Directorate for Mathematical and Physical Sciences
Advisory Committee Meeting Minutes
November 3-5, 2004

Wednesday, November 3, 2004
Afternoon Session

Welcome and Introductions

The meeting of the Directorate for Mathematical and Physical Sciences Advisory Committee (MPSAC) was called to order at 12:45 PM. Dr. Michael S. Turner, Assistant Director of the Directorate for Mathematical and Physical Sciences (MPS) introduced Dr. Carl Lineberger, Chair of the MPSAC. Turner also introduced Dr. Jakob Yngvason, Director of the Erwin Schrödinger International Institute for Mathematical Physics, Vienna, and an observer for the European Science Foundation. Members of the MPSAC then introduced themselves. Attendees at the meeting are listed in Appendix 1.

Remarks of the Chair

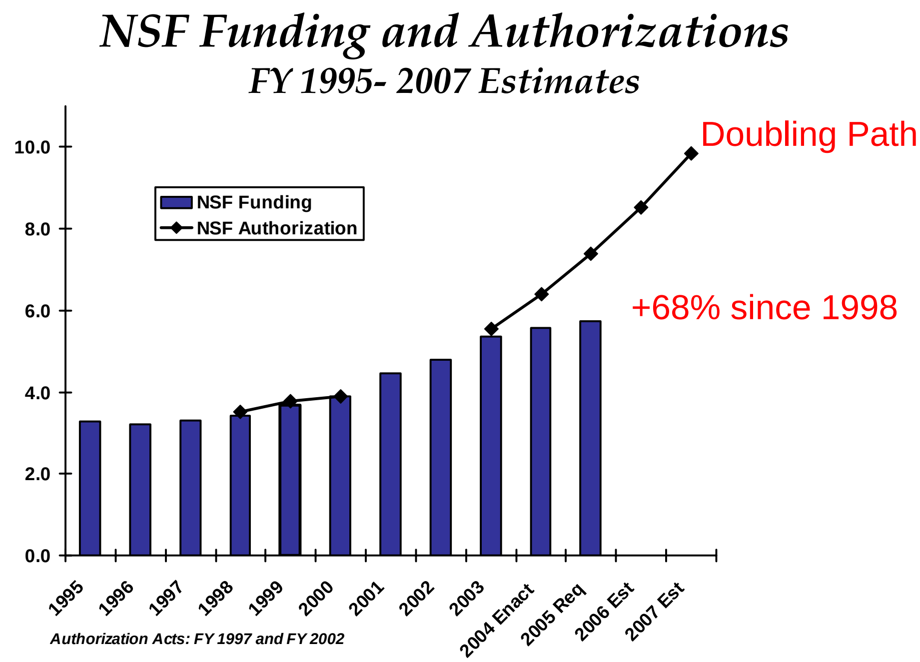
Lineberger began with a discussion of the role of the MPSAC. He noted that while giving advice on items of common interests is important, the MPSAC is not a governing board. He stated that breakout sessions with Divisions are important and very useful at the divisional level. He was concerned about the current one-year term of the MPSAC Chair. He felt it was too short to be effective and wondered if the term of the Chair should be longer, if there should be a Vice Chair, and if there should be a small steering committee that met between the regular meetings. There was also the question of whether there should be more frequent meetings of the MPSAC, if there should be more breakout sessions, and how could one go about making MPSAC more engaged. One member commented that having an extended term for the MPSAC Chair might increase the difficulty of getting a Chair. Lineberger responded that overlapping terms might help prepare and/or involve the following year's Chair. He felt that continuity in the leadership of the MPSAC Chair was important. Another member felt that having a steering committee would be a good idea. Another member thought that a 4-year, rather than 3-year term might be considered.

State of the Directorate, Goals of the Meeting

Turner began his presentation by introducing Elizabeth Grossman, an observer for the House Science Committee. Acting Director Arden Bement, Jr. had been nominated by the President to be the Director of the National Science Foundation (NSF). Dr. Andrew Lovinger, program director for polymers in the Division of Materials Research (DMR) had been inducted into the National Academy of Engineering. The National Science Board (NSB) had approved the Advanced Laser Interferometric Gravitational Observatory (LIGO) as a new start in Fiscal Year 2007 or later. The 2004 Nobel Prize in Physics had been awarded to Dr. David Gross (Director of NSF's Kavli Institute of Theoretical Physics (KITP), Dr. H. David Politzer (a former NSF Graduate Fellow), and Dr. Frank Wilczek (a former NSF Graduate Fellow) "for explaining why quarks are weakly bound in neutrons and protons and yet cannot be freely produced (asymptotic freedom)"[1]. In other news, Turner noted the NSB had ended cost sharing for various types of NSF grants. This was to take effect in January 2005.

Turner then provided an update on the budget. The President's budget had requested an increase for NSF of 3%. The Senate markup included a zero percent increase for MPS, and an additional $8,000,000 for the National Radio Astronomy Observatory (NRAO), and no new starts. NSF was currently under a continuing resolution until November 22. Funding trends for NSF are shown in the following diagram.

[1] From the Nobel Prize citation



Turner discussed the FY2006 MPS budget drivers and themes. These were strengthening the core, facility stewardship, broadening participation, and science. The science areas included the physics of the universe, the molecular basis of life processes, cyberscience/cyberinfrastructure, the mathematical sciences priority area, and nanoscience and engineering.

With respect to goals for the meeting, there would be considerable discussion of major facilities with MPS in order to educate the MPSAC on facilities within the MPS directorate and receive MPSAC input on its current design and development investment strategy. In addition, there would be a discussion of the Advanced Technology Solar Telescope (ATST), and the role of the MPSAC in the Major Research Equipment and Facilities Construction (MREFC) process.

With respect to the FY 2007 budget process, the MPSAC was being asked to provide strategic input at the front end of the planning process.

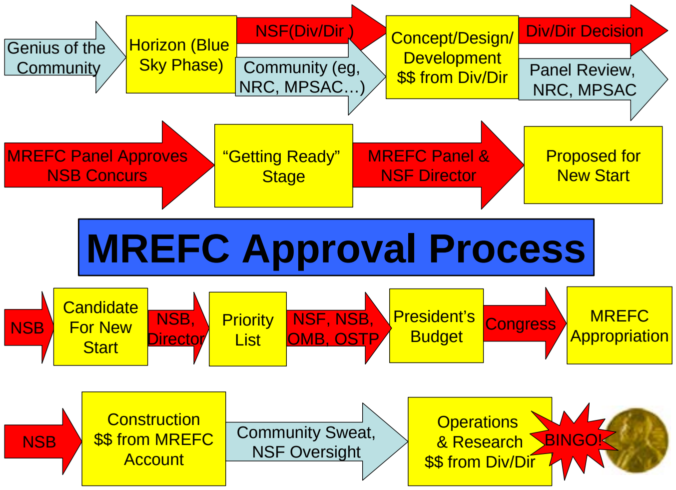
Major Facilities

Introdution

Turner began by noting that the principal driver for all of the MPS facilities was science. Some compelling science requires large tools. Characteristics of an NSF facility were that it was innovative and transformational and often multi-disciplinary in nature. In many cases there was strategic partnering with other US agencies, universities, and foreign partners. In all cases there was integration of research and education at the undergraduate, graduate or postdoctoral level, with attention to broadening participation and public outreach. Facilities were open to all on the basis of merit, and this included users from other countries.

Funding for construction of large facilities at NSF took place through the Major Research Equipment and Facilities Construction (MREFC) account. Directorate facilities that were funded through this process were those that had a total cost in excess of 10% of the directorate annual budgets. For MPS this meant that total construction costs had to exceed approximately $110,000,000.

Turner then reviewed the MREFC process illustrated in the diagram below:



A very important aspect of NSF's MREFC process was that the MREFC account only pays for construction and it is the responsibility of the directorate to provide the funds for operation of the facility. The total cost of a major facility could be said to be the sum of three quantities:

Cost = Design & Development + Construction + Operations/Maintenance/Research.

If construction costs were $X, then design and development is generally of the order of $0.1X, while operations/maintenance/research averaged between $0.1X to $0.2X per year. Assuming a lifetime for the facility of from 10 to 20 years led to total costs of between $2X and $4X. Thus, while the MREFC account paid for construction most of the costs of the facility over its lifetime were borne by the directorate and the division (between an amount equal to the construction costs to as great as three times the construction cost).

Facility operations accounted for approximately 20% of the annual MPS budget. Within the Division of Astronomical Sciences (AST) facilities operations were about 50% of the annual budget, within the Physics Division (PHY) operations were about 30% of the annual budget, and within the Division of Materials Research (DMR) facility operations were about 10% of the annual budget.

Current Facilities

Division of Astronomical Sciences (AST): Dr. G. Wayne van Citters, Director of the Division of Astronomical Sciences (AST) commented on facilities supported within AST. Astronomy facilities include the National Radio Astronomy Observatory (NRAO), the National Astronomy and Ionosphere Center (NAIC), the National Optical Astronomy Observatory (NOAO), the National Solar Observatory, and the Gemini Observatory.

The goals of these facilities are to provide observing capability on the basis of scientific merit through proposal competition, to develop advanced instrumentation, and to promote public understanding and support of science. NRAO and NOAO each serve approximately 1000 users annually, NSO serves about 100 users annually, and NAIC serves about 200 users annually. Approximately 15–20% of these users are graduate students.

At NAIC, a program solicitation for "Management and Operations of NAIC" had been issued, and the deadline for these proposals was March 12, 2004. Proposals for five-year period beginning October 2005 were under review. At NRAO, construction of the Enhanced Very Long Baseline Array (EVLA) Phase I continues, and has been provided for in the NRAO base budget.

The Atacama Large Millimeter Array (ALMA) is a partnership between North America (the U.S. and Canada) and Europe [the European Southern Observatory (ESO) and Spain], with an estimated cost of $552,000,000 (FY 2000 dollars). It will consist of 64 12-meter antennas located in the Atacama Desert of Chile. It is hoped that initial science operations will begin by the end of 2007, and the array should be completed in 2012. In FY 2004 $50,700,000 was provided, and groundbreaking took place at the site in November 2003. Japan has received funding (approximately ¥30,000,000,000 over 8 years) to enhance ALMA by the addition of a compact array of 16 antennas, and an agreement was signed in September 2004.

At the National Solar Observatory there is continued progress on the Advanced Technology Solar Telescope (ATST). The project is estimated to take approximately five years, with an estimated project cost of $161,000,000. A full construction proposal is currently under review.

At the Gemini Observatory, which consists of two 8.1-meter telescopes (one in Chile and the other in Hawaii), 70% of the time is now being used for science observations. A workshop was held at Aspen, Colorado in July 2003 on future Gemini instrumentation and the workshop identified the compelling science questions Gemini and the partnership are in a position to answer.

In concluding his presentation, van Citters described radio facilities supported by AST through grants to university community. These were the Caltech Submillimeter Observatory, the Combined Array for Millimeter Astronomy (CARMA) (a joint effort between the University of California, Berkeley, the University of Illinois, and the California Institute of Technology), the Five College Radio Astronomy Observatory of the University of Massachusetts, and the Northeast Radio Observatory's Coordinated millimeter-VLBI Array (CMVA).

During the discussion period, van Citters was asked how AST determines that 55% of its total budget is the correct percentage to provide for facilities. He responded that this is based on community input, the decadal studies of the National Academy of Sciences, and review by the National Research Council's Committee on Astronomy and Astrophysics. He was then asked if the decadal study is done with a budget envelope in mind. He responded that this was not the case, and that occasional mid-course corrections are needed. In response to a question to how the remaining 45% of the AST budget was allocated, van Citters responded that it went to support of individual investigator awards and some facility observing support.

Division of Materials Research (DMR): Dr. Tom Weber, Director of the Division of Materials Research, described facility support within DMR.

The National High Magnetic Laboratory (NHMFL) is a partnership between Florida Statue University (FSU), the University of Florida (UF), the Los Alamos National Laboratory (LANL) and the NSF and Department of Energy (DOE). Its goal is to develop and operate high magnetic field facilities and state-of-the-art instrumentation for research in physics, biology, bioengineering, chemistry, geochemistry, biochemistry, materials science, medicine, and engineering. It provides support services for research by users through a peer-reviewed process, and promotes science education and assists in developing the next generation of scientists, engineers, and science education leaders.

A primary issue at NHMFL concerns whether the current cooperative agreement will be renewed or whether it will be competed. The National Science Board recently approved a two-year extension of the current cooperative agreement. An NRC study will be issued soon, and a decision on renewal or recompetition of the NHMFL will be made in Summer 2006.

Division of Physics (PHY)): Dr. Joseph Dehmer, Director of the Physics Division, described facilities within its portfolio.

Current facilities supported within PHY included the Indiana University Cyclotron Facility (IUCF) (phased out in FY 2001), the Cornell Electron Storage Ring (CESR)/CLEO detector, which is planned to be phased out in FY 2008, the National Superconducting Cyclotron Laboratory (NSCL), which was recently upgraded, and the Laser Interferometer Gravitational-Wave Observatory (LIGO), which has started science runs. Midscale facilities include the Pierre Auger Observatory, the High Resolution Fly's Eye (HiRes), Milagro, Borexino, the Cold Dark Matter Search (CDMS), the Large Plasma Device (LAPD), the Solar Tower Atmospheric Cherenkov Effect Experiment (STACEE), Amanda, and the nuclear physics laboratories at Stoney Brook, Florida, and Notre Dame.

Dehmer provided an overview of CESR activities, and noted that outcomes of this support had been the discoveries of the b quark, the B meson, penguin decays, the development of superconducting radio-frequency technology, pretzel orbits, and various educational, outreach and diversity activities. He also described proposed future activities at CESR, where the focus will shift to studies of the charm quark, the tau lepton, and the gluon boson. LIGO's science goal is to make the first direct detection of gravitational waves and to probe the strong gravity regime of Einstein's theory of General Relativity. LIGO is on schedule to meet its design goal by early 2005 and to acquire one year of data by the end of 2006.

Discussion: In the discussion that followed these three divisional a question was asked concerning university-based facilities supported by NSF and DOE-based facilities. How is a trade-off made between larger facilities as compared to participation and support of university activities? Turner commented that a key issue is the integration of research and education. The MPSAC noted that students can gain operational experience at university facilities.

The discussion then turned the changing Federal budget situation and its impact on NSF and MPS. How is the MPS strategic planning process taking these changes into account? Dehmer responded that in lean times one had to back off on the rate of building instruments. Weber commented that one couldn't afford to lose highly qualified teams that build instruments, and van Citters said that the community itself was looking at this issue. AST would be conducting a senior review of all of its facilities.

Major Facilities—Facilities of the Future

Division of Astronomical Sciences (AST): Van Citters described the process used in astronomy to establish priorities at the beginning of each decade. The National Academy of Sciences has been asked to recommend priorities for an integrated ground-based and space-based program for astronomy and astrophysics each decade since the 1960s. Other major studies such as the NAS report *Connecting Quarks with the Cosmos* (Q2C) also play a role. The study *Quarks to the Cosmos* garnered attention from the Office of Science and Technology Policy (OSTP) and resulted in a coordinated Federal plan, entitled *Physics of the Universe*, involving NSF, NASA, and DOE. The most recent decadal survey also recommended formation of a multi-agency advisory committee, the Astronomy and Astrophysics Advisory Committee (AAAC) that currently involves NSF, NASA, and DOE. The planning environment for major projects includes:

- The Advanced Technology Solar Telescope (ATST) – a potential flagship facility for ground-based solar research.
- The Giant Segmented Mirror Telescope (GSMT) – a 5- to 7-year planning effort is underway to develop the technology (including adaptive optics) needed for this project. The planning effort is expected to evolve into a public-private partnership for a 30-meter class optical telescope.
- The Large Synoptic Survey Telescope (LSST) – an 8-meter class, wide field optical telescope to provide digital imaging of faint astronomical objects across the entire sky.

Division of Physics (PHY): Dehmer outlined the drivers for major facilities undertaken by PHY. Facilities must be science-driven, contribute to NSF's stewardship of a field, involve leadership by universities, contribute to education and workforce development, and be complementary to programs of other agencies. Major future facilities being developed or envisioned include:

- The ATLAS and CMS detectors to be installed at the Large Hadron Collider (LHC) at CERN in Geneva, Switzerland;
- The IceCube neutrino observatory being instrumented as a kilometer-scale cube of detectors under the ice at the South Pole;
- The Rare Symmetry Violating Processes (RSVP) project to detect rare conversion processes of muons and kaons giving information about physics beyond the Standard Model;
- Advanced LIGO (AdvLIGO), an upgrade to the Laser Interferometer Gravitational-wave Observatory (LIGO) to increase its sensitivity by a factor of 10; and
- A possible future Deep Underground Laboratory (DUL).

The NSB has approved the LHC, IceCube, RSVP, and AdvLIGO. NSF is exploring options for an underground laboratory prior to a decision on whether to proceed with serious design efforts. Mid-scale projects being pursued or planned include VERITAS, the Atacama Cosmological Telescope, the Energy Recovery Linac, and a number of other projects relating to *Physics of the Universe*.

Division of Materials Research (DMR): Weber described two approaches to future coherent x-ray light sources: an Energy Recovery Linac (ERL) project at Cornell University and an X-ray Free Electron Laser (XFEL) project at the Massachusetts Institute of Technology (MIT). Each would offer orders of magnitude improvement over existing synchrotron X-ray sources in reduced pulse duration and intensity of coherent X-ray flux. The coherent fraction produced by the ERL varies from 0.5% to 20%, depending upon the mode of operation, while the XFEL is designed to produce fully coherent radiation.

Discussion: Dr. Venkatesh Narayanamurti inquired about the role of a university location and the educational aspects of a project in priority setting. Turner assured him that it is a very important aspect, especially in certain fields such as accelerator physics. There was general agreement that accelerator physics is an example of a field where students need special training and where more people are needed. Dr. Sol Gruner noted that a limiting factor for future projects is the availability of people. Dr. Robert Kohn asked whether facilities are always “science-driven.” Turner responded that this is always true for MPS facilities. Dr. Lucy Fortson pointed out that it is sometimes necessary to nurture the community and that the time scales for major facilities are very long.

Joint Session with EHR Advisory Committee

Joint Subcommittee on Undergraduate Education (JSAC) Report and Discussion

Lineberger began the session by thanking Dr. Jeanne Pemberton, Chair of the Joint Subcommittee on Undergraduate Education (JSAC) and former Chair of the MPSAC. Pemberton began her presentation by reviewing the reasons for studying undergraduate education, the formation of the JSAC, as well as the organization and timeline of their study. She then outlined the philosophy for preliminary recommendations, which included discipline-specific solutions and not a one-size-fits-all fix, the need for department-level reform and a focus on integration of two-year colleges. The final report contains the following four additional recommendations:

- Creating a program called Research Experience for Early-Career Undergraduates (REECU) based on the current REU model;
- Starting a pilot program of REECU at two-year colleges with a smaller scope that might reinvigorate faculty at those institutions;
- Forming an EHR/MPS Undergraduate Education Working Group with representatives from each Division and senior staff of the Directorates that come together to focus on issues, not money;
- Encouraging MPS to better use the expertise in EHR on program assessment and evaluation during development of program solicitations.

Pemberton concluded her presentation by mentioning that the JSAC still needs to further look into science, technology, engineering, and mathematics (STEM) preparation of K-12 teachers and the transition of two-year students to four-year STEM programs. JSAC was unable to do this because of time limitations.

In the discussion that followed it was noted that for someone from a small, liberal arts college, where mathematics and the physical sciences are often lumped together into one department, the discipline focus may create concerns This may apply to two-year colleges as well. Pemberton responded that a concept such a REECU would require a workshop before any implementation efforts took place. In response to a question concerning the possibility of targeting high school students in addition to undergraduate students, Pemberton responded that there was a huge attrition in MPS majors at the undergraduate level. She agreed that getting high school students interested in pursuing the MPS disciplines when then enter college needs attention, as one needs to create enthusiasm for the MPS science early.

Pemberton was asked whether the JSAC had considered questions that freshmen could undertake. She responded that the definition of appropriate research projects is covered in the Undergraduate Research Centers Workshop report (http://urc.arizona.edu/). She noted that one had to broaden the view of “acceptable” research. It should focus on new ideas to the students, not necessarily new ideas to the field. In addition, industry and government labs need to be polled on this subject, because they have very strong views on what undergraduate research should entail. Pemberton was asked whether the emphasis of the recommendation was on producing research or on training a new generation to be researchers. She replied that the emphasis was on using the activity of research to enhance undergraduate education in the MPS sciences. In order for such an effort to be a success, and to motivate research faculty into wanting to participate in a program involving undergraduate research, wider dissemination of how to get an undergraduate research supplemental award was required, student project had to be small (not thesis-type projects) principal investigators had to be informed as to how to include money for undergraduate research in their proposals, supplements should be provided for curriculum-based undergraduate research projects, and MPS should promote collaborations for REU supplements with other federal agencies.

Lineberger thanked Pemberton for her presentation and all the effort that she and her committee had devoted to producing the report.

Adjournment

The meeting was adjourned at 5:45 P.M.

Thursday, November 4, 2004
Morning Session

Lineberger convened the meeting of the MPSAC at 8:30 am.

The National Academy of Sciences Brinkman Report

Dr. Lee Magid, Acting Executive Officer of the Division of Chemistry, presented the findings of the National Academy of Sciences (NAS) Brinkman Report. The study originated in response to a letter from six U.S. senators to the NAS and language in the NSF Authorization Act of 2002. Membership on the committee represented a broad range of experts in science, engineering, project management, and national policy. The Chair of the Committee was William Brinkman of Princeton University. The Committee recommended that:

- The National Science Board (NSB) should oversee a three-stage process whereby NSF develops a 10-20 year roadmap for large facility projects;
- Three levels of criteria categories – scientific and technical, agency strategic, and national criteria – should be used to rank projects within disciplines, sets of disciplines, and across all fields;
- New starts should be ranked in annual budget request using clear rationale based on the roadmap;
- NSF should support enhanced project preapproval planning and budgeting;
- During the execution phase, projects need greater independent oversight and review; likewise, effectiveness of the new NSF deputy for large facility projects should be reviewed in 2 years;
- OSTP should coordinate roadmaps across agencies and countries; and
- NSF leadership and NSB should pay careful attention to implementation of proposed reforms as outlined in the committee's six step process

The three levels of criteria to be used in the ranking of projects were 1) Science and Technology criteria; 2) Agency Strategic criteria; and 3) National criteria. There is a need to consider ranking projects with the three criteria, support project development, and enhance project oversight and review. With respect to support project development, there is a need for clearer definition of what is being built, what it will cost, and what will be achieved.

The National Science Foundation Response to the Brinkman Report

Van Citters presented the National Science Foundation's response to the Brinkman report. The National Science Board (NSB) had endorsed the report. The report calls for transparency of the selection process for facilities, and NSF agrees. The report also calls for a roadmap, to which the NSF Facility Plan is being created to outline objectives and opportunities for the next twenty years. The remainder of his presentation discussed the stages through which a project would pass prior to funding by Congress. These included a horizon stage, a concept stage, a development stage (guided by the facility plan and with consideration of NSF Merit Review Criteria 1 and 2), and a readiness stage when the project was ready to present to the NSB. A member of the MPSAC commented that the NSF plan seems more flexible than the Brinkman Report recommended. Another member commented that while the Senate was concerned with the lack of transparency and lack of oversight on projects, the Brinkman Report did not address management and oversight of current facilities.

Nanoscale Science and Engineering Committee of Visitors Report

Dr. Lynn Jelinski, Chair of the Nanoscience and Engineering Committee of Visitors (COV), discussed the report of the Committee of Visitors for the NSF nanoscience initiative. The programs that were reviewed were the Nanoscale Science and Engineering Centers (NSEC), the Nanotechnology and Interdisciplinary Research Teams (NIRT), Nanoscale Exploratory Research (NER), and Nanoscale Undergraduate Education (NUE). The COV was overwhelmingly positive on these crosscutting nanoprograms. The COV identified significant and enduring results of these programs: the creation of a community of nano-researchers and a strong culture of an interdisciplinary approach to nano. Some minor weaknesses were noted. Reviewers were drawn strongly from universities, and the COV felt that more are needed from national labs and industry. This was particularly important as this field moves towards having significant impact in manufacturing areas. Jelinski also provided details on award rates in these programs, and noted that 12% of principal investigators in nano areas are underrepresented minority group members. This is much higher than the NSF average. Forty percent of the principal investigators are female.

Report on the MPS Theory Workshop

Dr. Thomas Appelquist, a former member of the MPSAC and Chair of the MPS Theory Workshop steering committee, reported on the preliminary outcomes of the MPS Theory Workshop that had just been held at NSF. The workshop addressed three questions:

- The frontiers of theory in the mathematical and physical sciences;
- The modes of support for theory in the mathematical and physical sciences; and
- Support for education and outreach in theory in the mathematical and physical sciences.

The workshop began with five frontier science presentations from the five MPS disciplines (astronomy, chemistry, materials research, mathematics, and physics). After these presentations workshop participants went into breakout sessions with the MPS divisions and addressed questions concerning discipline specific science frontiers, the breadth of theory supported in the division, approaches to the support of theory in the division, the relationship between theory and experiment in the division, and concerns about the support of theory in the division.

With respect to the breadth of theory, Appelquist noted that the problems theory in the mathematical and physical sciences attack range from the fundamental constituents of matter to the large-scale structure of the Universe, from abstract mathematical concepts to computational tools to analyze large data sets, and from single object to organized behavior. Approaches to the support of theory included basic research, programmatic research, analytical theory, computational theory (simulations and modeling), phenomenological research (applied theory), theory research in support of missions, grand challenge problems, and the support of groups and centers. In the area of the interaction between theory and experiment, Appelquist stated that experiment needs theory more than ever, that theory drives major experiments, that modern instruments/experiments require a theoretical understanding for proper design, that fields such as astronomy are now very data rich, that experiments increasingly require theory for their proper interpretation and *vice-versa*, and that theory stimulates new experiments and can set new agendas.

Concerns expressed by the workshop included the fact that the theoretical component of laboratory astrophysics was, in effect, and “endangered species,” that interdisciplinary theory was falling through the cracks, that algorithmic development needs to be recognized as an important component of theory, and that there was a lack of consolidation of multi-disciplinary knowledge back into the disciplines.

Recommendations (still in draft form) from the workshop with respect to actions to be taken by MPS included the following: MPS should:

- Preserve curiosity-driven, basic research;

- Preserve the breadth of effort (in science and funding modality);
- Develop mechanisms for handling interdisciplinary proposals, including algorithmic ones;
- Support research at the frontiers;
- Enhance synergies with other agencies and scientific organizations;
- Be responsive and flexible to new opportunities and emerging disciplines; and
- Develop metrics to evaluate the scientific effectiveness of centers. It should ask an outside group such as the NRC to aid in this.

The workshop found that within the Division of Astronomical Sciences the funding balance of theory and observation within the grants program is appropriate and the review of theory proposals is being well handled with the current organization. Other draft recommendations from the workshop were that individual investigator grants should remain the core method for the support of theory, that focused research groups and group grants can be an effective way to support theory, that each MPS division should examine its theory components to determine if they are appropriately serving the needs of its theory community, and that MPS should foster additional institutional mechanisms for handling inter-disciplinary, inter-divisional, inter-directorate, and inter-agency theory. The workshop participants were largely opposed to an MPS-wide postdoctoral fellowship program. NSF had little statistical information specifically identifying theory students and their support. The workshop recommended that this information be routinely collected and maintained.

Lineberger commented that the workshop, although it had made recommendations applicable to theory, had consistently felt that their recommendations could be applied more generally than just in theory areas. There was strong feeling at the workshop that NSF should be aggressive in pushing areas where it is the sole advocate, such as education and outreach.

Report on MPS Cyberscience Workshop

Dr. Shenda Baker presented the recommendations of the MPS Cyberscience Workshop that had taken place in April 2004. The purpose of the one-day workshop had been to identify needs for cyberscience for MPS. For purposes of this workshop cyberscience was defined as the science that cannot be done without the advanced capability of cyberinfrastructure. Science drivers that were discussed during the workshop included basic predictions using models and simulations, simulations of events that are not practical (supernovae, nonlinear fluid dynamics no nuclear testing, etc), cosmological problems, particle theory, predictions/determinations of biological and chemical assembly and processes, biochemical/biophysical questions in genomics, complex adaptive systems, and emergent behavior (from fundamental particles to life)

Workshop recommendations were:

1. Tools for cyberscience should be supported, must be shown to support accountable science research and sit on the cyberinfrastructure being funded by NSF. The needs of each division will vary across MPS, so *guidelines must be developed* to allow for these variations. These guidelines *must clearly define consistent and sustained policies* and programs.

> - *For example*, for smaller projects, an SBIR-like process should be developed for support of such development, with successful Phase 1 projects leading to further support as Phase 2 projects, ultimately supported in larger centers;

2. Coordination of cyberscience as seen by MPS and cyberinfrastructure as seen by the Directorate for Computer and Information Science and Engineering (CISE) should be addressed “up front.” The crosscutting office, such as an Office of Shared Cyberscience and Cyberinfrastructure, could oversee these efforts.

> - A “Cyber working group” subcommittee with members from MPS and representation from the CISE should be immediately convened to develop the detailed guidelines based on enabling science.

3. The ITR portion of the MPS budget should be reallocated to the divisions (nominally to support cyberscience awards, with supplements to proposals with cyberscience tool components.)

- As much as possible, reasonable collaborative efforts with CISE should be encouraged; and
- Interagency collaborations should be encouraged

4. Divisions within the directorate should determine what they are currently spending on cyberscience and what their expected needs are and share this information with the MPS Directorate and MPSAC for planning purposes.

5. Metrics and assessment guidelines must be developed up front to assure accountability and to assess effectiveness of the crosscutting program.

6. MPS should develop a means to communicate the opportunities and advances in cyberscience and cyberinfrastructure internally and externally.

- The current "ITR" working group internal to MPS could serve as one mechanism for information dissemination; and
- An external mechanism would be to add an obvious cyberscience component to its web page.

During the discussion period that followed, Baker was complimented on the recommendations of the workshop. Dr. Art Ellis, Director of the Chemistry Division (CHE) noted that CHE had recently held a computational workshop, and that a report of the workshop would be issued shortly. Weber commented that DMR had also held a computational workshop, and its report would be out soon.

The report and recommendations of the workshop were unanimously accepted by the MPSAC.

Divisional Breakout Groups

Charge to Breakout Sessions

Sunley reviewed the charge to each of the MPSAC Divisional breakout sessions. Each of the breakout sessions was to consider the following during its meeting:

1. NSF faces tight budgets for the foreseeable future.
    a. Identify three areas or new opportunities that warrant the highest priority; and
    b. Are there areas or activities that could be trimmed?
2. Take one or more of the areas of emphasis at this meeting (Facilities, Theory, Cyberscience, Undergraduate Education).
    a. What is the importance of this area for the division/community?
    b. What steps are the division and/or the community taking to articulate issues and devise responses?
    c. What advice do you have for division or directorate courses of action?
3. What are the most significant issues facing the division? How do they fit into the framework of the MPS Planning Document?
4. Scientific themes in the MPS Planning Document.
    a. In which scientific themes is the division most vested?
    b. What actions are being taken by the division and/or the community to help refine or enhance the description of status or opportunities in the area?
    c. What is missing from either the set of themes or the description of the themes that is important to the division?

The MPSAC then adjourned for lunch and met with the individual breakout groups.

Afternoon Session

Reports from Divisional Breakout Groups

The MPSAC reconvened in plenary session at 4:30 to hear reports from the breakout groups. (Membership within each breakout group can be found in Appendix II and the written reports from each of the breakout sessions are found in Appendix III.)

Division of Mathematical Sciences (DMS): Dr. David Morrison provided the DMS report. He stated that with respect to future tight budgets, trimming would have to be done within disciplinary programs, based on quality rather than based on scientific topics chosen in advance. In the area of cyberscience, DMS plans to devote previous ITR funds to computational issues, and hopes that CISE will match these investments. Investments would be in three areas:

– Multiscale modeling;
– Interesting interface between probability, statistics, modeling (stochastic computing); and
– Other computational issues in mathematical sciences.

There is a need to develop the computational tools for use by mathematical scientists, and modelers in other fields

With respect to theory, the bulk of the research supported by DMS is theoretical. The Mathematical Sciences Priority Area (MSPA) has enabled DMS to amplify theoretical research in other divisions, and this can be a model for all theoretical sciences within MPS to make impacts in other areas. The core is extremely important, equally important to the interdisciplinary initiatives.

Morrison noted that DMS has invested heavily in undergraduate programs [REU, Vertical Integration of Graduate Research and Education Program (VIGRE)]. The breakout group endorses the preliminary recommendation of the Theory Workshop to create a 21st century version of the Student Science Training Program (SSTP) for high school students, and hopes that this can be done in partnership with EHR.

The most significant issues facing DMS are the very low success rate (26%), which leads to a high rate of discouraged applicants, who don't apply again. He noted that DMS is responsible for 75%-80% of all federal funding in the mathematical sciences. Broadening participation remains a challenge, and staffing within DMS is a concern.

With respect to scientific themes within DMS, they range from abstract mathematical concepts to computational tools to analyze large data sets. Mathematics and statistics contain many interesting "core" problems, in addition to those articulated in the MPS planning document, in traditional areas such as number theory, geometry, topology, differential equations, analysis, probability, statistic. He noted that the recent solution of the Poincare conjecture through singularity development in Ricci flow is a reminder that singularity development is an important feature of other equations, such as the Navier-Stokes equations describing fluid flow.

During the discussion period following Morrison's presentations, an MPS member asked whether mathematicians pay attention to funding opportunities from industry. The response was that there was some attention was there, but not much. It was noted that the increased funding available in DMS had been used for partnering with other divisions across NSF, supporting the workforce, and increasing award size (which also contributes to workforce by supporting graduate students and postdocs).

Division of Chemistry (CHE): Dr. Jean Futrell presented the CHE breakout session report. He noted that the CHE breakout group had diverse opinions on the issues and did not reach consensus. The general discussion of the issues reflected the need for *balance* – both within CHE and across agencies. It was felt that MPS was underfunded, and because of this there is anecdotal evidence from the community that hiring and long-range workforce are being adversely affected. The tight budget implies a 30% cut in equipment budgets and this gives rise to another balance issue: maintaining the fraction of CHE support going into instrumentation. It is essential that instrumentation support be maintained. The field of academic chemistry research is really a *cottage industry*, with 70% of the CHE budget going to individual PI grants.

With respect to CHE priority areas, the interface with biological science is strong and will continue to grow. The same can be said of the interface with materials science. The breakout group recommends that CHE conduct a series of workshops with both senior and young principal investigators to identify new challenges in chemistry and to explore new interfaces with other disciplines. There should be a strategy of collaboration with other fields in order to preserve strength and creativity. An area of particular interest is that of weak interactions in the molecular sciences. The field is on the threshold, *via* theory and experiment, of understanding how these weak forces apply to other areas.

It is absolutely essential to protect the core, to define it inclusively, and to connect it with other sciences.

With respect to facilities, CHE should not be parasitic users of large facilities. Chemists want to be included in the planning process. As has already been noted, cyberscience is important to CHE. There is a strong interest in mid-range instrumentation, including large magnets for mass spectroscopy. There must be dialogues and workshops with the community in order to position the field and CHE for future opportunities.

The most significant issues facing CHE involve the need to focus on the core and to balance the portfolio. Scientific themes include:

- Creating molecules and materials that will transform the 21st century;
- Discovery, innovation; and
- Larger-scale processes, connecting to the rest of the world, as in: “charting the evolution of the universe,” and geosciences.

Finally, environmental sciences remain very important as humans interact with the environment. There is major national interest here.

Division of Astronomical Sciences (AST): Dr. John Huchra provided the AST breakout session report. With respect to identifying three areas or new opportunities that warrant the highest priority, the breakout group felt these were protecting the grants program, scientific opportunities in new interagency initiatives in *Physics of the Universe*, and investing in enabling technologies for Decadal Survey priorities. The breakout group endorsed the concept of having a senior review that will include broad community input. The breakout group felt that the areas of emphasis (Facilities, Theory, Cyberscience, Undergraduate Education) were all important, and the group endorsed the three reports the MPSAC has received on theory, undergraduate education and cyberscience. Facilities and data are the lifeblood of astronomy, but their support must be balanced with support for people to maximize science.

The breakout group recommended that AST include the advice from the theory, education and cyberscience workshops in its planning process, and to continue stressing the importance of project management and best practices in management of facilities and large projects. It noted that the community’s ambitions for facilities in the next few years will require additional manpower and other resources in the Division, and that management of facility operations should stay in the Division. MPS can enhance its visibility by sharing the excitement of astronomy with the public. The agency as a whole should support media relations.

The largest problem facing AST is implementing the plan prioritized by the community in the decadal survey. This includes support of basic research. The breakout group noted that AST is very well aligned with several of the Directorate’s scientific themes.

With respect to the MPS scientific themes, the areas most closely associated with AST are the evolution of the Universe and its contents and the fundamental nature of space and time.

Division of Materials Sciences (DMR): Dr. Venkatesh Narayanamurti provided the DMR breakout session report. He noted that DMR is, inherently, very interdisciplinary, and there are exciting emerging opportunities in the field. Quantum behavior is arising in many situations, new materials are being created, and there are increasing connections with biology. DMR is a bottoms-up field, with discoveries being made by individuals in labs. There is a bottoms-up approach to dealing with areas that should be reduced, in the sense that this is being done by program directors all of the time.

With respect to facilities, new tools are extremely important. Small instruments are needed in labs, and there is some use of the large-scale facilities of the Department of Energy. He noted that there would be no cyberscience if the materials needed to create new types of chips or magnetic materials are not developed. Materials research is in fact the key to the "virtual world" of the computer.

The breakout group was in full agreement with the report of the joint MPS-EHR education working group, and felt that there could be further leveraging of activities by combining resources with NSF's Directorate of Education and Human Resources (EHR).

With respect to initiatives, the nano initiative was very important to the core activities of DMR, but the initiative could overload DMR with proposals. The area of condensed matter physics was very important.

Division of Physics (PHY): Dr. Lars Bildsten provided the PHY breakout session report. Priority had to be given to the *Physics of the Universe* recommendations. PHY had stewardship of a number of Major Research Equipment (MRE) projects. PHY had to support what they were already building, but it should not miss new opportunities. It had to protect the core, which should always be supported by at least 50% of the budget. It should increase the support of theory by about five percent per year for the next few years. If cuts had to be made, then the low priority facilities should be cut first, there should be a slowdown of the Physics Frontier Centers program, which could be increased or decreased needed. The last thing that should be cut is support to individual investigators. Their support should always be at least 50% of the PHY budget.

The breakout group found that there was a clear integration of education and broadening participation throughout the PHY programs (i.e. PI's, Centers, Facilities and targeted programs). The group noted that fields with no MRE facility need to receive special attention within the grants program, especially when NSF is a primary steward. New initiatives in computational physics should be broad.

With respect to core planning, the breakout group felt that the *Quarks to the Cosmos* report and the OSTP *Physics of the Universe* have had significant impact at the intersection of these fields. Physics has a number of advisory panels [High Energy Physics Advisory Panel (HEPAP), Nuclear Sciences Advisory Committee (NSAC), and the Scientific Assessment Group for Experiments In Non-Accelerator Physics (SAGENAP)], but advice concerning the core from areas outside of physics, such as the NAS Decadal Review is not a primary input into PHY planning.

Given the uncertain times/inflation, budget projections that include MREFC operations are needed for planning/scope and protecting the core. Since there is a significant amount of astrophysics supported by PHY, the standing National Research Council (NRC) Committee on Astronomy and Astrophysics (CAA) should establish a closer contact with PHY.

Observations by Dr. Jakob Yngvason, European Science Foundation Physical and Engineering Sciences (PESC) Unit Representative

In his opening remarks, Dr. Yngvason noted that the European Science Foundation (ESF) is a non-government organization headquartered in Strasbourg, France. The ESF consists of 76 national research organizations from 29 countries. Within the ESF all disciplines are covered, including the physical and engineering sciences (PESC), the life and environmental sciences (LESC), the medical sciences, the humanities, and the social sciences.

The basic aims of ESF are to advance European cooperation in basic research, to examine and advise on research and science policy issues of strategic importance, to plan, and, where appropriate, to manage cooperative research activities.

Within the physical sciences and engineering unit (PESC) the fields that are covered are mathematics, physics, chemistry, information sciences and technology, the engineering sciences, and the material sciences and engineering. There are 35 members and five institutional observers. A standing committee meets twice a year, and core groups meet four times a year.

The ESF sponsors a number of research infrastructure activities, including exploratory workshops, scientific networks, European research conferences, scientific programs, and science policy studies. Yngvason proceeded to describe a number of these activities, and details can be found at http://www.esf.org/.

Adjournment

The meeting was adjourned at 6:00 P.M.

Friday, November 5, 2004
Morning Session

The meeting of the MPSAC reconvened at 8:30 AM.

Continued Discussion of MPS Major Facilities and MPSAC Role in Planning Future Facilities

Initial MPS Response to the Cyberscience Workshop Report:

Turner provided an initial MPS response to the Cyberscience workshop report. He noted that cyberinfrastructure (CI) is broadly defined and includes more than hardware. It involves hardware, networking, middleware, software, algorithms, and problem formulationThe NSF Assistant Directors are working closely with the Director and the Deputy Director to implement a plan for the management of shared cyberinfrastructure. The main principles for management of shared cyberinfrastructure are the following:

- Investments in shared Cyberinfrastructure must be driven by the science, engineering and education research needs;
- Shared Cyberinfrastructure investments must be responsive to and accountable to the Research Communities and Directorates for which they are being made;
- Shared Cyberinfrastructure investments must be coordinated with the domain-level investments; and
- Shared Cyberinfrastructure must respond to experts and beginners.

Discussion of MPS Major Facilities

Turner informed the MPSAC that their assignment was to:

1) Provide feedback on the current investment structure;
2) Assess the Advanced Technology Solar Telescope (ATST); and
3) Discuss the future MPSAC role in large facilities planning.

Turner wanted a response from the MPSAC with respect to 1) and 2), but 3) was optional. He then provided the MPSAC with the current MPS investments for design and development (D&D) of facilities, and requested feedback from the MPSAC concerning strengths, weaknesses and gaps.

Baker asked where the Advanced Technology Solar Telescope (ATST) had ranked in the National Academy of Sciences Decadal Survey. Turner responded that the Survey had provided six lists, and the ATST was second in the medium-size list. He added that one could not simply go down the list, as readiness was an important factor. For example, the Extremely Large Telescope (ELT) could not be done first even though it was top ranked. Van Citters commented that the top-ranked medium sized project is already being done [the Telescope System Instrumentation Program (TSIP)], and that ATST was actually the fourth-ranked project. However, the second- and third-ranked projects were space-based, making the ATST the second-ranked ground-based project.

Huchra noted that the Decadal Survey acted as a strong filter since it had selected only the top 10 to 20% of all projects considered. Bildsten felt that there should be a number for how much of the total budget should go to design and development (D&D). Van Citters responded that ideally for AST this would be about $20, 000,000 per year, or 10% of the total budget. He said that AST was headed in that direction. Bildsten then commented that operations costs must be carved out of the budget, so D&D should also have a baseline amount carved out of the budget, and a rational process for determining that number.

Lineberger asked van Citters if he could give examples of projects that were not yet in the budget, but which might appear in a year or two. Van Citters responded by saying that AST had not had sufficient funds for D&D for the Square Kilometer Array (SKA). Huchra commented that the SKA had not been marked for construction in the decadal survey. Turner asked about the amount spent on these projects to date, and van Citters responded that it had been $11,000,000 for the ATST and $1,000,000 for the SKA.

Turner asked if there were projects that had been proposed but which had not been supported. Van Citters responded that the proposed 25-meter millimeter antenna was overtaken by science, the millimeter array (MMA) morphed into the Atacama Large Millimeter Array (ALMA), a number of initiatives for 2-meter to 4-meter telescopes never made it. Dr. Craig Foltz, the National Optical Astronomy Observatories Program Manager in AST commented that the ATST is the successor to the failed LEST (Large Earth-based Solar Telescope) project, and Dr. Pat Bautz, the PHY Executive Officer added that the National New Technology Telescope (NNTT) was not supported. Van Citters commented that there was a lot of technology development associated with the NNTT that was used in the Gemini Telescopes Project and other projects, and Huchra added that the 8-meter spectroscopic telescope was never supported.

Dehmer stated that in the Division of Physics the Electron Positron Collider (EPIC) dropped out, although it may re-emerge. The various underground laboratory experiments (e.g. proton decay) mostly moved to Japan and Europe. Another example was the high-density laser facility. Additionally, a large number of particle physics experiments have not been supported.

Baker commented that the previous day's presentation showed an operating budget that would be required to achieve the recommendations of the decadal survey and the numbers shown were very high, with about $140,000,000 per year rising over ten to twenty years to $270,000,000 per year, just for the operating costs. To what are we committing ourselves? Van Citters responded that the previous day's presentation showed everything – these facilities and more, including facilities operations. He stated that AST would not continue an investment in a new facility if it could not operate it. Baker then asked how the MPSAC was to give advice if the projections on costs were unclear, to which van Citters responded that the MPSAC could comment on new starts and technology development.

Turner directed the MPSAC's attention to the questions on the agenda, noting that MPS was not committing to funding all of the projects. He asked the MPSAC: Is the MPS D&D investment in these projects worthwhile? It is clear that some would not survive, but the D&D was a buy-in that could be considered as venture capital. Oxtoby commented that that this was way big science was done, and a way of determining which projects should go forward. Turner noted that the idea of a 30-meter telescope has strong scientific justification, but can it be built? D&D is "buying down risk", with precursor and enabling technologies. LEST failed because the technology was not ready.

Dr. Frances Hellman commented that the 3% budget increase shown by Turner demonstrated that this could all be done. However, MPS divisions that do not have facilities do not have the issue of facilities versus the core program. Consider the case where the NSF budget is cut and there are large facility operations budget – would other MPS divisions lose core money? Can MPS reassure those divisions that do not build large facilities that they would not lose money?

Lineberger commented that responsible planning for the future looks at a variety of budget envelopes, and one needs to have a set of thoughtful projects available for any such envelope. Does MPS have the right palette of options? Fortson responded that the MPS feedback should be on the process and not on the actual set of options. Hellman commented that the MPSAC could decide that there are too many things in the box.

Sunley noted that AST had the largest list of possible future projects, which is why the focus at present was on AST. Three years ago it would have been quite different, with more PHY (AdvLIGO, RSVP, LHC – items that have gone through and moved off, all of which needed D&D with five to ten year lifetimes). With respect to AST, are these the right set of items to be looking at? One obvious area of MPSAC feedback that had already been mentioned was that MPS had to be very careful that it was not over-committing itself and that it not damage the core areas.

Dr. Sol Gruner commented that we had to remember that we live in a world with competitors, and we must compare ourselves to Europe and Asia. Also we must consider what will happen if we *do* have money. The investment mix falls into one of two categories – either observatories or enhanced analytic capabilities. A balance is needed between the two as they affect different communities very differently.

Dr. Mostafa El-Sayed stated that it was very hard for chemists to choose between these projects. Has building these big things in the past cut into the core of the other divisions? That is, has it eroded the core of other divisions in the past? If this has *not* happened, then he felt that the MPSAC could just take the advice of the discipline experts.

Turner stated that what he had gathered from the discussion was:

1) In making D&D investments, one must not eat away at the core; and
2) Do not unrealistically "launch ships" - make sure you can do things, and if you're really over-committed, stop.

Huchra noted that the astronomical community has vetted these projects, and a background exists. The list is long because the AST budget is heavily invested in facilities. It was his opinion that even if the budget were flat, AST would want to go ahead with new projects even if it had to shut down existing facilities. Aizenman commented that the Decadal Survey went from about 350 members of the community down to 15 people within the National Academy who made the final choices. The AST projects proposed have all survived this process, and are part of the Decadal Survey recommendations.

Futrell commented that the MPSAC seemed to be agreement with the principles discussed. The MPSAC will insist that the core be protected. He added that DoE has arranged to have a single person responsible for facilities, and the NSF has also moved in this direction, which is good. DoE includes the full life cycle cost of projects – NSF should do the same. NSF should also explain why facilities are more important to some disciplines than to others. In addition, one must deal with reality, perhaps by staggering the starts. Adjustments can be made. He endorsed the plan proposed by MPS.

Dr. Elizabeth Simmons felt that the MPSAC should consider the scientific strengths and weaknesses of a project, and also look at what is operating and under construction, as well as what is proposed. There should be a balance between observatories and analytic capability. She asked whether AST and PHY saw the same balance.

Narayanamurti commented that he had chaired the last condensed matter Decadal Survey, and it had included both large and small facilities. There must be a balance – for example, light sources, and X-ray light sources, are critical. It is not so clear how the resources are paid for, and this needs to be looked at institutionally.

Bautz added that D&D is a way to get the best facility. The weakness is in right-sizing the amount of D&D investment related to the amount spent operating the facilities. In AST the size of D&D is about equal to the size of the grants program. A problem was in determining how much a division should spend in its D&D investment compared to operations expenses. Van Citters responded that what AST wanted to show was that it was doing the planning for future facilities, was protecting the grants program, and was following the highly filtered Decadal Survey list. The Decadal Survey includes about ten percent for D&D. AST was looking at the entire portfolio to get the D&D money without affecting the grants program. Dehmer commented that in PHY the grants program has gone up at the same rate as the division, and Ellis said that the same was true in CHE.

Lineberger said that he concluded from the discussion that the MPSAC feels that MPS is doing the right thing when it is looking at future facilities. Baker added that it was the MPSAC's advice to protect the core and not to overstretch. This was general advice and not specific to actual projects. Lineberger added that the proposed projects all had good pedigrees, and the MPSAC did not have the expertise to get into the details of any particular project.

Case Study: "Agency Strategic Criteria" – The Advanced Technology Solar Telescope (ATST)

Turner stated that the ATST was the only project mature enough for MPS to advance to the readiness stage (defined by the Brinkman report), and there would not be another one soon. It was a good test case for the process recommended by the Brinkman report. The Brinkman report "second" criteria specifically restated for the ATST are:

1. What is the impact of ATST on scientific advances in the related set of fields it impacts taking into account the importance of balance among fields for NSF's portfolio management?
2. What are the opportunities for ATST to serve the needs of researchers from multiple disciplines or the ability to facilitate interdisciplinary research?
3. What are the commitments from other agencies or countries to ATST that should be considered?
4. What is the potential for education and workforce development?
5. Is ATST ready for further development and construction?

Van Citters then described the history of the ATST project. The ATST is aimed at understanding the nature of solar magnetism and activity crucially relates to many pressing scientific issues, ranging from global climate change through the safety of astronauts in space to the basic physics of plasma magnetohydrodynamics. Van Citters noted that the newest US large solar telescopes were now more than 30 years old. He reviewed the history of the proposed project. It dates back to 1991, when a proposal was submitted to NSF for US participation in an international "Large Earth-based Solar Telescope" (LEST). However, the LEST effort failed, primarily because the anticipated international collaboration failed to assemble, and partly because the required technology was too immature. After the LEST failure, a decade-long effort was begun by solar astronomers to develop the science case for a major new telescope and define the technology advances that it would require. A milestone in this effort was the completion of a design study by the National Solar Observatory (NSO) for a 4-meter aperture, technologically challenging telescope called "CLEAR." The CLEAR study uncovered no technological showstoppers. The National Solar Observatory (NSO) then formed the nucleus of a formidable community team to develop the CLEAR concept into a buildable "Advanced Technology Solar Telescope" and to collect the required endorsements from NRC studies. A Design and Development proposal was submitted to NSF that was subsequently funded for $11,000,000 ($10,000,000 from AST, $1,000,000 from the Division of Atmospheric Research (ATM) over the period FY 2001 – 2005). The "Parker Report" on ground-based solar research, *Astronomy & Astrophysics in the New Millennium*, and the Solar and Space Physics Decadal Survey, have endorsed the ATST. The ATST is approaching readiness for consideration as an MREFC start. Total cost including four instruments and a single-conjugate adaptive optics system is estimated to be $161M. There are 17 partner institutions involved in the project.

Van Citters then discussed the ATST with respect to the "second criteria": He concluded his presentation with the statement that AST considered the ATST Project ready for consideration for promotion to "ready" status by the MREFC panel and the NSB.

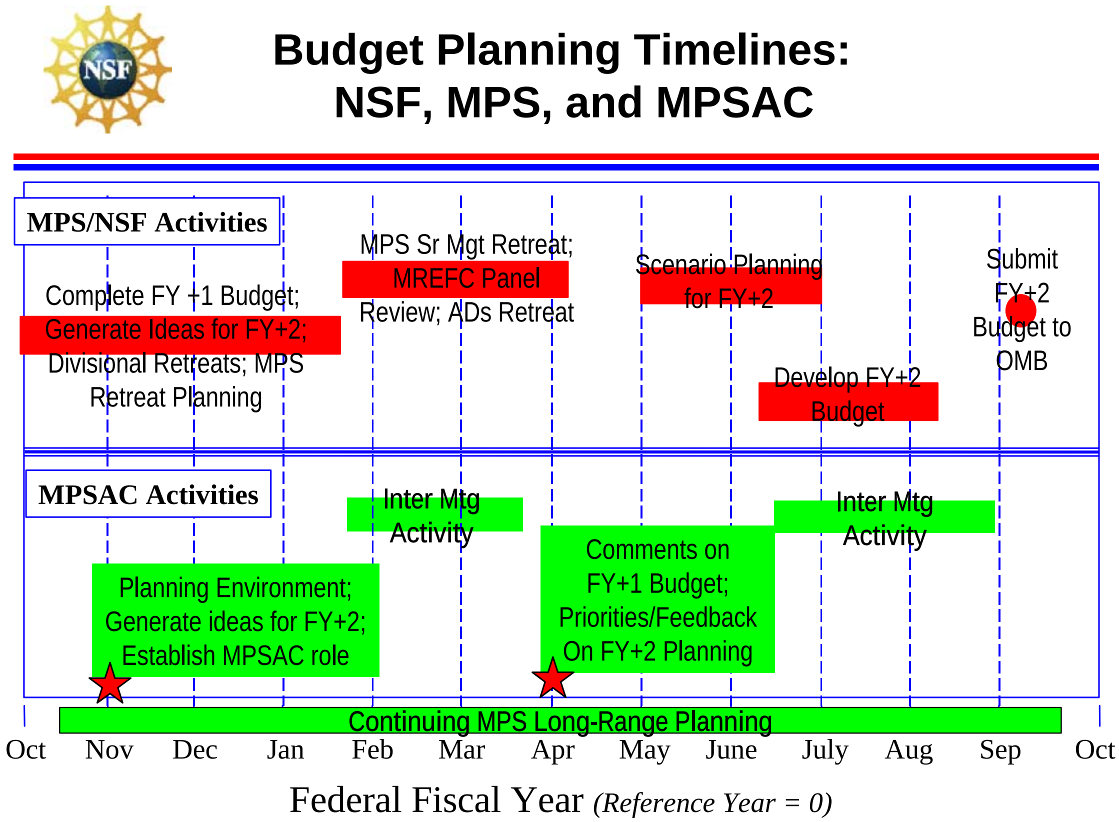
In the discussion during his presentation, van Citters was asked where the ATST would be situated. He responded that Haleakala, Hawaii had been chosen, but there are backup sites in case of problems. The NSO would be the operating entity of the partnership. There were different levels of partnership, including parts of the design and construction, but the telescope will be open under merit review to everyone, not just to the partners. Commitments from other agencies are for both construction and operation.

Kohn noted that the ATST was very impressive and would permit older facilities to close. Shouldn't closings be settled at the time the funding for construction is committed? Van Citters responded that the solar community has agreed to this, although the timetable is still under discussion. AST also expects significant restructuring of NSO and possible relocation of some facilities. Foltz commented that ATST supersedes the older ones to the point where they no longer have a role. The closures should save about half of the increase in operations cost. In response to a question as to what would be ready next, and when would such a project be proposed, van Citters responded that the next project was sufficiently distant in time as to justify supporting the ATST at this time. Turner commented that the number one project in AST was the Giant Segmented Telescope, but its earliest possible start was 2012.

Lineberger stated that the MPSAC now has the information to make a recommendation, and asked the MPSAC as to whether it was satisfied that the ATST satisfied the criteria of the Brinkman Report. There was unanimous agreement on this by the MPSAC.

Planning for FY 2007 and Beyond

Turner described the steps needed for input for the FY 2007 budget and began with the timeline for budget preparation. It is illustrated below:



He noted that early input of ideas was the best and most effective. This should be done in the context of the MPS Themes and the FY 2006 drivers. MPS had a budget in excess of one billion dollars, and one had to focus on what one could do with that money.

With respect to FY 2006, the MPS budget drivers were strengthening the core, stewardship of its facilities, broadening participation, and, in the science disciplines, the Physics of the Universe, the Molecular Basis of Life Processes, Cyberscience/Cyberinfrastructure, the Mathematical Sciences Priority Area, and Nano Science & Engineering. MPS had certainly heard the message to protect the core. The MPS science themes were:

- Charting the evolution of the Universe from the Big Bang to habitable planets and beyond;
- Understanding the fundamental nature of space, time, matter, and energy;
- Creating the molecules and materials that will transform the 21st century;
- Developing tools for discovery and innovation throughout science and engineering;
- Understanding how microscopic processes enable and shape the complex behavior of the living world;
- Discovering mathematical structures and promoting new connections between mathematics and the sciences; and
- Conducting basic research that provides the foundation for our national health, prosperity, and security.

Turner concluded his presentation by presenting a slide of the divisional breakout session priorities.

Discussion: Lineberger noted that the core appears in multiple places within NSF and that the message from the community had been received. Kohn commented that the science drivers were multi-year activities, and that cyberinfrastructure was already planned for in the budget. But theory was not on the table, and the MPSAC ought to spend time discussing how the output of the theory workshop can provide input into budget decisions. Hellman agreed and added that some of the comments from the theory workshop were applicable to more than theory. She asked what the intent was of a crosscutting priority? For example, if NSF is the primary source of support for some communities should they be higher on a priority list? Baker asked Turner if the MPSAC could have meetings in between its Fall and Spring meetings. She wondered if the MPSAC could break up into smaller groups, meet, and provide feedback around February. Bildsten said that NSF needs to do more advertising of its results. NSF web sites are not helpful to the community. NSF should work to get the news on the front pages of newspapers.

Lineberger commented that the molecular basis of life was a real opportunity because it cuts through biochemistry, materials, across math and the physical sciences and represents small science. Gruner felt this was an area where NSF could really contribute. Turner responded that CHE has taken the lead and MPS needs help to define the theme.

Baker asked if the MSPAC could break into small groups to discuss these topics. Neuhauser agreed, adding that she liked the idea of working groups that could focus on scientific themes. Fortson added that perhaps a working group could be created for each of the drivers. Lineberger felt that the MPSAC was moving towards the concept of forming subgroups to work on themes and then to report to the Advisory Committee. Futrell suggested that the MSPAC experiment. He noted that part of the MPSAC had spent a day with staff and learned “on-the-ground” problems. Also the organization of the breakout sessions was by disciplines. He endorsed working groups, but not on a disciplinary basis.

Meeting of the MPSAC with NSF Acting Director Arden Bement

Lineberger welcomed Dr. Arden Bement, Acting NSF Director. Bement noted that the FY 2005 budget has been before both the House and the Senate. The FY 2006 budget has been sent to the Office of Budget and Management for their guidance. NSF is taking an aggressive approach to the 2006 budget given the tight budget climate it is facing. Another important issue is the declining success rate at NSF. Some of this has been caused by overly broad solicitations that generated a tremendous number of proposals. NSF needed to do something about this problem because the low success rate is bad for morale in the scientific community and the large increase in proposals puts a strain on NSF resources.

Lineberger commented that the MPSAC had been discussing a number of crosscutting activities and a recurring theme had been the importance of the core programs in the success of these activities, and the importance of recognizing the differences between disciplines. Bement responded that the fraction of interdisciplinary proposals has been rising at NSF. NSF has been responding to that demand. However, having said that, interdisciplinary research requires strong core programs. NSF must continue to pay close attention to the core areas. For example, young principal investigators in the core areas continue to rely on getting NSF grants to achieve professional status.

Baker asked about his views on cyberinfrastructure. Bement responded that most disciplines are moving towards complex modeling. This is especially true in computationally intensive areas in Earth Sciences and Biology. These problems represent a mathematical and a statistical challenge. NSF wants to see increases in both computational capacity and computational efficiency. It was possible to envision universities having their own high performance computing centers because one needs to move to a more distributed model. Putting these architectures in place requires the right mix of people. This is as true of small and medium scale facilities as it is of large ones. CISE will continue to take the lead, but the future efforts will require a different mix of people than what has been seen do date. NSF has a plan in the works that the Assistant Directors are developing.

Huchra noted that the MPSAC has been asked to look at the management of MREFC account. He asked Bement how he saw this process going forward. Bement responded that this has evolved over the last year and a half with the National Science Board. The Board schedule has to be coordinated with the budget schedule. NSF will have a list of goals for each of the Directorates that will help with the review of these centers. One will have to rely heavily on the judgments of our Science Board. NSF has committed to life-cycle costing with these centers, and this raises a number of issues. NSF had to be careful to avoid becoming facility rich and science poor because of the financial obligations. NSF estimates the recurring annual costs of a center to be about 15-20% of the cost to develop the center.

Narayanamurti commented that the volume of work for Program Directors has increased dramatically. Program Officers are now very overworked. It appeared to him that NSF looked very lean in terms of staff. Bement responded that NSF was trying to address this in three ways: use of internal tools such as Fastlane and the electronic jacket (E-Jacket); employing a contractor (Booz-Allen) to perform a study on how NSF can improve its productivity; and NSF has requested additional program officers in the budget request. He added that another concern he had was that there is now less time for intellectual activity and training for program officers.

Dr. Bement turned to the issue of undergraduate education, and noted that NSF has made some changes in its international program and expects that the budget for this program to grow faster than that of NSF as a whole. The relevance of this to undergraduate education is that he would like to extend NSF’s REU program to include an education abroad component.

Oxtoby commented that in the area of the public dissemination of science it was something that NASA does very well. What is NSF doing to improve in this area? Bement responded that NSF was in the process of redesigning its web site, which should greatly improve the Foundation’s ability to promote the science it funds. The recent NOVA episode featuring Brian Greene was another good example of what NSF should be doing more of to enhance the dissemination of science.

Lineberger: thanked Bement for taking the time to meet with the MPSAC.

Friday, November 5, 2004
Afternoon Session

The meeting of the MPSAC reconvened at 1:00 P.M.

Formulation of Recommendations for FY 2007 and Beyond

The general consensus of the MPSAC was that the FY 2006 recommendations were multi-year goals, and would comprise the bulk of the FY 2007 recommendations. One member noted that cyberinfrastructure and cyberscience would be included in the 2006 goals, and that it will continue to grow as it is folded into the core programs, but asked how to include theory and whether it should be an MPS priority. The responding comment was that based on information from the recent MPS Theory Workshop, the bulk of funding for theory comes from core programs already, but that perhaps theory should be a “driver.” The topic then turned to the Molecular Basis of Life Processes (MBLP). A comment was made that the name “Molecular Basis of Life Processes” did not capture the whole interaction between MPS and the Directorate for Biological Sciences (BIO) because it did not include earth systems, geology or the environment. It was agreed that an additional FY 2007 “Driver” should be Environmental Impact and Sustainable Energy.

Dr. Luis Echegoyan, the representative of the Committee on Equal Opportunity in Science and Engineering (CEOSE) committee to the MPSAC, was asked to share his thoughts on efforts to broaden participation. Echegoyan’s comments covered several considerations of CEOSE, such as how to persuade the top 10 or top 20 schools to increase the number of women and minorities. He explained that CEOSE is working on a biannual report to Congress including a 25-year review of the committee’s recommendations, which he pointed out have not changed much in that time. CEOSE is also considering how to pull out highlighted achievements asking,, in effect, what NSF has done in comparison to other agencies. El-Sayed suggested that the tenure system needs to be more flexible to allow for more women to enter academia. The discussion about efforts to broaden participation concluded with the suggestion that there could be an MPS-level workshop on the topic, and that it should be a discussion item at the April 2005 MPSAC meeting.

The last few items of discussion concerned extending the term of the MPSAC Chair in order to enhance the continuity of MPSAC activities, as well as forming a Steering Committee of MPSAC members to support the Chair. It was also suggested that an MPS-CISE working group be formed to focus on cyberscience. Finally, members were asked to sign up (via e-mail to the MPSAC Chair) for participation in groups involving

1) Publicity (including website);
2) Molecular Basis of Life Processes; and
3) Broadening Participation.

Action Items and Future Activities

1. Response of MPS to the JSAC Report;
2. Initial Response of MPS to the draft report of the MPS Theory Workshop;
3. Response of MPS to the MPS Cyberscience Workshop;
4. Breakout Session Chairs to provide Breakout Session Report to Lineberger;
5. MPSAC to provide MPS with its recommendations concerning readiness of the ATST

Adjournment

The meeting was adjourned at 3:00 p.m.

Appendices

APPENDIX I

ATTENDEES

MPSAC Members
Shenda Baker, Harvey Mudd College
Janet Conrad, Columbia University
Luis Echegoyen, Clemson University
Mostafa El-Sayed, Georgia Institute of Technology
Lucy Fortson, Adler Planetarium and University of Chicago
Jean Futrell, Pacific Northwest National Laboratory
Peter Green, University of Texas-Austin
Frances Hellman, University of California, San Diego
John Huchra, Harvard-Smithsonian Center for Astrophysics
Raymond Johnson, University of Maryland
Jon R. Kettenring, Telcordia Technologies
W. Carl Lineberger, University of Colorado
David Morrison, Duke University
Venkatesh Narayanamurti, Harvard University
Claudia Neuhauser, University of Minnesota
Gary Sanders, California Institute of Technology

MPSAC Members Absent
Dr. Steve Koonin, British Petroleum, Inc.
Dr. Marcia Rieke, University of Arizona

MPS Staff
Morris Aizenman, Senior Science Associate, MPS
Adriaan de Graaf, Senior Advisor, MPS
Laura Bautz, Acting Executive Officer, Division of Physics
Henry Blount III, Head, Office of Multidisciplinary Activities
Joseph Dehmer, Director Division of Physics
Arthur Ellis, Director, Division of Chemistry
Eileen Friel, Executive Officer, Division of Astronomical Sciences
Adriaan de Graaf, Executive Officer, MPS
Lance Haworth, Executive Officer, Division of Materials Research
Deborah Lockhart, Acting Executive Officer, Division of Mathematical Sciences
Lee Magid, Acting Executive Officer, Division of Chemistry
William Rundell, Director, Division of Mathematical Sciences
Judith Sunley, Executive Officer, MPS
Michael Turner, Assistant Director, MPS
Thomas Weber, Director, Division of Materials Research

Visitors
Arden Bement, Acting Director, NSF
Craig Foltz, Program Manager, National Optical Astronomy Observatories, AST
Elizabeth Grossman, House Science Committee
Lynn Jelinski, Sunshine Consultants International
Mitch Waldrop, Office of Legislative Affairs, NSF
Jakob Yngvason, Director, Erwin Schrödinger International Institute for Mathematical Physics, Vienna

APPENDIX II
MPS Advisory Committee Meeting
November 3 - 5, 2004
Divisional Breakout Group Assignments

			AST	PHY	CHE	DMR	DMS
			Room	Room	Room	Room	Room
			365	320	370	375	530
Term Ends 09/30/05							
	BAKER				X		
	GREEN					X	
	FUTRELL				**R**		
	MORRISON						**R**
	NEUHAUSER						X
	SANDERS		X				
Term Ends 09/30/06							
	CONRAD			**R**			
	ECHEGOYAN				X		
	EL-SAYED				X		
	FORTSON		X				
	HELLMAN					X	
	HUCHRA		**R**				
	JOHNSON						X
	KETTENRING						X
	LINEBERGER			X			
	NARAYANAMURTI					**R**	
Term Ends 09/30/07							
	BILDSTEN			X			
	COPPERSMITH					X	
	GRUNER					X	
	KOHN						X
Absent	KOONIN						
	OSTRIKER		X				
	OXTOBY				X		
Absent	RIEKE						
	SIMMONS			X			

APPENDIX III
MPSAC DIVISIONAL BREAKOUT SESSION REPORTS

Report on MPSAC Breakout Session with Division of Astronomical Sciences (AST) November 4, 2004

Attendees: *MPSAC:* Lucy Fortson, John Huchra (reporter), Elizabeth Ostriker, Gary Sanders

The astronomers on the MP SAC met with the AST Division staff on Thursday afternoon of the fall MPS Advisory Committee meeting. In attendance were Lucy Fortson, Eve Ostriker, Gary Sanders and John Huchra from the MPSAC and Wayne Van Citters, Richard Barvainis, Mike Briley, Andy Clegg, Craig Foltz, Tom Gergely, Vern Pankonin, Randy Phelps and Nigel Sharp from the AST Division.

The group first heard and discussed a presentation from Foltz on the status of the proposal for the Advanced Technology Solar Telescope (ATST). The ATST is an optically clean, off-axis 4-meter telescope designed for high spatial resolution adaptive optics observations of the surface of the Sun. This proposal is the outgrowth of 20 years of planning by the solar physics community and is now extremely well advanced. The ATST has been vetted by both the Astronomy and Astrophysics decadal survey (*Astronomy and Astrophysics in the New Millennium*, NRC 2001) and the Solar and Space Physics decadal survey (*The Sun to the Earth --- and Beyond*, NRC 2003).

We then discussed the questions posed to the Divisional breakout groups by the MPS Division. Below are the questions and our responses.

1. NSF faces tight budgets for the foreseeable future.

(a) ***Identify three areas or new opportunities that warrant the highest priority***.

The astronomers universally believed that protecting the grants program should be the highest priority of the AST Division. Currently about 2/3 of the Divisional resources are spent on major facilities, private or public. While a high level of institutional support is appropriate in a field that depends on large-scale, multi-user facilities, the funding of basic research by individuals and groups is where the rubber hits the road in research productivity. Only about 15% (~$30M) of the Division's budget goes towards individual investigator research grants.

The division has made great strides in improving the proposal success rate of individual investigators in the last few years from a dismal low near 20% at the end of the last decade. We applaud this progress and encourage the AST Division to continue promoting individual investigator-led research.

After the basics, there was strong agreement that there are substantial scientific opportunities in new interagency initiatives in physics of the Universe. The breakout group was apprised of the interagency roadmap and was strongly supportive of the goals it espoused for breakthrough programs on dark energy, fundamental stellar astrophysics, cosmology and gravity.

Next on our list was support for investments in enabling technologies for Decadal Survey priorities (e.g. diffraction limited imaging from the ground, RFI mitigation, and tools for high performance computing).

Finally, there was strong support for the other priorities identified in the extant Decadal Survey(s) such as filling the Virtual Observatory with an LST and enabling archives.

(b) Are there areas or activities that could be trimmed?

The astronomers agreed that it is absolutely necessary to "trim" or reprioritize if we are to make any progress on the issues discussed in (a). We strongly endorse the Senior Review process that is currently being planned which will include broad community input. This process is aimed at identifying facilities and programs worthy of continued or increased support and those that should be phased out in the near future to provide resources for new initiatives. We recognize that this is an extremely hard endeavor, but one with the possibility of substantial positive consequences.

2. Take one or more of the areas of emphasis at this meeting (Facilities, Theory, Cyberscience, Undergraduate Education).

(a) What is the importance of this area for the division/community?

This was a very difficult question for the group because all are important! We endorse the reports on theory, undergraduate education & cyberscience.

Facilities and data are the lifeblood of astronomy but their support must be balanced with support for people to maximize science. Again, we recognize that this is not an easy exercise and support the Senior Review concept for examining the intermediate term balance between facilities, astronomer support, Divisional support for education activities, etc.

(b) What steps are the division and/or the community taking to articulate issues and devise responses?

Astronomy is policy rich. Decadal surveys for astronomy and astrophysics, as well as several major subfields such as solar astronomy and planetary science, exist as well as mechanisms (e.g. the NRC's Committee on Astronomy & Astrophysics, the newly created interagency Astronomy & Astrophysics Advisory Committee, and ad hoc committees such as the NRC's Mid-Course Review) to guide the process. AST is reviewing the balance and content of its programs, including both optical and radio long range planning committees, which will lead to a Senior Review in 2005.

(c) What advice do you have for division or directorate courses of action?

In planning for the near term, the Division and Directorate should be sure to include the advice from the theory, education, and cyberscience workshops. We also believe that it is imperative for the NSF to continue to stress the importance of Project Management and Best Practices, both for facility development as well as operations.

The community's ambitions for facilities in the next few years will require additional manpower and other resources in the Division (form follows function, so as the business of the AST Division becomes more complex, additional staff are required if the NSF is to get value for its resources). We believe that the management of AST facilities operation should stay in the Division.

We also strongly believe that MPS and AST can enhance its visibility by sharing the excitement of astronomy with the public. The agency as a whole should support media relations. Although the NASA EPO model might not work for the NSF, the current record of the NSF's receiving credit for many of the discoveries and much of the research it supports is not good.

3. What are the most significant issues facing the division? How do they fit into the framework of the MPS Planning Document (as originally provided for the April 2004 meeting)?

The largest problem facing the division is implementing the very ambitious plan prioritized by the community in the decadal survey. We stress again that this plan includes maintaining and improving support of basic research. The astronomers on the MPSAC recognize that the Decadal Survey plan is more than a ten year undertaking.

Astronomy is very well aligned with several of the Directorate's scientific themes, and this will hopefully allow appropriate resources to be brought to bear.

Finally, Astronomy as a field is undergoing a cultural shift, both in the way much science is now done (large research groups, often multinational, large facilities), and also in the interaction of the field to other sciences, especially, but not only, physics (c.f. precision cosmology and its impact on field theories), and biology (the discoveries of large numbers of extrasolar planets and the concurrent rise in astrobiology). This cultural shift will impact the support needs of astronomers and facilities as astronomers move away from the "single observer" paradigm to mining data archives or joining larger collaborations.

4. Scientific themes in the MPS Planning Document.

(a) In which scientific themes is the division most vested?

Astronomy has a major role to play in several of the Division's scientific themes:

The Evolution of the Universe & its Contents
The Fundamental Nature of Space, Time, Matter & Energy
Tools for Discovery
National Health, Prosperity & Security

The first two are very obvious by the very nature of the field. Astronomy is also a discipline driven by forefront efforts in detector technology, computation, theory, visualization and the manipulation of large datasets, all tools for discovery. Lastly, astronomical efforts have been critical in areas such as the development of x-ray scanners (both medical and security), image processing and, more broadly, the development of a scientifically educated public, especially K-12 students. In the future, astronomical programs such as synoptic survey telescopes, could contribute to safeguarding the planet from asteroidal impacts.

(b) What actions are being taken by the division and/or the community to help refine or enhance the description of status or opportunities in the area?

In the past year, AST Division members participated in the development in the interagency report *Physics of the Universe*, a significant effort in cross agency planning, between NASA, the NSF and DOE, to address the fundamental questions put forward in the NRC report on *Quarks to the Cosmos*, science at the interface between physics and astronomy. Division staff also participate in community activities at American Astronomical Society and American Physical Society meetings, and in long range planning exercises with the community such as the Decadal Surveys. There is also heavy community and Division involvement in non-specialist education.

(c) What is missing from either the set of themes or the description of the themes that is important to the division?

We support the notion of themes as aids for development and planning, and as a means of selling the research program of the NSF to the public, but fundamental work in areas such as standards and calibration and algorithmics is also critical to the future of the field and to progress in the themes as well.

Report on MPSAC Breakout Session with Division of Chemistry (CHE) November 4, 2005

Attendees: MPSAC Members Jean Futrell (reporter), Mostafa El-Sayed, Shenda Baker and Luis Echegoyan
Absent: David Oxtoby, Carl Lineberger

CHE Members Art Ellis, Don Burland, Kathy Covert, Rich Foust, Janice Hicks, George Janini, Raima Larter, Lee Magid, Ty Mitchell, Charles Pibel, Lindsey Rich, Celeste Rohlfing, Phil Shevlin, Joe Templeton, Brian Tissue

Before undertaking discussion of the four assigned questions we engaged in a general discussion that included topics of concern to CHE program officers expressed at recent staff meetings. Many of these were related to issues/concerns about the impact of budget constraints, low and declining success rates for certain classes of proposals, and the increased burden on both the community and program staff as we work harder and harder to ensure that both merit review criteria are met. We also discussed the initiative to present a poster session of nuggets illustrating means for fulfilling "criterion 2" that will be presented at the next ACS meeting. "Judging" the top fifty of the approximately 120 entries is a homework assignment for the MPSAC chemistry members. A CD with the nugget entries was provided to each of the MPSAC chemistry members.

Not surprisingly, protection of the core is the first priority for CHE in a time of financial stress. We discussed the several new programs that CHE has introduced in recent years—Discovery Corps Fellowships, CRC's, REU's, EMSI's, CRIF, etc—to test whether any of these programs might be cut to preserve success rates and funding levels for individual PI grants. Our conclusion was that these programs are in some sense an integral part of the core for chemistry research. A brief discussion of the Cyberscience,Ttheory and MPS/EHR workshops validated that these are important programs that deserve support in shrinking as well as in expanding budgets. Leveraging funding with NIH and other agencies with respect to the "Molecular Understanding of Life Processes" initiative was discussed as both an important way to stretch funding, and a means to identify important opportunities for chemical research. The special opportunities that arise from recent advances in theory and measurement to understand the role of weak noncovalent interactions in biological reactions and self assembly of molecular structures in general falls into the category of opportunities that must be explored even in resource-limited scenarios.

In a brainstorming session we tried to identify places where cuts could be made to preserve the core and preserve headroom for at least a small number of new initiatives. No obvious alternatives emerged, partly because over 70% of the CHE budget is for single investigator research and another 15-20% is considered vital to the core. It was noted that the elimination of the cost-match requirement in instrumentation grants already has dropped the buying power of CHE's budget. We also discussed the unanticipated consequence of budget doubling in the NIH budget, which anecdotally has introduced perturbations in hiring and tenuring practices in chemistry. In many ways this is more disturbing than modest declines in budgets for NSF-supported chemical sciences research. Again no clear ideas on dealing with this problem emerged from our brief discussion. Taking a holistic view of the support of fundamental research in chemistry, opportunities for leveraging with other Federal agencies, particularly NIH, at the interface between chemistry and biological sciences, broadly defined, were briefly discussed as useful ways to address balance (or rebalancing) of disciplinary support for chemical sciences. The importance of creative approaches for support of young investigators was clearly emphasized.

We also reviewed briefly the third meeting with CHE staff attended by MPSAC chemists between the two prescribed MPSAC meetings. This was regarded as valuable but an experiment we would not repeat this year. Rather, joint meetings at such venues as ACS meetings are favored as a means for engaging the broader community with CHE and MPSAC activities. In addition, we favor undertaking one or more cyber-enabled meetings as the FY 2005 experiment. Some organization and data gathering in preparation for such a meeting is necessary and will be arranged through discussions with Art Ellis or a designee.

The designated breakout group discussion questions were then addressed, as follows:

1. Guidance to CHE for dealing with tight budgets. (a) The molecular basis of life processes, or more broadly the interface between the molecular sciences and biological sciences is a key intellectual challenge already adopted by chemists. The intersection with materials, particularly nanomaterials and self-assembly, is another research frontier. Cyberscience, including theoretical modeling and simulation, is also very important to modern chemical research. Underlying these three themes is achieving an understanding of weak, non-bonding interactions that are clearly involved in molecular self-assembly. (b) There are no easy solutions and no way to avoid cutting core support in some way. As noted above the core budget for CHE is between 70 and 90%, so there is no place to cut without impacting core support in some way. This point can profitably be discussed in dialogue with the broader community and will require a great deal of care and exercise of good judgment to do minimum harm.
2. Interest in the main topics emphasized at the meeting. (1) Our interest in major facilities is important to chemistry, primarily to segments of our profession rather than all chemical scientists, but certain major

facilities are vitally important to chemistry. Light sources, including next- generation light sources, neutron sources, and high magnetic fields are vitally important, and we believe that our community should be involved in the planning and construction of new facilities as well as key users of existing facilities. Access is important to the training of next-generation chemical scientists and to frontier research in chemistry. We want to be engaged at early stages rather than later and as key users rather than incidental users. (b) Cyberinfrastructure's importance to CHE was articulated by Shenda Baker in reporting the results of the MPS workshop. Similarly our interest in undergraduate education was articulated by Jeanne Pemberton. (b) A series of workshops recently completed and/or on the drawing boards for calendar 05 will engage the community in the planning process. These are in addition to planned events at professional society meetings and interagency and NAS activities related to priorities in the molecular sciences.

3. The most significant issue faced by CHE is maintaining balance in the program during an extended period of restrained budgets. Virtually 90% of the ensemble of programs supports core research in the chemical sciences. There are opportunities for leveraging CHE programs with other divisions within MPS and elsewhere in NSF. There are also opportunities to leverage CHE investments in collaboration with other Federal agencies supporting the chemical sciences. Sustaining the support of individual investigators, recruiting and supporting students and developing new faculty are among our highest priorities. At the same time there are opportunities arising from new developments in instrumentation, nanoscience, and infrastructure that must be supported. Engaging the community in priority setting will be a major challenge.
4. Core science themes for chemical sciences enumerated in the MPS list of last April. We embrace all the themes presented earlier in the meeting and our goal is preserving opportunities for creative research in chemistry. (a) The science theme closest to our domain is creating the molecules and materials that will transform the 21st century. Developing tools for discovery and innovation throughout science and engineering and understanding how microscopic processes enable and shape the complex behaviour of the living world are close seconds. All three play into the choice of the priority intellectual research challenge defined by the interface between physical and biological sciences. However molecular science is engaged in all the science themes articulated for MPS. (b) Actions taken by the division and the community are a series of workshops just completed, in progress, or in the advanced planning stage. These workshops plus special events planned for upcoming American Chemical Society meetings will provide focus and direction to CHE. (c) We argue that Environmental Science should be added to the list explicitly as an area where chemistry and much of MPS can? contribute to society [Energy was later added to the list in subsequent discussion but not called for in our breakout group. We endorse adding both E's to the MPS Themes list.].

Report on MPSAC Breakout Session with Division of Materials Research (DMR) November 4, 2004

Attendees: *MPSAC:* Peter Green, Frances Hellman and Venkatesh Narayanamurti

DMR is, inherently, very interdisciplinary, and there are exciting emerging opportunities in the field. Quantum behavior is arising in many situations, new materials are being created, and there are increasing connections with biology. DMR is a bottoms-up field, with discoveries being made by individuals in labs. There is a bottoms-up approach to dealing with areas that should be reduced, in the sense that this is being done by program directors all of the time.

With respect to facilities, new tools are extremely important. Small instruments are needed in labs, and there is some use of the large-scale facilities of the Department of Energy. Upgrading of larger facilities such as CHESS and NHML is under consideration. Balancing the needs of small and larger facilities is always a delicate matter in DMR. He noted that there would be no cyberscience if the materials needed to create new types of chips or magnetic materials are not developed. Materials research is in fact the key to the "virtual world" of the computer.

The breakout group was in full agreement with the report of the joint MPS-EHR education working group, and felt that there could be further leveraging of activities by combining resources with NSF's Directorate of Education and Human Resources (EHR).

With respect to initiatives, the nano initiative was very important to the core activities of DMR, but the initiative could overload DMR with proposals. The area of condensed matter physics was very important. The number of proposals coming to DMR has continually increased and the success rate in several programs is low. Program officers have a very heavy workload.

Report on MPSAC Breakout Session with Division of Mathematical Sciences (DMS) November 4, 2004

Attendees: *MPSAC:* Raymond Johnson, Jon R. Kettenring, David Morrison (reporter), Claudia Neuhauser,

With respect to future tight budgets, trimming would have to be done within disciplinary programs, based on quality rather than based on scientific topics chosen in advance. In the area of cyberscience, DMS plans to devote previous ITR funds to computational issues, and hopes that CISE will match these investments. Investments would be in three areas:

– Multiscale modeling;
– Interesting interface between probability, statistics, modeling (stochastic computing); and
– Other computational issues in mathematical sciences.

There is a need to develop the computational tools for use by mathematical scientists, and modelers in other fields

With respect to theory, the bulk of the research supported by DMS is theoretical. The Mathematical Sciences Priority Area (MSPA) has enabled DMS to amplify theoretical research in other divisions, and this can be a model for all theoretical sciences within MPS to make impacts in other areas. The core is extremely important, equally important to the interdisciplinary initiatives.

DMS has invested heavily in undergraduate programs [REU, Vertical Integration of Graduate Research and Education Program (VIGRE)]. The breakout group endorses the preliminary recommendation of the Theory Workshop to create a 21st century version of the Student Science Training Program (SSTP) program for high school students, and hopes that this can be done in partnership with EHR.

The most significant issues facing DMS are the very low success rate (26%), which leads to a high rate of discouraged applicants, who don't apply again. DMS is responsible for 75%-80% of all federal funding in the mathematical sciences. Broadening participation remains a challenge, and staffing within DMS is a concern.

With respect to scientific themes within DMS, they range from abstract mathematical concepts to computational tools to analyze large data sets. Mathematics and statistics contain many interesting "core" problems, in addition to those articulated in the MPS planning document, in traditional areas such as number theory, geometry, topology, differential equations, analysis, probability, statistic. He noted that the recent solution of the Poincare conjecture through singularity development in Ricci flow is a reminder that singularity development is an important feature of other equations, such as the Navier-Stokes equations describing fluid flow.

Report on MPSAC Breakout Session with Division of Physics (PHY) November 4, 2005

Attendees: MPSAC: Lars Bildsten (Chair), Carl Lineberger, and Elizabeth Simmons

In the afternoon, Lars Bildsten (Chair), Carl Lineberger, and Elizabeth Simmons met with the PHY division, led by Joseph Dehmer. Bildsten and Dehmer co-chaired the session, with Dehmer beginning by giving the PHY divisions answers to the points raised in the document given to MPSAC to lead the breakout discussions

Question 1a: The top three priorities of the PHY division are:

- Most importantly: strengthening/maintaining the core (i.e. the grants program). PHY intends to keep this at no less than 50% of the total PHY budget. PHY plans to strengthen theory by increasing support by an amount of order 5% per year.
- Physics of the Universe (implement Quarks to Cosmos as envisioned in the OSTP planning document "Physics of the Universe). This is being done via support of dark energy studies via the Atacama Radio Telescope, enhance numerical relativity in order to support LIGO, and support dark matter experiments (CDMS2, and development of liquid xenon).
- Stewardship of the MREFC projects currently in operation (CESR, LIGO, NSCL), or under construction (LHC, ICECUBE)

PHY noted that there are many priorities that deserve support but that cannot be major initiatives in the current budget climate, These include biological physics, cyberscience, mid-scale instrumentation and accelerator physics.

The MPSAC breakout group supports PHY priorities and is heartened to see the strong PHY position of protecting the core and strengthening theory. The discussion touched on some important issues of balance: While one wants to support as many good groups as possible, grants need to be large enough to support quality research through to success. One also needs the funding success rate to be such that only high-quality science is being supported and this rate may differ by subfield (and over time).

We also felt that fields with no MRE facility need to receive close attention within the grants program, especially when NSF is a primary steward of the field. PHY's plans for theory support are one such example; others would include emergent fields. We were not convinced that numerical relativity needed to be singled out for special support, especially in light of the three avenues of support for LIGO related research. That being said, we do encourage PHY to consider supporting a broader scope of computational physics. Advice and direction on this is likely to come from the report of the Theory Workshop, as well as the in-hand report from the workshop on Cyberinfrastructure.

Question 1b: The PHY approach to trimming is to first cut support to the lower priority MRE facilities and slow down growth in new MRE facilities. The second program where costs could be controlled is the Physics Frontier Centers (PFCs). The last item to trim would be PI support; even then it must comprise at least 50% of the PHY program.

PFC plans: There are presently 10 PFCS, five of which will be re-competed against each other in FY06. The next open PFC competition will be in FY08; the other 5 existing centers will compete against brand-new proposals. In an asymptotic state there will be a new competition every 3 years; awards will be for 5 + 1 year extension. The advantage of this structure is the ability for PHY to fund fewer (or more) PFCs depending on the budget outlooks at the time of the competitions.

Question 3: There is clear integration of education and broadening participation throughout the PHY programs (i.e. PI's, Centers, Facilities, and targeted programs).
The REU, RET programs are in a separate education piece of the PHY budget (~2% per year), and OAD/MPS (IGERT/ADVANCE) is a separate ~3 % per year of the budget.
An MPS workshop on these topics would help set further priorities in this area.

Question 4: We lacked time to address computing needs and cyberinfrastructure in any depth. We did note that the migration of ITR funds from CISE into the other directorates and divisions to support more disciplinary-related research seems to be working well (e.g. as described in the reports to MPSAC earlier today).

Cross-Cutting Comments

PHY planning clearly reflects the input from the community. For example, the OSTP Physics of the Universe report (an implementation plan following *Quarks to Cosmos*) impacted the new Physics of Universe initiative within the PHY division, thus supporting these efforts at the intersection of Physics and Astronomy. The core discipline advisory panels' recommendations also appear to direct PHY planning. Core field advice from outside PHY(for example, the Decadal Survey) is not a PHY primary input.

We eagerly await the new NSF website, as the current website did not seem especially well suited to the NSF's outreach mission.

We found it extremely helpful to see PHY projections and plans for future efforts.
Given the uncertain budgetary times and inflation, budget projections that include MRE operations are needed for planning/scope and protecting the core.

Given the amount of astrophysics supported by PHY, the standing NRC Committee on Astronomy and Astrophysics should establish a closer contact to PHY. Bildsten (as a member of CAA) has agreed to discuss this with CAA.

We wondered whether the 50% fraction for support of the core program is the right fraction. This depends on taking a close look at the grants program and we recommend it be addressed more thoroughly during the next PHY COV gathering.

APPENDIX IV
FINAL REPORT FROM THE EHRAC/MPSAC JOINT SUBCOMMITTEE ON UNDERGRADUATE EDUCATION IN THE MATH AND PHYSCIAL SCIENCES

THE UNIVERSITY OF ARIZONA®
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October 19, 2004

Dr. W. Carl Lineberger, Chair
NSF MPS Advisory Committee
Department of Chemistry and Biochemistry
Joint Institute for Laboratory Astrophysics
University of Colorado at Boulder
UCB 440
Boulder, CO 80309-0440

Dear Carl:

Attached is the final report from the EHRAC/MPSAC Joint Subcommittee on Undergraduate Education in the Mathematical and Physical Sciences (JSAC) that we submit for approval by the MPS Advisory Committee (MPSAC) at their upcoming meeting in November. Since much of the background material is contained in the interim report that was submitted last April, you may wish to consider having the interim report included in the AC briefing book for the meeting. I will be present to discuss this final report at the joint session of the EHRAC and the MPSAC on Wednesday, November 3 at 4:30 PM.

Finally, along with the specific recommendations contained in the report, the EHR/MPS JSAC also wishes to express its dismay at the continual decline of the budget for the Division of Undergraduate Education (DUE). The Joint Subcommittee urges the MPSAC to continue to voice their strong support of this unit as one of the foundational pillars of undergraduate education in the mathematical and physical sciences at NSF.

I look forward to seeing you in November.

Sincerely,

Jeanne E. Pemberton

Jeanne E. Pemberton
for the EHRAC/MPSAC JSAC

Attachment
cc: M. Aizenman, J. Sunley, H. Blount, M. Turner

Undergraduate Education in the Mathematical & Physical Sciences: Report of the Joint Subcommittee of the NSF EHRAC and MPSAC

October 2004

Undergraduate education in STEM disciplines is of vital importance to the nation. Within the mathematical and physical sciences, the core disciplines of mathematics, chemistry, and physics play a central role in producing baccalaureate degree recipients who support the graduate enterprise in these and related disciplines, who become K-12 STEM teachers, and who represent the entry-level technical workforce in many industries. The research and education frontiers of these disciplines are changing rapidly with important implications for the nature of modern professional practice, the preparation of new professionals, the creation of pathways that broaden participation, and the education of the U.S. citizenry. Assessing the implications of these changes in the context of undergraduate education in these disciplines is essential to ensure maintenance of a robust and dynamic undergraduate enterprise responsive to the scientific and technological needs of the U.S.

This study was undertaken at the request of the Education and Human Resources (EHR) and Mathematical and Physical Sciences (MPS) Directorates of the National Science Foundation (NSF) in order to assess the current state of the undergraduate education of majors in the mathematical and physical sciences, with a focus on the core disciplines of mathematics, chemistry, and physics, and to provide recommendations to EHR and MPS for activities that they might undertake to improve undergraduate education in these areas. Towards this end, the EHR and MPS Advisory Committees established a Joint Subcommittee on Undergraduate Education in the Mathematical and Physical Sciences and NSF staff charged it with conducting this study. This Subcommittee met three times during the past 18 months, held numerous discussions both among its members and with representatives from the affected communities, and held conversations with NSF senior management from EHR and MPS. Much background material on the current state of undergraduate education in the mathematical and physical sciences can be found in the interim report from this Joint Subcommittee and is not repeated here. Based on instructions from Assistant Director Judith Ramaley of EHR and Assistant Director Michael Turner of MPS, the Joint Subcommittee has cast the **additional** recommendations contained herein as focused, actionable steps that can be implemented immediately for positive impact on undergraduate education in the mathematical and physical sciences. These recommendations are made here without extensive written justification or background.

It is imperative that these recommendations be considered in the context of the current activities of NSF in undergraduate education in the mathematical and physical sciences.

Discussions of the Joint Subcommittee with NSF staff revealed a commitment on the parts of both EHR and MPS to the cooperative spirit that underlies this joint activity of the two Advisory Committees. Indeed, innovative activities and programs have been initiated over the past several years that have been borne of the vision and creative collaboration of senior management and staff throughout all levels of EHR and senior management and staff from several Divisions and the Office of Multidisciplinary Activities within MPS. Thus, the recommendations contained here should be viewed as additions to existing activities and programs designed to improve undergraduate education in the mathematical and physical sciences.

The Joint Subcommittee offers the following recommendations:

Recommendation 1: Although undergraduate research has proven to be a highly effective pedagogical tool, it is not being used sufficiently to broaden participation in the mathematical and physical sciences.[1] Therefore, the Joint Subcommittee recommends that EHR and MPS jointly develop a new program called **Research Experiences for Early Career Undergraduates (REECU)** with funding for both sites and award supplements. This program would use the existing Research Experiences for Undergraduates (REU) program as a model but would be targeted exclusively to freshmen and sophomore students in the mathematical and physical sciences.

Many models are conceivable for the increased use of research at the early undergraduate career stage as a mechanism for broadening participation in the mathematical and physical sciences. The Undergraduate Research Center (URC) and Undergraduate Biology and Mathematics (UBM) programs have recently been implemented at NSF and represent two such models. The Joint Subcommittee recommends that the REECU program be initiated in addition to these existing programs, since all three approaches represent new paradigms for broadening participation in undergraduate research in the mathematical and physical sciences and each has the potential to have a favorable impact on a different segment of the student population.

In addition to the inherent strength of research as a pedagogical tool, its use at the early undergraduate level also has the potential to facilitate development of a greater multidisciplinary perspective on the part of participating undergraduates. Moreover, REECU sites based on multidisciplinary research might provide a foundation on which to base development of true multidisciplinary undergraduate programs in which an early career undergraduate research experience serves as a central element.

[1] Statistics that support this position are available in S. H. Russell, *Evaluation of NSF Support for Undergraduate Research Activities: 2003 NSF-Program Participant Survey* (DRAFT REPORT), SRI International: Menlo Park, CA, 2004.

Recommendation 2: Two-year colleges are playing an increasingly important role in undergraduate education. Although the range of capabilities of two-year colleges and two-year college faculty in research is highly variable, efforts should be made to increase the capacity of these institutions to engage in research through an experimental program that supports **Research Experiences for Early Career Undergraduates at Two-Year Colleges (REECU-TYC).** The expectation is that these programs would be of smaller scope than their REECU counterparts. Such programs have the potential to produce mid-career undergraduates better equipped and better motivated to pursue four-year degrees in the mathematical and physical sciences and to reinvigorate two-year college faculty in a way that should have long-term positive benefits.

Recommendation 3: A gap in culture exists between the EHR and MPS Directorates that must be bridged to further undergraduate education in the mathematical and physical sciences. Both Directorates fund exceptionally successful programs related to undergraduate education, but these are in somewhat discrete domains. Multiple opportunities exist for more cooperative efforts, but no effective mechanism for identification of the appropriate connections between the two Directorates has been sustained over time. Nonetheless, several recent examples (e.g., NSSE, NUE, URC, Discovery Corps in CHE, QuarkNet and PhysTEC in PHY, and UBM in DMS) from the interaction of the CHE, PHY and DMS Divisions of MPS with multiple units of EHR suggest that EHR and MPS working in cooperation can indeed achieve results that are greater than the sum of the parts. As a mechanism for facilitating greater interaction between the two Directorates, the Joint Subcommittee recommends that a joint **EHR/MPS Undergraduate Education Working Group,** comprised of representatives from DUE, HRD and REC within EHR and representatives from each of the Divisions within MPS along with senior staff from these Directorates as deemed appropriate by the Assistant Directors, convene on a regular basis to discuss existing or potential programs that impact undergraduate education. The Joint Subcommittee anticipates that this Working Group would provide a vibrant and multifarious environment from which concepts for new programs could emerge and within which new program solicitations for any program impacting undergraduate education could be productively and efficiently considered. In short, such a body would provide a core group through which to explore emerging areas of common interest between the Directorates in undergraduate education in the mathematical and physical sciences.

Recommendation 4: Considerable expertise in program assessment and evaluation exists within EHR, particularly in the REC Division. MPS has not yet taken full advantage of this expertise in the development of program guidelines and solicitations for programs impacting education. For all such programs, **MPS should seek the expertise in EHR (e.g., in REC, DUE, and HRD) on program assessment and evaluation during development of program solicitations.** As has been amply demonstrated by several recent examples from the CHE Division (e.g., URC, Discovery Corps), such expertise can greatly enhance new programs with components related to education and may help build capacity for assessment and evaluation activities within the MPS disciplinary communities with whom MPS interacts.

Areas for Future Joint EHRAC/MPSAC Attention in Undergraduate Education

The EHRAC and MPSAC are encouraged to request regular reports on progress towards implementation of the recommendations made here. Moreover, several important areas of undergraduate education were not adequately addressed by this study as a result of time limitations. These areas are ripe for future exploration in a manner that brings the expertise of the EHR communities and the MPS communities to their consideration. Specifically, these areas include:

1. **Preparation of K-12 teachers in the mathematical and physical sciences.**

2. **Transitions of two-year college students to four-year programs in the mathematical and physical sciences.**

Such complex issues, like others in undergraduate education, are more amenable to exploration with the broad expertise available within these two communities than by either community individually. Indeed, success in addressing these issues will require systems-level efforts that are best conceived through such joint consideration. Therefore, the Joint Subcommittee strongly urges the EHRAC and the MPSAC to accept these important challenges in undergraduate education as the basis for future joint activities.

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APPENDIX V

Certification of Accuracy of Minutes of November 2004 MPSAC Meeting

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February 2, 2005

Dr. Michael S. Turner, Assistant Director
Directorate for Mathematical and Physical Sciences
National Science Foundation
4201 Wilson Boulevard
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Dear Michael:

I have reviewed the final version of the minutes of the Directorate for Mathematical and Physical Sciences Advisory Committee meeting that was held on November 3-5, 2004 (attached), and am pleased to certify the accuracy of these minutes. I especially appreciate the efforts of Morris Aizenman, both in preparing this record, and in incorporating those changes suggested after my review of the draft minutes.

With best wishes,

W. Carl Lineberger

W. Carl Lineberger
Chair, MPS Advisory Committee