

**ReSTAR Meeting Summary**  
**Renewing Small Telescopes for Astronomical Research**  
**July 2007 - Arlington**

The ReSTAR committee met on July 30-31 at the National Science Foundation in Arlington to continue its discussions concerning the future of small and moderate aperture telescopes through the next 10 years, particularly in the pre- and post-LSST and Pan-STARRS era. In attendance were Charles Bailyn (Yale University), Michael Briley (University of Wisconsin Oshkosh), Chris Clemens, (University of North Carolina), Jennifer Johnson (Ohio State), Deidre Hunter (Lowell Observatory), Robert Joseph (University of Hawaii), Steven Kawaler (Iowa State), Lucas Macri (NOAO), Randy Phelps (Sacramento State), Caty Pilachowski (Indiana University), John Salzer (Connecticut Wesleyan University), Michele Thornley (Bucknell University), and David Weintraub (Vanderbilt University). Tom Barnes attended representing the National Science Foundation. Suzanne Hawley (ARC Observatory Director) and George Jacoby (WIYN Observatory Director) participated in portions of the meeting as representatives of the group of private observatory directors. Vera Rubin attended as a guest of the ReSTAR Committee, and William Smith and Jay Frogel from AURA also attended part of the meeting, as did many colleagues from the NSF Astronomy Division.

We are grateful to the National Science Foundation for hosting our meeting, and especially to Tom Barnes and Liz Pentecost for their efforts to assure a successful meeting.

**Summarizing the Community Survey**

The meeting began with a general review of comments received from the community via the ReSTAR website and email. One hundred thirty nine online survey forms were received before July 30, 2007. Responses were sorted electronically and tabulated by question. Summaries of the numerical responses are given below, while written comments will be summarized in comments about scientific programs later in this summary. Note that numerical results may be biased by selection effects.

**1. To which of the following areas of scientific research does your own research expertise most closely relate? (Mark all that apply)**

The number of responses is given in parentheses below.

- Stellar physics (59)
- Structure and evolution of galaxies including stellar populations (50)
- Star formation and the interstellar medium (47)
- Cosmology, including the distance scale, supernovae, dark matter, and dark energy (32)
- Extra-solar planets (31)
- Accretion, high energy processes, AGN, and black holes (27)

- The Solar System (22)

Additional scientific areas identified include astrochemistry, gamma-ray bursts, massive stars, astrometry, time-domain astronomy, planetary nebulae, globular clusters, old stellar populations in the Milky Way Galaxy, binary Stars, fundamental calibrations, and nebular physics, many of which overlap with the categories above.

**3. Please rank which capabilities you will need to carry out your research on small and mid-size (1-5 meters) during the next five years (2008-12) and beyond 2012, after ALMA, NVO, LSST, Pan-STARRS, JWST, and GSMT come into operation. Rank the importance of all of the instrumental capabilities you would likely use, with “1” being the most important. If you are unlikely to use a particular capability, leave it unranked.**

Capabilities (Rank: 2008-12, 2012+)

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Wide field, broad band, optical imaging (1,1)  
 Moderate resolution optical spectroscopy ( $1,000 < R < 10,000$ ) (2,2)  
 High resolution optical spectroscopy ( $10,000 < R < 50,000$ ) (5,3)  
 High spatial resolution imaging in the infrared (7,4)  
 1-5 micron infrared imaging (3,5)  
 Wide field, narrow band, optical imaging (6,6)  
 1-5 micron infrared spectroscopy ( $R < 20,000$ ) (4,7)  
 1-5 micron infrared spectroscopy ( $R > 20,000$ ) (10,8)  
 Low resolution optical spectroscopy ( $100 < R < 1,000$ ) (8,9)  
 Very high resolution optical spectroscopy ( $R > 50,000$ ) (9,10)  
 Mid-Infrared (8-13 micron) spectroscopy (12,11)  
 Mid-infrared (8-13 micron) imaging (11,12)

Other (number of times suggested):

Integral Field or wide field, multi-object spectroscopy, all bandpasses (8)  
 High spatial resolution imaging in the visible (6)  
 Polarimetry and spectropolarimetry, optical/IR, high, low spectral resolution (6)  
 Optical/NIR interferometry (3)  
 Narrow field, broad-band optical imaging (2)  
 IR+mid-IR spectroscopy; very high resolution mid-IR spectroscopy ( $R > 30k$ ) (2)  
 Wide field, broad band, NIR imaging  
 LSST for brighter stars ( $V < 13$ )

**4. Consider what operational modes will be most important to you on small and mid-size telescopes in the next 10 years. How should time be allocated among the different operations modes during those two time periods to your science? For the modes listed below, indicate a percentage of time that should be available to the community through public access.**

Classically scheduled PI programs:	25.1%
Service or queue observing modes:	23.2%
Classically scheduled PI programs/remote observing:	20.9%
Time domain observing modes:	16.5%
Large, community-based survey projects:	14.4%

Comments received via the survey form represented a diversity of points of view. The committee noted that 139 responses are still less than 5% of the ground-based, OIR community and that we should not consider the responses to be representative. In particular, respondents who have stopped using public access facilities may be under-represented. The judgment of the ReSTAR will be important in balancing the various needs identified by the community.

The Committee noted several important points and a diversity of viewpoints in the survey responses.

- The diversity of science proposed by respondents is impressive.
- Many respondents noted that research on transient phenomena is becoming increasingly important and described research programs of interest.
- Some respondents argued that publicly accessible facilities needed to work at a high level of reliability while others felt that access was more important than reliability and that some unreliability might even be beneficial in providing a learning environment for students.
- For some, access to processed data was important, while others felt that the availability of pipeline processed data would lead people away from an adequate understanding of the limits of data. Others noted that the goal is for users, including students, to understand their data, but that goal doesn't necessarily mean astronomers must be present at telescopes themselves.
- Respondents also differed on the issue of building new facilities vs. refurbishing older ones. Building new, high-tech telescopes meeting modern performance specifications may be less expensive than trying to bring older facilities up to similar specifications.

The survey suggested that many astronomers remain primarily concerned with what's needed now to conduct their own research programs, but have not yet identified how their research needs and goals will change as new facilities such as LSST become available. Many were skeptical about LSST, and many expect to continue with large, wide field surveys even in the LSST era. These perspectives will likely change over the next few years, but the ReSTAR survey does indicate that community education will be an ongoing need. Our survey is a good starting point, but the responses do not clearly define what the system should be in 5-10 years.

Many respondents stress that observing experience for students remains essential, both to attract undergraduates into the field and to provide training for graduate students. Others felt that the system for national access was not the appropriate place for training students, and that university facilities should be used for training. For example, students can be trained to handle data at relatively low cost, using 14" telescopes and small CCDs. But at

least some students also need to learn to solve more complex problems. Large projects need managers who can understand very complex instrumentation and data systems. Nonetheless, mechanisms for the development of human resources, including advanced training for students in observing and in instrumentation, need to be built into the system, either at national facilities or at private ones. There is also a difference, between a student's experience on a small telescope and on a large one. Students observing on big telescopes don't see much technically. Perhaps the most important skill today is to teach students how to look critically at data. There is a concern that if astronomy becomes an NVO science, we will have trouble attracting the best and brightest students.

A number of thoughtful comments were received by email as well as through the survey. Comments from Bruce Weaver and Dave Silva provided particularly interesting perspectives.

The role of adaptive optics for small telescopes was not emphasized by the community, yet would likely transform the science that could be done with small telescopes, increasing their sensitivity substantially. Bill Smith noted that ACCORD will revisit and revise the AODP roadmap. Adding small telescopes to that roadmap should be considered.

George Jacoby and Suzanne Hawley, representing the group of private observatory directors, provided additional input. Jacoby reminded us that the system must include four major components - telescopes, instruments, astronomers, and software. He also noted that the Senior Review emphasized the importance of operations costs. The sum of operations costs for the existing facilities plus ALMA, GSMT, and LSST will use the entire NSF astronomy budget. We must consider the impact of operations costs in our planning.

Both Jacoby and Hawley noted the interest of the private observatory directors and the ACCORD group in the deliberations of the ReSTAR Committee, and those groups will continue to provide us with input. They are particularly interested in knowing how many nights of public access time the community will want on various facilities. Hawley emphasized that the private observatory directors want to know what facilities the community is interested in, and how those facilities will need to be improved to meet public access needs. Practical guidance from ReSTAR is needed, but she stressed that it is ReSTAR's job to see the big picture and the impact of new facilities in the future.

The diversity of capability desired by the community is extraordinary, and will likely never be achieved without extraordinary resources. While economies of scale may help to increase access beyond what is currently available, it is unrealistic to expect that all desired capabilities can be made available to the community through public access. Our system of small and midsize telescopes should, however, be responsive to those capabilities in highest demand and with the broadest and most compelling scientific rationale. The response of the system to the community's needs must be dynamic, providing for the greatest good, but not necessarily providing something for everyone.

Todd Boroson reported by phone that most of the directors of 2-5 meter telescopes have responded to express their interest in participating in a public access program to the extent of a few to a hundred nights per year.

### **Comments from Members of the Senior Review Panel**

Roger Blandford joined the committee by telecon to discuss the perspective of the Senior Review panel on small and mid-size telescopes, noting that the view of a 6-m as a small telescope is surprising but realistic. The SR tried to be clear and concise in its statements about small and mid-size telescopes, but the report has been misunderstood by some who see tension between the users of large telescopes and the users of small telescopes. The SR does not specifically support such constituencies, but instead aims to support the best science, independent of aperture. The SR report is advisory to NSF, which is responsible for implementation.

The SR noted three compelling reasons for continued support of small and mid-size telescopes: exciting and durable science, student training, and instrumentation development, and argued that resources should be allocated on the basis of competitive peer review rather than on the basis of access. The current status of many telescopes leaves much to be desired, and small application of funds could address infrastructure problems at CTIO and Kitt Peak, allowing effective use of these telescopes for excellent science.

Vera Rubin, who also served on the SR, described the intensive work of the panel, and thanked Wayne van Citters and Eileen Friel for the help they provided. She noted that although the cost of operations integrated over many years can be larger than construction costs, supporting a few small telescopes at national observatories provides access to many users without adding substantially to the financial burden.

Discussion continued among Committee members, Roger Blandford, and Vera Rubin. It was the SR's view that support for small telescopes would not be very expensive in the context of GSMT. A one-time application of funds could be used to reduce operations costs but funding should depend on scientific opportunities, assessed competitively.

The SR did not expect that new facilities would be built at Kitt Peak, which was seen to have a limited lifetime, but other northern hemisphere sites could be considered. Facilities might be built at San Pedro Martir, for example although travel would be more difficult for many U.S. astronomers. It is not clear whether other continental sites would remain competitive. The Happy Jack site of the Discovery Channel Telescope probably could not accommodate another large telescope. In the southern hemisphere, sites on Las Campanas might be considered.

Opportunities for interactions with the private observatories should be explored. Attitudes are changing, and the SMARTS, WIYN, and SOAR consortia are evidence of this change. Learning to work together on small telescopes is a similar but different process than collaborating on large telescopes like GSMT. Agreeing on priorities - a new

instrument vs. additional staff, for example, is a challenge, but not an insuperable one. NOAO can take the lead in representing the community. NOAO might provide project management for universities building new facilities or instruments.

## **The Science**

The Committee turned to a discussion of the science proposed through the online survey. Each of the ReSTAR science subcommittees presented a summary of the science described by survey respondents and the capabilities needed to carry out the research. The discussion also considered major science themes and goals in each science area that were not expressed through the survey but which are likely to be important science goals utilizing small and mid-size telescopes in the next decade.

**Cosmology** - Salzer summarized the twelve scientific programs described in the general area of cosmology, including the distance scale, supernovae, dark matter, and dark energy. Such programs included five investigations of gamma ray burst afterglows, seven programs monitoring supernovae, four wide field, narrow band, imaging surveys, two redshift surveys, three investigations of dark matter out to  $z=1$  using galaxy kinematics, and one study of distant, early type galaxies using photometric redshifts in the near IR. Fields that were not represented in the survey include lensing studies, both weak and strong. Several weak lensing surveys (especially the Dark Energy Survey) are already underway and it may be that LSST will dominate future lensing studies in the longer term.

What small and mid-size telescopes will do that Pan-STARRS or LSST won't do is rapid followup of transient sources using quasi-dedicated telescopes in the range of 2-3 meters aperture with a good IR camera. Local supernovae will probably saturate detectors with LSST or Pan-STARRS. LSST will find nearby supernovae, but other resources will be needed to monitor them. Many nights will be needed for this work.

Key instrumental capabilities include wide field, near IR cameras (are 16K arrays possible?) on 2-3 meter telescopes, and wide field, narrow band, optical imaging, also on modest-sized (2-3 meter) telescopes. Narrow band, wide field IR imaging will benefit from larger apertures, in the range of 4-6 meters, and while adaptive optics may not be essential for this work, it will provide greater depth for the same aperture.

Most spectroscopic followup of cosmological sources will need bigger telescopes, although redshift surveys of the nearby universe can still take good advantage of 1.5-m telescopes.

Investigators using galaxy surface photometry will want deep images, rather than relying on Sloan data. Will LSST meet this need? The VISTA and UKIDSS infrared surveys will eventually provide all-sky imaging in the IR.

Studies of galaxy clusters were also missing from the science described in the online survey. Sloan observations are not sufficient for the science to be done with the galaxy clusters discovered in the survey. Velocity dispersion observations are needed and can be obtained with 3-6 meter telescopes with multi-object capability.

Calibration of the distance scale using Cepheids and RR Lyraes variables will require wide field, broad band IR imaging, but from space, and are not key science drivers for ground-based OIR telescopes.

**Solar System** - Deidre Hunter reviewed the 18 Solar System science responses in the online survey. Light curves of asteroids were frequently mentioned, but didn't provide motivation or context. Hunter sought help from the Lowell Observatory staff. It was clear that access to small ground-based telescopes for Solar System science is important.

Large statistical samples of Solar System objects are needed to sort out important differences in properties. Long-term monitoring is important, and observations depend critically on remote observing with flexible scheduling. Many different time scales and special events dominate observing schedules, and many programs need small amounts of time every night or periodically. This requires scheduling for partial nights; remote observing, rather than queue or service observing, is desired.

The main science themes include a variety of studies.

- Kuiper Belt Objects, which form a bridge between the solar system and stellar astrophysics. Observational programs include dynamical studies, light curves, and spectroscopic studies of larger objects. The instrumental capabilities needed include wide field (2 degree FOV), 4-m class telescopes in both hemispheres.
- Asteroids, including physical characterization, dynamical studies, near Earth objects, and the search for hazardous objects. Broad-band, wide-field imaging with a 3-day cadence is critical.
- Comets, particularly the population beyond 3-7 AU. The big question is the origin of comets and the effects of solar heating at large distances. About 30 comets per year at distances between 3-7 AU are bright enough for spectroscopic studies with a 4-m telescope. Narrow band imaging through a specialized filter set for 2D information is needed, as well as long slit spectroscopy. Scheduling requires only parts of nights.
- Atmospheres of Planets, including the changes in gas composition with time (e.g. methane on Pluto), and atmospheric processes in general. This work requires high dispersion IR spectroscopy on 4-m class telescopes.
- Outer planets and satellites, including dynamical history, seasonal effects (Pluto), providing context for spacecraft fly-bys, and other cyclic activity (Io volcanoes have a two year activity cycle). This work requires requires optical and near-IR imaging capability on 2-m telescopes.
- Physical changes of properties of human debris in space.

Beyond 2012, planetary science will require many different time scales and targets of opportunity. Large FOV instruments on 4-m telescopes are particularly important.

The Committee also recommended that an astronomer with expertise in Solar System science be added.

**Stellar Physics** - Jennifer Johnson reviewed the science proposed for stellar physics. She noted that many stellar physics investigations involve relatively bright stars. For some, small apertures are required and for many large telescopes are not required. Important new instrument capabilities include NIR high resolution spectroscopy, mid-IR imaging and spectroscopy, polarimetry, and interferometry. The continued availability of high spectral resolution is especially important for progress in stellar physics; spectrographs with good blue response are needed, and throughput may be improved at longer wavelengths with adaptive optics.

Areas of stellar astrophysics highlighted in the many programs described in the online survey include determinations of stellar properties, studies of star clusters, characterization of planet host stars, exploration of the fossil record of the history of the Milky Way through observations of stellar kinematics and composition, stellar nucleosynthesis, variable stars, low mass stars, and calibration. Observations of transient events and long-term monitoring programs will be particularly fruitful. Little input was received from the microlensing community, and it is unclear whether national facilities are of interest for that science. Microlensing surveys will require telescopes in the 2-m class, preferably with longitudinal coverage.

**Compact Objects, Accretion Physics, (GRBs, AGNs, XRBs, CVs)** - Charles Bailyn noted that few respondents addressed science programs in this area and he supplemented this discussion from conversations with colleagues. Bailyn emphasized two key science goals: 1) the structure and evolution of sources, CVs and SN Ia precursors, GRB sources to obtain accurate physical parameters and demographics; and 2) understanding physical processes such as GRB mechanisms and accretion disk structure and evolution.

Time domain observations are very important in this field. Different observational problems will require a different response time. GRB optical/IR afterglows will require an instant response, while AGN reverberation mapping requires multiwavelength observations with time delays, for example. The need for different time scales can interfere among programs when targets of opportunity, coordinated observations, long term monitoring, dense monitoring, and very rapid time variability compete on the same facility.

The instrumental and observational capabilities needed to carry out time domain science effectively include

- Photometry on 1-2 meter class telescopes and spectroscopy on 3-5 meter class telescopes.
- Multiple sites for continuous coverage and to allow competing cadences.
- High speed (but not necessarily continuous) photometry.
- Real-time scheduling coordination.
- Uniform instrumentation among telescopes and sites.
- A rapid user-friendly data reduction pipeline.



The approach of the LSST era will drive the need for additional time-domain facilities. A "mini-LSST" will be essential. The saturation limit of LSST will be around 17.5. A smaller telescope, chained to LSST and in the same hemisphere, will be needed to provide a similar cadence of all-sky observations to a brighter saturation limit. A one day cadence will largely be covered by LSST/mini-LSST, but these facilities will generate a huge demand for other cadences, as well as a huge demand for spectroscopy of the brightest sources.

Other capabilities that will become important in the LSST era include low resolution, synoptic spectroscopy. Ultra high resolution imaging may also provide insight into the structure of inner accretion flow in all sources and the early stages of jets. For this purpose, one site is sufficient, either north or south, and should produce images below 0.1", in the magnitude range from 12-14. An interferometer comprised of 2-4 meter class telescopes with AO compensation will be needed.

**Structure and Evolution of Galaxies and Resolved Stellar Populations** - Deidre Hunter summarized the 34 responses in this category, which fell into several subcategories.

- Studies of the resolved stellar populations in nearby galaxies require imaging with apertures from 2-3 meters.
- Studies of the extreme outer disk of galaxies, as relics of the star formation histories, require both imaging and spectroscopy (for kinematics) on 2-4 meter class telescopes. Moderate to high resolution spectroscopy on larger apertures (around 4-m) is needed to probe chemical enrichment histories of nearby galaxies.
- Imaging on 4-m class telescopes will be needed for studies of the RR Lyrae populations to disentangle the star formation histories of local group galaxies.
- To investigate star formation processes in nearby galaxies will require 2-4 meter telescopes for imaging, particularly in the outer disks - where gas density is low and standard star formation processes don't work.
- Galactic superwinds can be studied with 0.9-m telescopes using narrow band imaging.
- Studies of interacting and merging galaxies require surface photometry in K band to search for tidal debris.
- Finding intracluster stars and starlight - evidence of ongoing tidal stripping, especially as a function of redshift, requires narrow band imaging with 4-m class telescopes.
- Beyond 2012, LSST and Pan-STARRS will provide target lists and broad band colors for spectroscopic targets.
- ALMA and JWST will extend this science to more distant galaxies, and also complement existing studies from other wavelength regimes.

In summary, science in this category will require optical spectroscopy in the resolution range  $1000 < R < 10000$ . Wide field, broad-band, as well as narrow-band optical imaging will also be important. For some programs, higher resolution spectroscopy, up to

R=50000 will be needed. In addition to optical instrumentation, near-IR imaging and spectroscopy (R<20000) will be needed.

**SF and ISM** - David Weintraub noted very few respondents addressed science in this area, but identified several key programs, including:

- Surveys of star-forming regions.
- Spectroscopic confirmation of the many brown dwarfs that will be found.
- Followup of the Spitzer Warm Mission as well as of other wide field NIR surveys. A 4-m class telescope for deep, wide-field NIR imaging is particularly needed in the northern hemisphere for followup. Spitzer followup will require roughly one-year of ground-based time with a one-degree field of view on a 4-m telescope.

Weintraub stressed that time domain observations will be especially important in studies of star formation, with sampling rates from a few seconds on up. Science programs will include searches for and study of extrasolar planets and proto-planets via transits studies of microlensing, rotation, rotational evolution, and accretion phenomena. Searches for young eclipsing binary systems are needed to determine masses for young stars.

For studies of the interstellar medium, high resolution spectroscopy will remain the essential tool, and both optical and near-infrared spectrographs will be needed.

**7. Exoplanet Science** - Mike Briley reviewed responses in the area of exoplanets science. 31 respondents indicated interest, 19 described specific science programs. He noted that proposal pressure for studies of exoplanets has increased from 14 to 30 proposals in the last two years. The key science questions include:

- What is the fraction of stars with planets?
- What is the average number of terrestrial planets per star?
- How do planets form (accretion/instabilities)?
- What are the characteristics of host stars?
- Where do hot Jupiters come from?

Four principal techniques require access to small and mid-size OIR telescopes.

- Radial velocity measurements using echelle spectrographs on telescopes mostly with apertures less than 4 meters account for most of the 200+ exoplanets now known. Observations in the NIR will become more important, both because young stars are bright in the NIR and because the velocity jitter should be less in the NIR than in the optical.
- Four planets have been found using microlensing on telescopes of modest aperture (OGLE is a 1.3-m telescope). Surveys are ongoing, and followup observations are well-organized.
- Transits require only relatively small telescopes, and the observations are important for confirmation of exoplanets found spectroscopically, providing inclinations, size estimates, and some information on compositions. The ability to obtain high resolution, high S/N ratios spectra during transits will be important to

determine spectral lines asymmetries, from which the orientation of orbit with the rotation axis and the direction of revolution with respect to host stars may be determined. An echelle on a 3-m telescope would be appropriate for this science. Studies of the atmospheres of planets may be difficult with ground-based telescopes and may require space instruments.

- Interferometric imaging will become more important in exoplanets science, but no public access is available at this point.

Imaging debris disks to look for planet-induced gaps may be better done on Gemini.

### **Core Science Drivers**

Summarizing the above review of science to be done on small and mid-size telescopes, the ReSTAR committee identified the following core research programs that should be emphasized in designing a public-access system for telescopes in the aperture range 2-6 meters.

- Detailed studies of extrasolar planets and planet systems
- Exploration of the Kuiper Belt
- Exploration of the epoch of reionization
- Refinement of the supernova distance scale
- Understanding nearby sample of galaxies out to  $z=1$
- Understanding nearby supernovae
- Tracing the assembly of the Milky Way and identifying substructure in nearby galaxies
- Timing of transits to find earth mass planets, ensembles of earth-mass planets, followup observations of these ensembles in the time domain
- Exploring the "brown dwarf desert"
- Investigations of dark matter, including the shape of dark matter halos, the size distribution of dark matter clumps, and identification of substructure in local dark matter
- Studies of dark matter aimed at understanding the origin of gravity.
- Calibration of tools for dark energy
- Understanding the origin of elements
- Tracing the evolution and characteristics of circumstellar disks
- Understanding the origin of proto-stellar outflows
- Determining fundamental properties of stars, including the mass radius relationship for low mass stars and proto-stars

Time domain science is an important aspect of many of the above science goals. However, in order for the system of small and mid-size telescopes to enable this science to be done, new tools must be created. We need to assure that we can train students in the techniques of time domain science, and that we can develop needed algorithms, provide the basic infrastructure (including timing precision in telescope and instrument

control systems), and ensure that telescope operational modes address the needs of time domain observations, and address.

In addition to these specific science areas, small and mid-size telescopes will be needed for preparatory, followup, and supporting observations with GSMT, LSST, ALMA, and JWST. Synergy with those facilities will benefit the science productivity of all facilities.

### **Instrumentation and Facilities**

The above science drivers also suggest particular instrumentation should be widely available on telescopes in the system. Key instrumentation and facilities that need wider availability include the following, for which order-of-magnitude cost estimates should be obtained.

- Low resolution, high throughput spectrographs, including multi-slit and integral field, imaging spectrographs (The Goodman spectrograph at SOAR may be a model)
- Large (16k x 16k), wide field IR imagers in both hemispheres. (Should NEWFIRM be cloned?)
- Efficient, single-object, optical echelle spectrographs on 4-m telescopes north and south
- Single-object, IR echelle spectrometers, covering the J, H, and K windows in cross dispersed mode.
- Southern clone of the IRTF
- A 1.5m LSST clone for ongoing, all-sky monitoring for transient sources that will be saturated on LSST
- A global system of 1-meter telescopes equipped for optical imaging for time domain science
- A system of 2-meter class, small-field, robotic telescopes with efficient imaging spectrographs and small FOV IR imagers (5-10')

The public accessibility of data obtained through the system of small and mid-size telescopes will amplify the productivity of such telescopes. Archiving is an issue that needs to be addressed by the system.

The Committee also emphasizes that standards for telescope control systems, software, and instrument control will be essential to achieve the scientific productivity desired of the system.

### **Next Meeting**

Our next meeting will take place in Chicago on Oct. 15-16, 2007. The goal for that meeting is to draft our preliminary recommendations. In preparation, the science subcommittees should prepare 1-2 page written reports of key science programs that provide guidance on the capabilities needed in a system of small and mid-size telescopes available through public access. In addition, we will consider methods for estimating the

number of telescope nights in various aperture ranges that should be available through public access. Finally, we should investigate in more detail both the role of interferometry and the importance of adaptive optics in the system of small and mid-size telescopes.