCD photometer (CCDPHOT), which is used on the 0.9-m telescope. Since assuming the position in summer of 1993, he has worked to make the system operate more smoothly and to improve and clarify the documentation. He is currently in the process of testing a new CCD detector in order to obtain better response in the U band. Secondly, Sarajedini is the Staff Contact for all non-Schmidt imaging proposals. As a part of this responsibility, he also performs new-observer starts for imaging programs on the 0.9-m, 2.1-m, and 4-m telescopes.


**Nigel Sharp** - Large scale structure in the Universe; the dynamics and evolution of double galaxies; image processing in astronomy.

Sharp’s current accumulation of data for the peculiar active galaxy NGC 3310 should enable a fairly comprehensive paper, perhaps settling some of the puzzles that remain. Sharp is preparing a double galaxy atlas and some dynamical analyses of double galaxy samples for publication. He has recently become involved in a project about large scale outflows from Herbig-Haro and other young stellar objects, with David DeYoung. He expects to continue working on NOAO’s World Wide Web presence, responding to events like the near-earth asteroid encounter observed at the 2.1-m (http://www.noao.edu/asteroid/asteroid.html), as well as enhancing NOAO’s general information and services. He anticipates some involvement with the Kitt Peak Visitors’ Center, including image collections for sale.

As a support scientist, most of Sharp’s work is service. He will continue to operate and manage the VMS cluster and the Scientists’ Workstation Network, as well as the extra Digital systems used for testing purposes. He will also be tracking and organizing the cabling of offices, and handling computer power-related questions in conjunction with Central Facilities Operations. He will also be helping with computer-related activities for special events, such as the forthcoming ADASS V conference. Sharp provides general image services for staff (e.g. IC4182), for the PIO general collection, for Web pages
Francisco Valdes - Data analysis algorithms, cosmology, SETI, spectroscopy.

In the next year Valdes plans to begin a program to collect a digital library of moderately high resolution spectral types. This library will be used to improve automated spectral classification algorithms. These algorithms will then be used to classify large numbers of stellar spectra from surveys to obtain physical properties of the stellar population in the solar neighborhood. Other projects are in developing new data analysis algorithms for spectroscopy and data quality assessment at the telescope.

Valdes’s service work is in the support of existing data reduction software and in the development of new data reduction software for IRAF and FOCAS. The software includes those programs used at the telescope to evaluate data quality, those used at the telescope and at home institutions for basic CCD reductions, and software for complete data reduction and analysis of deep galaxy imaging and spectroscopy.


Lloyd Wallace - Planetary atmospheres, changes in constituents in earth’s atmosphere, radiative transfer, infrared spectroscopy of stellar atmospheres.

Lloyd Wallace plans (with Ken Hinkle) to perform a systematic analysis of moderate-resolution spectra in the 2 μm region of standard stars in the Morgan-Keenan classification system. These spectra of bright stars are from the Fourier transform spectrometer at the 4-m telescope. The objectives are 1) to determine the variation of the strengths of the various absorbers with spectral class and luminosity and 2) to determine, where possible, the correlation of the infrared spectral character with M-K type. Another program, also with Ken Hinkle, is the analysis of a smaller number of fully-resolved spectra of a sample of the brightest standard stars in the 2 μm band.

Wallace’s main contribution is in the support of the Telescope Allocation Committee in preparing documentation and recording committee recommendations and supervising the writing of the observing schedule. He also advises the library on acquisitions and general policy matters.

Wallace, L., Livingston, W., Bernath, P. 1994, NSO Technical Report 1994-01, “An Atlas of the Sunspot Spectrum from 470 to 1233 cm⁻¹ (8.1 μm to 21 μm) and the Photospheric Spectrum from 460 to 630 cm⁻¹ (16 μm to 22 μm)”
APPENDIX 3

National Solar Observatory

Scientific Staff: Primary fields of interest and 1994 publications.

Richard Altrock - Studies of the long- and short-term variation of the solar corona.

R. Altrock (USAF/PL) will work on solar-cycle studies of the solar corona, using data from the SP Emission-Line Coronal Photometer (ELCP). This will include investigation of the variation of activity and rotation as a function of latitude and various periodicities in activity. Efforts to understand the implications of, and to refine knowledge of, overlapping solar cycles as observed in the corona will be continued. Studies of the variation of Fe XIV and Fe X coronal flux and their relationship to other global solar parameters will be performed. ELCP data will be searched for transients, and correlations with chromospheric, upper-corona (from space-based instruments), and possibly solar-wind and geomagnetic data will be investigated. Studies of coronal mass ejections will begin with data from the full-limb “One-Shot” coronagraph after modifications to add a CCD camera are complete. Altrock will continue work on the design and construction of a new space-based system to observe interplanetary disturbances, called the Solar Mass Ejection Imager (SMEI). Investigations of the spatial and temporal variations of coronal temperature will continue. Correlations will be performed on east-limb ELCP Ca XV intensities and flare intensities of associated active regions during their disk passage. Studies of the relationship of coronal hole properties to solar wind speed will be carried out.

Altrock tracks the effects of pollution on Sac Peak skies. He became a member of a new NASA working group, “The Thermosphere, Thermal Environment and Solar Conditions Working Group of the Space Environment and Effects Program.” Altrock was responsible for the upgrade of the “One-Shot” coronagraph, which is now proceeding towards the goal of obtaining high-resolution electronic images of the corona, and for ELCP synoptic program. ELCP data acquisition and reduction programs were improved and modified to accept data from the new data acquisition computer, ESFICC. He began in 1994 to obtain data at four heights in Fe X and Fe XIV. He continues to manage the CORONALERTS worldwide alerting system for unusual activity in the solar corona. Daily data products continue to be faxed to the NOAA Space Environment Services Center and the Air Force Space Forecast Center. He continues to supply coronal data to NOAA for publication in Solar Geophysical Data and wrote an updated description of the data for publication therein.


**Karatholuvu Balasubramaniam** - Solar activity evolution, Stokes polarimetry, solar mass ejections.

K.S. Balasubramaniam (USAF/PL) will analyze data acquired during the past maximum of solar activity to seek velocity and magnetic field characteristics of active region evolution in support of the solar activity modeling initiative. This includes data obtained with the Narrow Band Filter and the Advanced Stokes Polarimeter. He will work on the large scale flow patterns of the Sun, seeking possible velocity signatures leading to solar mass ejections. He will also attempt to explore measurements of near-infrared magnetic fields.

Balasubramaniam is actively involved in the Research Experience for Undergraduates Program and the Summer Research Assistant Program at NSO/Sac Peak.


Doug Braun - Helioseismology.

D. Braun (SPRC/NSO) will continue his NSF- and NASA-sponsored research into the scattering of solar p-modes from sunspots and sub-surface magnetic fields. Using observations obtained from the geographic South Pole by S. Jefferies, T. Duvall, and J. Harvey, as well as data available from the GONG project, Braun intends to measure the scattering properties (absorption, phase shifts and mode-mixing) from a wide variety of active regions. Braun will seek to verify a signature of p-mode scattering from sunspots prior to their emergence on the solar surface, which has recently been observed for one such evolving region in the 1988 data set. In addition, Braun will continue to collaborate with Y. Fan and D.Y. Chou (Tsing Hua U., Taiwan) on phenomenological modeling of the observed p-mode scattering, from which they hope to deduce the sub-surface morphology and scattering strength of sunspots. Braun will also continue his collaboration with C. Lindsey on developing holographic techniques for probing the sub-surface structure of solar magnetic fields.

Sydney D’Silva - MHD studies of the structure and evolution of magnetic fields inside the solar convection zone, theoretical helioseismic investigation of local, sub surface flows and fields.

The theory of magnetic flux tubes in the convection zone has been successful in describing most of the magnetic features we see on the solar surface, such as the tilts of sunspot pairs and rotation velocities. However, plages and ephemeral regions, which are also believed to emerge from the base of the convection zone, remain elusive. D’Silva’s interest in this field will be in trying to understand this intriguing behavior exhibited by plages and ephemeral regions, and generating a unified scheme of flux tube dynamics which can explain the observed behavior. Understanding the sub-surface structure of these magnetic features and the velocity fields in the convection zone will aid this pursuit, and in this direction, “time-distance helioseismology” seems to be a potential tool. D’Silva will be involved in exploiting this tool and other possibilities which would aid our attempts in understanding the sub-surface structure and dynamics of magnetic fields, and thereby the mechanism that drives the solar cycle.


Richard Dunn - Image restoration, instrumentation.

R. Dunn plans to continue his work on the solar adaptive optics program.

**Yu Hong Fan - Solar MHD; dynamics and structure of active region flux tubes; sunspot seismology.**

Y. Fan (ONR) will continue her work on the theoretical modeling of the emergence and structure of subsurface active-region flux tubes and will compare the results with observed properties of sunspot groups and active regions. The work is carried out in collaboration with G. Fisher (Space Sciences Lab, U.C. Berkeley) and R. Howard. Y. Fan will also continue her collaboration with D. Braun and D.-Y. Chou on theoretical study of the scattering of p-mode waves by sunspots.


**Mark Giampapa - Stellar dynamos, stellar cycles and magnetic activity; asteroseismology.**

M. Giampapa will obtain and analyze WIYN/Hydra observations of Ca II H and K emission in a survey of the numerous solar-type stars in the galactic open cluster M67. In this way, the mean level and the range of chromospheric emission in this solar-age (and solar-metallicity) cluster can be determined. This project is a necessary prelude to the implementation of a long-term program at a 4-m class facility to study the cycle and rotational properties of stellar analogs of the Sun. Giampapa also intends to utilize the McMath-Pierce FTS to simultaneously obtain He I 5876 Å and 10830 Å spectra of solar active and quiet comparison regions. The strengths of these purely chromospheric features will be compared to the predictions of model computations by Andretta and Giampapa. This work will be followed by the acquisition of contemporaneous, high spectral resolution observations of the same He I features, but as they appear in F and G dwarf stars. The 5876 Å spectra will be obtained using the McMath-Pierce solar-stellar spectrograph while the near IR 10830 Å data will be obtained with the NICMOS array that is now resident at Kitt Peak. The results will be used to estimate the filling factor of magnetic active regions on solar-type stars. Giampapa will continue to investigate the feasibility of programs in asteroseismology using the McMath-Pierce solar-stellar spectrograph. The recent installation of the new cross-dispersed system provides the advantage of being able to observe many spectral lines simultaneously. Giampapa will first determine if solar oscillations can be detected with this system when the Sun is viewed as a star. Finally, Giampapa will continue his studies of stellar coronal structure via his approved programs of ROSAT HRI and EUVE spectrometer observations.

Giampapa serves as the Project Scientist for the McMath-Pierce nighttime synoptic program of high resolution stellar spectroscopy. This activity includes supervising and conducting the program, its review and advocacy, upgrading of instrumentation so as to maintain competitive capabilities in stellar spectroscopy, providing information to current and prospective users, and establishing data dissemination and archiving methods and policies, in accord with NSO data policies. Giampapa chairs the McMath-Pierce nighttime TAC, which meets each semester. He interacts with the technical staff on scheduling, especially in those cases where special scheduling requirements are involved. Giampapa is supervising the upgrade of the stellar spectrograph through the introduction of a cross-dispersion capability and a large format array. The cross-disperser has been installed and is undergoing testing.

Other activities included recent service as a member of the LOC for the Tucson/AAS meeting and membership in the SOC for the forthcoming Ninth Cool Stars Workshop in Florence, Italy, during October 1995. In addition, Giampapa serves as a member of the editorial boards for the journals Solar Physics and Vistas in Astronomy. Giampapa serves on the board for the recently established Global Network of Automated Telescopes (GNAT, Inc.). This organizational entity was established to facilitate
the implementation of a world-wide network of small aperture, robotic telescopes that would provide photometry to a wide range of astronomical programs.


Ye Ming Gu - Solar physics, computational physics, and numerical analysis.

Y. Gu's (SPRC) research program for FY 1996 will concentrate on two subjects: 1) Stochastic radiative transfer in inhomogeneous media, with emphasis on its applications to the solar atmosphere (in collaboration with J. Jefferies and C. Lindsey); 2) Local helioseismology (in collaboration with C. Lindsey). He will also study general inverse problems.

Gu will continue to serve on the Solar Data Archive Committee. He will keep in touch with the solar physics group at the Physics Department of the University of Arizona and maintain relations and collaborations with scientists at the Yunnan Observatory in China.

John Harvey - Solar magnetic and velocity fields; helioseismology; instrumentation.

J. Harvey will concentrate on reducing and analyzing helioseismology data from the GONG network, from sixty-four days of data obtained at the South Pole during the past austral summer, and from an instrument designed to produce data at two different heights in the solar atmosphere. This work will be in collaboration with S. Jefferies (Bartol), T. Duvall (NASA), and Y. Osaki and H. Shibahashi (U. of
Harvey will also continue to use the 10830-Å filtergraph and spectromagnetograph instruments installed on Kitt Peak. A key goal will be to explore the utility of the 10830-Å line for detecting the roots of coronal mass ejections. Harvey will finish analysis of full-disk K-line observations obtained as a precursor to the RISE program.

Harvey performs observatory service as Chair of the NSO/KP TAC, Instrument Scientist for the GONG project, Telescope Scientist for the KP Vacuum Telescope, and Project Scientist for the 10830 Video filtergraph. In addition, he does outside service as a member of the NASA Solar MOWG, the NASA Solar Probe Science Working Team, and the NASA Mechanisms of Solar Variability Working Group. He is also assisting with editing of the journal Solar Physics.


Komm, R., Howard, R., Harvey, J. 1994, SP, 151, p. 15, "The Covariance of Latitudinal and Longitudinal Motions of Small Magnetic Features"


Karen Harvey - Solar cycle, active regions, ephemeral regions, coronal bright points, and magnetic fields.

K. Harvey (SPRC) will continue her research in four primary areas: (1) Collaborative studies with the Soft X-ray Telescope onboard Yohkoh. Of primary interest is a study of X-ray bright points and their association with the evolution of the underlying photospheric magnetic field and with their chromospheric counterparts, observed in He I λ10830 and Hα. Additional research areas will be coronal holes observed in He I λ10830 compared with those in soft X-rays, coronal mass ejections and their disk sources, and a collaboration with the SWICs Ulysses team comparing the behavior and characteristics of
magnetic field, the He I $\lambda$10830 line, and X-ray structures with the properties of events seen by this Ulysses instrument. (2) A study of solar irradiance based on the separation of magnetic structures observed in the photosphere. Use will be made of the NSO full-disk magnetograms to define objectively magnetic network elements and active regions to determine (a) a mapping function with Ca II K intensity, He I $\lambda$10830, and (b) the variation of the magnetic flux in these structures as a function of the cycle to establish their relative contributions to the total solar irradiance. (3) A project to estimate the contribution of ephemeral regions to the large-scale poloidal field and to determine more accurately the dependence of the tilt of their magnetic axes on latitude. (4) The study of the configurations and evolution of the large-scale magnetic field patterns that lead to the formation of filaments and filament channels.


Schrijver, C., Harvey, K. 1994, SP, 150, p. 1, "The Photospheric Magnetic Flux Budget"


**Frank Hill - Helioseismology, the fluid dynamics of the solar convection zone, and the solar activity cycle.**

F. Hill plans to continue collecting data using the High-L Helioseismograph at the Kitt Peak VTT. In collaboration with researchers at the University of Southern California, the Astrophysical Institute of the Canaries, the University of Colorado, and the University of Cambridge, he will continue to develop methods to infer the horizontal velocity field in the solar convection zone. Hill plans to analyze the data that will be available from the GONG prototype and field instruments to continue development of the merging algorithm for GONG. Hill will also test the GONG data reduction pipeline and quantify any systematic errors resulting from the data processing. He will use the GONG data to develop inversion methods and to infer the internal solar rotation rate. Hill will complete an analysis of the resolution and noise in the internal velocity field as inferred from ring diagram analysis of data from various instrumental scenarios. Hill will continue to work with the SOI personnel to develop methods of measuring frequencies and splittings from high-degree power spectra. The SOI group will also continue
to work on the effect of magnetic fields on observations of the solar oscillations. Hill will also work on the development of a solar data archive and on a concept for an imaging Fourier Transform Spectrometer.

Hill serves as the GONG Data Scientist, the FTS Instrument Scientist, and supervises the Applications Software programmers as ongoing functions. He is also a member of the Telescope Allocation Committee, the Project Review Committee (PRC), and the Mountain Operations Working Group. He is the chair of the Near-Surface Helioseismometer instrument group and a member of the Solar Data Archive group. He is the Co-Principal Investigator on the recently funded Astronomy Education grant. He is leading one of the GONG deployment teams. He obtains synoptic observations at the KPVT when necessary. He is currently leading projects to upgrade the FTS ADC and to study an imaging FTS concept.


Robert Howard - Observational study of surface magnetic orientations and velocity fields as diagnostics of the sub-surface dynamo process in the Sun.

R. Howard will continue studies of surface characteristics of solar active regions as diagnostics of sub-surface flux tube dynamics. This work promises to shed light on the dynamo process that is believed to operate near the base of the convection zone. These studies are being carried out in several collaborations. One is with P. Gilman (HAO) and K.R. Sivaraman (Indian Institute of Astrophysics). This project has involved the measurement of the positions and areas of all of the sunspots on the daily Kodaikanal (India) white-light, full-disk photographs of the Sun, starting in 1906. Analysis of these data, in conjunction with similar data from Mount Wilson measured several years ago, will continue during the next year. Rotation rates and meridional motions of these spots will be examined and the results from the observations at the two sites will be compared. Other collaborations with Y. Fan and S. D'Silva will continue. These studies will involve the Kitt Peak magnetograph archive, the Mount Wilson sunspot data set and the Mount Wilson magnetic active region data set, put together by Howard several years ago. These studies will center on the effects of Coriolis force and other effects that govern the orientation of the magnetic field lines that emerge to form active regions.

Howard provides editorial assistance for all NSO documents (quarterly reports, newsletter input, etc.) In addition he serves on the Scientific Personnel Committee and chaired a group that contributed solar data archive planning to the NSO Future Directions Plan. In addition, as a service to the community, he serves as co-editor of the journal Solar Physics.

Howard, R. 1994, SP, 149, p. 23, "A Possible Coriolis-Force Contribution to the Tilt-Angle Rotation of Sunspot Groups"


Komm, R., Howard, R., Harvey, J. 1994, SP, 151, p. 15, "The Covariance of Latitudinal and Longitudinal Motions of Small Magnetic Features"

**Stuart Jefferies - Helioseismology and image restoration.**

S. Jefferies' (Bartol) main research drive in FY 1996 will be to reduce and analyze the South Pole helioseismic data that was obtained during the Antarctic summer of 1994-1995. This data will allow him, with his collaborators, to determine the physics of the acoustic oscillations with frequencies above 4 mHz, the wave properties of the solar atmosphere, the variation of the acoustic oscillations with the solar activity cycle, and the sub-surface structures of magnetic features. The iterative, blind deconvolution image restoration algorithm that Jefferies has developed has been very successful, both for helioseismic work and general astronomical imaging problems. He plans to extend the algorithm for use with non-isoplanatic point spread functions. This work will be computationally expensive and will require the use of a parallel computer (e.g. the Paragon at SDSC).


Harrison Jones - Structure, evolution, and measurement of solar magnetic fields.

H. Jones (NASA/GSFC) will continue studies with V. Andretta of the formation of the He I triplet series resonance line at 10830 Å, using spectromagnetograph and rocket EUV observations as well as observations from the SOHO spacecraft when they are available. Jones will complete first analysis of multi-dimensional spectromagnetograph data to understand the origins of variations in bolometric solar irradiance. He will continue to pursue studies of filament formation and evolution with V. Gaizauskas and will apply a new method for mapping magnetic polarity inversion lines to studies of filament channels in collaboration with K. Harvey, J. Zirker, and V. Gaizauskas. Jones will also participate in the joint NASA/NSO instrumentation program for the NSO/KP Vacuum Telescope, which includes initial observations with a new 10830 Å video filtergraph and magnetograph and installation of a CCD-based guider and image-motion compensator.

Jones is project leader for continued development of spectromagnetograph software and co-leader with J. Harvey on development of the 10830 Å Video Filtergraph/Magnetograph and a fast image motion compensator for the KPVT. Jones serves as the Tucson “Partner” representative on the NSO management committee as well as on the Project Review Committee.

Stephen Keil - Solar atmospheric dynamics and active region development, predicting solar variability and its effects on the earth.

S. Keil (USAF/PL) will continue as a co-investigator on the joint APL/USAF/NASA/NSF flare genesis project. This is a program to fly an 80-cm telescope with a vector magnetograph on a balloon in Antarctica. The flight is currently scheduled for a December 10, 1995, launch. Keil, in collaboration with K. Balasubramaniam, Z. Mikic and D. Schnack (SAIC), and G. van Hoven (UCI), are using data on active region evolution collected during the previous solar maximum to analyze and model pre-activity dynamics, with a goal of developing predictive algorithms. Keil and Balasubramaniam are developing a narrow-band tunable filter that operates at 1.56 μm. The filter will be used at the VTT to make high-
resolution vector magnetograms in conjunction with the HAO/NSO Advanced Stokes Polarimeter. The goal of this project is to develop a simplified vector magnetograph that can be used in an operational mode. The ASP observations will be used to calibrate the vector field accuracy of the filter system.

Keil is responsible for the NSO-REU and SRA programs. He serves on the PRC to review projects and helps visiting astronomers with the narrow band filter and spectrographs at the VTT. Keil is in charge of the K-line synoptic program at NSO/SP which collects and distributes Ca II K-line data on a quasi-daily basis. Keil represents the Air Force program within NSO.


Christoph Keller - Study of small-scale magnetic and non-magnetic phenomena in the solar atmosphere, image reconstruction, post-focus instrumentation development.

C. Keller (Swiss NSF) will use the McMath-Pierce telescope to investigate solar magnetic fields in the quiet Sun, in particular the non-network fields, i.e. intra-network and turbulent background fields, by using the Zürich Imaging Stokes Polarimeter I and an enhanced version of the Near-Infrared Magnetograph. The weak non-network fields might be of considerable importance for our understanding of the solar cycle. Furthermore, new image reconstruction techniques will be used to reach the diffraction limit of the existing solar telescopes and will be applied to observations of the network magnetic fields to determine their intrinsic intensity. Collaborative studies in the optical, radio, and X-ray regimes will provide new hints on the three-dimensional structure of the quiet Sun from the photosphere to the corona. In collaboration with the Swiss Federal Institute of Technology in Zürich, the Zürich Imaging Stokes Polarimeter II will be developed.


Jeffrey Kuhn - Helioseismology, infrared solar physics, instrumentation, astrophysics.

J. Kuhn will continue working with the RISE/PSPT photometry experiment. Operational data from the prototype system at Sac Peak will be augmented by other working instruments during the year as they become available. He will also begin working on photometry data from MDI/SOI to study p-mode oscillations and to look for g-modes. A program to obtain infrared coronal spectra from the Evans Solar Facility continues, while the weather-limited IR coronal data from the last eclipse is also being studied. As resources become available, a new IR camera and narrow-band imaging system will be constructed. Efforts will begin in the study of a large reflecting coronagraph (CLEAR).

Kuhn serves as the project scientist for the community project PSPT instruments. He also serves on the site TAC and the PRC, as well as being the primary contact for all IR observations at NSO/SP.

Coulter, R., Kuhn, J. 1994, 13th Sacramento Peak Summer Workshop, ed. R.R. Radick, p. 37, “RISE/PSPT as an Experiment to Study Active Region Irradiance and Luminosity Evolution”


Penn, M., Kuhn, J. 1994, SP, 151, p. 51, “How Bright is the [Si-X] 1431 nm Coronal Emission Line?”


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John Leibacher - Helioseismology and atmospheric dynamics.

J. Leibacher will be devoting the majority of his efforts to assuring GONG's technical and scientific success. He will also continue work on techniques of time series analysis and — hopefully — return to work on chromospheric oscillations, as seen for example in Helium λ10830. Ideas on the observational signature of the convective excitation of p-mode oscillations and the detection of gravity modes will be pursued with data from GONG as well as the SOI/MDI on board the SOHO spacecraft.

Leibacher serves as the director of the Global Oscillation Network Group program. He also serves on the editorial board of Annual Reviews of Astronomy and Astrophysics and Solar Physics, and on NASA’s Space Science Advisory Committee.

Haosheng Lin - Solar irradiance variations, infrared measurements of solar magnetic fields.

H. Lin will be working on the construction and implementation of the Precision Solar Photometric Telescope (PSPT) for the RISE project. Lin expects to have the prototype PSPT operational in FY 1996, and to start providing the data to the solar community. The PSPT data will consists of high spatial resolution (1"/pixel) and photometric precision (better than 0.1%/pixel) full disk images in the Ca K line and two other continuum wavelengths that will be determined in the near future. This will be the beginning of the process to build up a database spanning over a solar cycle for the studies of the total solar irradiance variations observed from satellite experiments. In the short term, Lin is interested in using these data for the study of the energy balance of active regions, the continuum contrast of the faculae and network elements, and to search for brightness structures that may be related to large scale flow on the Sun.

Lin also plans to continue his earlier work on infrared measurements of solar magnetic fields. These include the measurement of the weak intra-network magnetic fields and vector magnetic field of sunspots and active region plages. His earlier results showed that the magnetic field strength of the intra-network magnetic field elements is intrinsically weak, approximately 500 G, and that the fields may not be generated by the same mechanism that produces the sunspots and active regions magnetic fields. He plans to obtain Stokes V data with better than 0.1% accuracy to study the characteristics (magnetic field strength, contrast, velocity) of the intra-network magnetic fields.
Charles Lindsey - Local helioseismology, infrared solar physics.

C. Lindsey (SPRC), S. Jefferies and D. Braun are working on a project to explore the prospect of using p-modes to detect sub-surface magnetic structure. The general concept is called “local helioseismology.” The particular goal of this project is to develop techniques in computational holography that will allow them to extrapolate the acoustic field observed at the solar surface into the interior. They have been using the NSO-Bartol-NASA South Pole Observations of 1987, 1988 and 1990 as their main database. They now hope to include the much more extensive and higher-quality database provided by the 1994-95 South Pole observations as well as the GONG database that is soon to come on-line. They have made a detailed survey of acoustic power maps of the 1987, 1988 and 1990 data in selected acoustic passbands and have seen instances where acoustic features are essentially invisible in solar images of plage and in magnetograms, but are clearly connected with surface magnetic structure, such as sunspots. They also see strong acoustic signatures from emerging plages long before a strong manifestation is seen in the K-line. They are preparing a preliminary program of holographic computations to determine whether some of the features they are seeing are caused by sub-surface interactions.

Lindsey, J. Jefferies and Y. Gu are working on a project to model inhomogeneous chromospheric structure, based on theoretical work originally developed by Jefferies and Lindsey to treat LTE radiative transfer in inhomogeneous media. They are now creating inhomogeneous models to match the extensive limb-profile observations in the sub-millimeter and near-millimeter continua made by Lindsey, Jefferies and other colleagues at the Kuiper Airborne Observatory (KAO) and the James Clerk Maxwell Telescope (JCMT) on Mauna Kea. Lindsey is now completing a program with Jefferies and former NSO postdoc G. Kopp to analyze sub-millimeter observations from the JCMT. These observations will contribute to improvements in models of sunspot umbrae.

Lindsey and D. Rabin have been involved in a program led by T.A. Clark (U. of Calgary) to determine the limb profile of infrared CO lines at ~4.5 μm. The program gave Clark 0.1" (75 km) height resolution and showed the lines to be truncated to heights considerably lower than previously thought, leading to the conclusion that the chromospheric medium contains no substantial component cool enough to support CO formation above about 1,200 km.

Lindsey serves as the NSO/T supervisor for the REU/Summer-Student Research program. He is also the organizer of the NSO/T Weekly Scientific Luncheon. Lindsey occasionally serves as host for NOAO’s Public Evening, and lends his support to scientific programs on the McMath-Pierce Solar Telescope. He has been closely involved with T.A. Clark’s infrared CO-line diagnostic program, which included highly successful limb-occultation observations of the nearly annular eclipse of 10 May 1994 on the McMath-Pierce Telescope.

Donald Neidig - Solar activity (especially flares), flare optical spectral analysis, flare high-energy emissions, instrument development, and the development of solar flare prediction methods and algorithms.
D. Neidig (USAF/PL) will continue in collaborative efforts to establish a unified understanding of flares and large-scale phenomena that are linked to coronal manifestations of solar activity; for example, the relationships between flares, Moreton waves, coronal mass ejections and particle acceleration; also, the flare "nimbus" phenomenon will be investigated. Predictive capabilities will be emphasized, making use of a statistical base of parameters derived from vector magnetograms. Work will begin on the Phase A study for CLEAR, including the capability of the latter instrument to detect orbital debris. Efforts to complete the instrumentation and science planning for the SWATH mission will continue as funds allow.

The Multiband Patrol will be tested and brought on line. D. Neidig will continue to assist in providing data acquired by NSO to outside users. He is serving as chairman of the Arts Committee for the Sunspot Education Center and NSO/SP Visitor's Center.


Laurence November - Solar polarimetry, polarization optics and solar convection.

L. November will continue work on solar magnetic-field measurements using liquid crystals. Initial tests demonstrate the power and feasibility of the polarimeter system, which utilizes a differential polarization analysis system based upon two CCDs, and the Fourier spectral analysis features inherent with our use of a Lyot filter to avoid magnetic saturation effects. With an upgrade to the LCP housing, and 403 x 256 MDA CCDs at the Tower, the system will be used for a magnetic field/chromospheric temperature run in collaboration with T. Ayres and D. Rabin. O. Bouchard is presently working on an improved data acquisition system based upon two 1024 x 1024 arrays, which will provide an enormous improvement in signal to noise and collecting area. It is anticipated that the data acquisition system will be in operation in the fall and provide the maximum polarimetric sensitivity for a number of scientific runs. In the winter, November will work on modifying an existing Lyot filter with liquid crystals to replace the existing VTT/UBF and provide a solid-state imaging polarimeter tunable in the range of 3000 Å to 11000 Å.

November is also analyzing the spatial distributions of velocity and intensity amplitude and phase in a number of lines that span the range of heights from the deep photosphere to the middle chromosphere, in order to investigate the wave mode distribution. Preliminary work reporting a number of new observational results on the height variation of the wave amplitude and phases is being submitted, and a mathematical scheme for recovering the spatial eigenfunctions is being developed. This scheme represents an improvement over more conventional methods which are based on approximate methods for estimating the p-mode eigenfrequencies.

November is responsible for the photolab, library, colloquia, and is a member of the TAC. He is responsible for the Liquid Crystal Polarimeter project. In an effort to consolidate the photolab-observing responsibilities, NSO/SP has worked to upgrade while simplifying the daily photographic Hα image service by providing higher quality digital data in Hα and K available through ftp. The daily images are now being scanned using our fast microphotometer to cover both the video SELSIS service used for the NOAA patrol and the Solar Geophysical Data publication.
Douglas Rabin - Magnetic fields and infrared solar physics.

D. Rabin will continue to study the structure of the magnetic field in the deep photosphere using the Near Infrared Magnetograph (NIM). The scientific goals include characterizing the spatial and statistical properties of magnetic flux tubes and measuring the vector magnetic field in and around sunspots. An initial attempt (with C. Keller, ETH/Zürich) to measure internetwork fields using a polarizing beamsplitter in the NIM optical path yielded results promising enough to justify a more systematic approach during FY 1996. Early in FY 1996, first light is expected from NIM-2, an imaging magnetograph based on a Fabry-Perot etalon. Rabin will continue his studies, with several collaborators, of thermal inhomogeneities and oscillations in the temperature minimum region using vibration-rotation lines of carbon monoxide near 4.7 µm. With J. Beckers and W. Livingston, he will analyze data from the image-quality sensors now installed in the McMath-Pierce Telescope.

Rabin serves as head of the NSO/Kitt Peak Science Branch, chair of the NSO/Tucson Project Review Committee, chair of the NSO/Kitt Peak Mountain Operations Working Group, and is a member of the NSO/Kitt Peak Telescope Allocation Committee. He leads the solar infrared program in Tucson and is PI on the NASA-supported Near Infrared Magnetograph project.

Richard Radick - High-resolution solar imaging and interferometry; solar and stellar variability.

R. Radick (USAF/PL) will continue to work with R. Dunn and T. Rimmele on the development of the Mark II solar correlation tracker ("tip-tilt corrector") for use at NSO telescopes, and the characterization and compensation of optical aberrations in the VTT at Sac Peak. He also plans to further pursue interests such as optical correlation, extended source wavefront sensing, aperture masking techniques, and interferometry, all aimed at improving the resolution of solar imagery. He will continue his studies of solar and stellar variability, focusing on long (greater than 10-year) time series observations of variability among solar analogue stars, in the field as well as in clusters such as the Hyades or M67, aimed at using stellar observations to broaden our understanding of solar variability and its role in driving global change.


Thomas Rimmele - Adaptive optics and high resolution imaging. Helioseismology. Active region dynamics.

T. Rimmele will work on improving the image quality at NSO facilities, in particular the Vacuum Tower Telescope at Sac Peak. He will concentrate on the development and implementation of wavefront sensing techniques, a key component of the solar adaptive optics (AO) system currently being developed by NSO. This AO system will incorporate a wavefront sensor, based on liquid crystal display technology, that will be largely insensitive to slowly varying aberrations, such as those in the optical system at the
VTT. A slow, low-order wavefront corrector, based on a Shack-Hartmann type wavefront sensor, will be implemented at the VTT in order to correct these optical aberrations, which are mainly introduced by the entrance window. Wavefront data taken at the tower show that the Strehl ratio of the VTT can be increased by a factor of 4-5. He will continue to study mechanisms for the excitation of p-modes in collaboration with P. Goode (NJIT), L. Strous (NJIT) and R. Stebbins (JILA), and study active regions dynamics in the visible and infrared spectrum in collaboration with W. Schmidt (Kiepenheuer Institut) and J. Kuhn.

Rimmele is PI for the development of the Mark II correlation tracker, an instrument that will provide tip/tilt correction at NSO telescopes. He is working with R. Dunn and R. Radick on improving the optical performance of the VTT. This effort includes design and implementation of a low order wavefront corrector. He is organizing the ongoing collaboration with the Kiepenheuer Institut for the development of a fast, large format CCD camera system. He is Co-Investigator on the CLEAR proposal.

**George Simon - Magnetic fields, convection, and oscillations.**

G. Simon (USAF/PL) will study long-lived solar convection flows using combined observations from NSO/SP and two European observatories. Simon will measure the geometric structure of vortices and compare it with a potential field model which predicts the form of the vortex flows. Simon will also investigate how the Sun can have a quasi-static appearance while actually undergoing a complete and rapid transformation of its magnetic structure using kinematical modeling. Kinematic modeling will also be used to explain the diffusion of magnetic flux elements across the solar surface. This process affects both the decay and build-up of solar activity. Simon will carry out an analysis of several unusually long time series of solar convection to determine the evolution of long-lived mesogranulation and supergranulation flow cells. Because of their length, these are the first data sets ever obtained that hold hope of determining the birth and death processes, the velocity structure, and the advection of these cells.


**Raymond Smartt - Coronal and prominence dynamics; instrumentation.**

R. Smartt will continue with the analysis of coronal loop interactions. Specifically, the relationship of the morphology of post-flare loops as observed in coronal line emission, and in Hα, will be investigated to provide more insight into details of the complex plasma processes involved in loop interactions. Comparison of these optical data with similar phenomena observed in soft X-rays will be attempted if joint data common to the same events can be obtained. Work will continue on the development of mirror-objective coronagraphs, in particular on the construction of the third, mirror-advanced coronagraph (MAC III) instrument.
Smartt continues to serve as chair of the NSO/SP Telescope Allocation Committee and frequently hosts visiting scientists. He is a member of the core planning group for the Sunspot Science Museum and Education Center, with special responsibility for the science exhibits. He is also responsible for the organization (together with key members of the AF/PL Staff) of the 1995 Sac Peak workshop, “Solar Drivers of Interplanetary and Terrestrial Disturbances.” He heads the program to produce the white-light coronagraph for the SWATH mission (under sub-contract to SAO), the in-house reflecting coronagraph (Mirror Advanced Coronagraph — MAC) program, and he is a co-Investigator on the CLEAR proposal. In addition, he is a member of the NSO Project Review Committee and continues to provide assistance, both directly and as a consultant, on various aspects of optical instrumentation refurbishment and development at NSO/SP.


Clifford Toner - Global and local helioseismology, and image restoration.

C. Toner plans to continue work on testing the GONG data reduction pipeline to quantify any errors resulting from the data processing. He expects to be involved with updating/modifying some of the algorithms as we learn more about merging simultaneous data obtained at multiple sites. He also plans to begin analyzing the data to determine which of the six sites would be best suited for the proposed GONG
extension. Toner will use GONG data to develop local analysis techniques to investigate the interaction of p-modes with both surface and sub-surface magnetic fields. He will use similar techniques to look for evidence for acoustic power deficits at the antipodes of solar active regions.

**Jack Zirker - Prominences, filaments and surface flows.**

J. Zirker plans to continue collaborating with S. Martin and her consortium on the formation and development of filaments. Data on filament channel formation will be analyzed to reveal the source of the hemispheric regularities, discovered by Martin, that vary with the solar cycle. A proposal with O. Engvold (Oslo) has been submitted for observations of flows in the fine structure of filaments, using instruments onboard SOHO, the Swedish Solar Observatory, and NSO/Sac Peak's VTT. If accepted, this program would be executed in FY 1996. Zirker will develop methods for deriving horizontal surface flows from time-series of Calcium K-line images obtained with the High-L Seismometer at NSO/KP, and later, with the prototype of the Precision Solar Photometric Telescope. Such flows tangle coronal magnetic fields, which then heat the corona.

Zirker serves as Science Branch Head at NSO/SP. In this capacity he has responsibility for many of the operational functions of the Observatory. In addition Zirker chairs the NSO Scientific Personnel Committee.


Zirker, J., Engvold, O., Zhang, Y. 1994, SP, 150, p. 81, "Flows in Quiescent Prominences"

Zirker, J., Cleveland, F. 1994, SP, 153, p. 245, "Searching for Nanoflares"
APPENDIX 4
NATIONAL OPTICAL ASTRONOMY OBSERVATORIES
FY 1994 USER STATISTICS

VISITOR TELESCOPE USAGE

<table>
<thead>
<tr>
<th>Visiting Observers</th>
<th>CTIO(^2)</th>
<th>KPNO(^3)</th>
<th>NSO(^4)</th>
<th>NOAO Totals</th>
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<tr>
<td></td>
<td>US</td>
<td>Foreign</td>
<td>US</td>
<td>Foreign</td>
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<td>51</td>
<td>26</td>
<td>89</td>
<td>35</td>
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</tbody>
</table>

1 The figures in this table reflect the number of observers/users physically present at each observatory for the fiscal period. Multiple visits by a single observer/user are counted separately. This table does not include NOAO staff.

2 During the period 1 July 1993-30 June 1994, a total of 235 observing programs were carried out by visitors and the NOAO staff at Cerro Tololo. Visiting astronomers were assigned 90% of the scheduled telescope time and the remaining 10% was assigned to the staff.

3 During fiscal year 1994 a total of 308 observing programs were carried out by visitors and the NOAO staff at Kitt Peak. Visiting astronomers were assigned 83% of the scheduled telescope time and the remaining 17% was assigned to the staff.

4 During fiscal year 1994 a total of 158 observing programs were carried out by visitors and the NOAO staff at the National Solar Observatory. Visiting astronomers were assigned 47% of the scheduled telescope time and the remaining 53% was assigned to the staff.

VISITOR REDUCTION FACILITIES USAGE
NOAO Tucson*

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<thead>
<tr>
<th>Number of Institutions</th>
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<td>Grant Comparator 2 axis</td>
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<td>VAX and Workstation Computing Facilities</td>
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<td>143</td>
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* The numbers in the table above reflect duplicated usage of NOAO Tucson reduction facilities by visiting scientists. NOAO staff are not included in these figures.
### TABLE I
FUNDING BY SOURCE
(Amounts in Thousands)

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<td>(645)</td>
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**STAFFING SCHEDULE**
(In Full Time Equivalents)

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<tr>
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<th>NSF Funded - Base Budget</th>
<th>Non-NSF Funded</th>
<th>Total</th>
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<tr>
<td>Total</td>
<td>56.78</td>
<td>275.95</td>
<td>332.73</td>
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</table>

1 FY-1995 Program Plan, Revision I
### TABLE II

**SUMMARY OF NSF FUNDING BY COST CATEGORY**

(Amounts in Thousands)

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<td>1,823</td>
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<td>1,649</td>
<td>486</td>
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<td>2,359</td>
<td>2,206</td>
<td>129</td>
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### STAFFING SCHEDULE

(In Full Time Equivalents)

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<th>FY-1994</th>
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<td>13.00</td>
<td>24.50</td>
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<tr>
<td>Engineers &amp; Scientific Programmers</td>
<td>17.50</td>
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<td>4.00</td>
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<tr>
<td>Administrators &amp; Supervisors</td>
<td>9.00</td>
<td>8.00</td>
<td>3.00</td>
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<tr>
<td>Clerical Workers</td>
<td>21.00</td>
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<tr>
<td>Technicians</td>
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<tr>
<td>Maintenance &amp; Service Workers</td>
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### TABLE III

**SCIENTIFIC STAFF & SUPPORT**  
(Amounts in Thousands)

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<td>23</td>
<td>16</td>
<td>131</td>
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<tr>
<td><strong>Total</strong></td>
<td>23</td>
<td>36</td>
<td>10</td>
<td>16</td>
<td>10</td>
<td>59</td>
<td>59</td>
<td>78</td>
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</tbody>
</table>

|               | NSO   |       |         |        |                          |                 |              |              |              |
| **Total**                                | 1,397 | 2,118 | 670     | 701    | 486                      | 104             | 5,476        | 5,825        | 5,825        |

### STAFFING SCHEDULE
(In Full Time Equivalents)

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<th>7.00</th>
<th>6.50</th>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Administrators &amp; Supervisors</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
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<tr>
<td>Clerical Workers</td>
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<tr>
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<td>1.50</td>
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<tr>
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## TABLE IV

### INSTRUMENTATION

(Amounts in Thousands)

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### STAFFING SCHEDULE

(In Full Time Equivalents)

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**OPERATIONS & MAINTENANCE**

(Amounts in Thousands)

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### STAFFING SCHEDULE

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TABLE VI

OPERATIONS & MAINTENANCE BY COST CATEGORY
(Amounts in Thousands)

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STAFFING SCHEDULE
(In Full Time Equivalents)

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¹ Includes support for all Directors' offices (NOAO, KPNO, CTIO, NSO), funds held by Directors and not yet allocated to specific programs, recruitment and relocation, insurance, administrative services, freight to Chile, committee and observer travel support, and indirect costs and miscellaneous credits.
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<td>Supplies &amp; Services</td>
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<td>Domestic Travel</td>
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<tr>
<td><strong>Total</strong></td>
<td>535</td>
<td>32</td>
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<td>2,399</td>
<td>1,771</td>
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**STAFFING SCHEDULE**

(In Full Time Equivalents)

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<tr>
<td>Scientists</td>
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<td>Maintenance &amp; Service Workers</td>
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<td><strong>Total</strong></td>
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