Report of the Committee of Visitors

Major Research Instrumentation Program

June 14 – 16, 2000

Jean'ne Shreeve

Committee Chair

EXECUTIVE SUMMARY

Overall, the Committee of Visitors (COV) is very impressed with the Major Research Instrumentation program. According to their evaluations, the program has effectively used the merit review process to fund awards that support Criterion 1 by being:

- At the very good to excellent level of quality in their scientific and engineering content ;
- Appropriate with respect to award, scope, size, and duration;
- Open to and supportive of new investigators (higher success rate than across the NSF);
- Pipeline to important discoveries and new knowledge and techniques;
- Resulting in supportive state-of-the art instrumentation being placed in appropriate laboratories across the research community (although only a small number of interdisciplinary activities are supported);
- Based on adequate reviews by persons with appropriate expertise;
- Absent of reviewer conflict of interest;

- Evaluated by reviewers with good geographic representation;
- Reviewed in a timely manner; and
- Balanced between high-risk, multidisciplinary, and innovative projects.

The issue covered by Criterion 2, however, appears to be addressed less adequately. The level of seriousness with which it is taken varies greatly from proposal to proposal and from reviewer to reviewer. Some reviewers ignore it completely in proposals they consider to be excellent for other reasons, and other reviewers may be using it as a reason for rejecting proposals that displease them for broader reasons. Frequently, funded exemplary as well as funded non-exemplary proposals make no mention of underrepresented groups in the integrative research and educational activities, and reviewers do not note this lack. The COV observed that when most of the reviewers are women, closer attention is paid to Criterion 2. A greater effort must be made to encourage women, minorities, and investigators from non-doctorate-granting institutions to participate as principal investigators (PIs) and reviewers. However, currently female PIs are more successful than their male counterparts.

While the MRI program measures up quite well under GRPA Outcome 1, evaluation of GPRA Outcome 2 is much more difficult given the data available. This is inherent in the program because final reports are due soon after the major instrumentation is purchased and before large amounts of data can be generated using the new instrumentation. In order to respond to GRPA Outcomes 1 and 2 in a meaningful way, the timeframe for collecting data must be modified; e.g., the COV believes that random technical audits and extended reporting periods may be useful. The COV felt that GPRA Outcomes 3 and 4 were beyond the goals of the MRI program.

It is impractical, given the nature of the instrumentation being developed, to anticipate more than a few partnerships between the academic, private, or federal communities. The real excitement of the program seems to arise from the development proposals; therefore, program staff should devise methods to attract greater numbers of such proposals.

BACKGROUND ON THE COV PROCESS

The Committee of Visitors (COV) for the Major Research Instrumentation program met at the NSF headquarters on June 14-16, 2000. This is the initial review of the program by a COV, and the time period covered was FY 1995-FY 1999 rather than the standard 3-year review period mandated by the Foundation. This was also the first COV review coordinated by a private vendor, in this case, Westat of Rockville, Maryland.

Members of the COV received a letter from Westat's MRI Evaluation Coordinator approximately 2 months prior to the scheduled visit concerning the trip, locale, and reimbursement arrangements. About a month before the COV meeting, a packet of materials was received by the COV members that included a) a program overview, *Research Instrumentation: Enabling the Discovery Process,* b) a formal charge and instructions to the COV, c) the FY 2000 Core Questions for NSF COVs, d) the FY Report Template for NSF COVs reflecting the content and structure of the Core Questions, e) an MRI program solicitation, and f) a data book containing program operating statistics. The data book contained an MRI overview, MRI award size and dollar amounts, MRI success rates, MRI proposals by PI and institution characteristics, and MRI proposals by review type.

The core questions to be addressed fell into four general categories: a) program processes and management; b) program results that included not only basic questions as defined by GPRA but also goals specific to the MRI program; c) other issues arising from each NSF directorate's technical coordinator; and d) NSF areas of emphasis.

The COV was welcomed by Joseph Burt, Staff Associate, Office of Integrative Activities, and Dr. Patricia Butler, Evaluation Coordinator, Westat. The committee members (who are identified elsewhere in this report) introduced themselves. Dr. Nathaniel Pitts, Director of the Office of Integrative Activities, expressed appreciation to the COV, presented a historical perspective of the MRI program, and answered questions from the COV. Dr. Loretta Hopkins, Staff Associate, Office of Integrative Activities, explained the GPRA role in the review content; Ms. Rowena Peacock, Director, Systems Management, in the Mathematics and Physical Sciences Directorate (MPS), and Craig Robinson, Acting Chief, External Systems Branch, presented information about FastLane. The necessity for maintaining confidentiality and freedom from conflict of interest was stressed.

After some discussion of the agenda, six two-person subgroups and one four-person subgroup were assigned to address the seven general categories that provided a common thread across two or more of the question areas.

The first afternoon was devoted to discussing the five topics in the Other Issues category. Discussion and information on these issues was supplemented by brief sessions with the technical coordinators or their representatives from a) Mathematical and Physical Sciences; b) Biological Sciences, and Social, Behavioral, and Economic Sciences, and Computer and Information Sciences; and c) Geological Sciences and Polar Programs. Westat provided the committee with tabular lists of available sources of information about each of the questions within the four general categories. Other documents were provided to the committee on an as-needed and on as-available basis.

At the beginning of the second day, each of the subgroups began its examination of materials relevant to its assigned topics. Additional materials that were available to the COV at the meeting included sample jackets for 30 proposals randomly selected from FY 1995-99. In addition, 15 randomly selected exemplary project jackets (nominated by the technical coordinators of each directorate), plus abstracts from 24 exemplary projects (4 from each of BIO, CISE, MPS, GEO/OPP, SBE and ENG) were available. All 15 of the random sample proposals and 15 of the exemplary proposal reviews were summarized giving number and fields of reviewers, number of mail reviews, use of panels, examples that Criteria 1 and 2 were employed in evaluation. COV members also received program final reports. For projects where the grant period had expired, most jackets contained final reports. In addition, 28 project abstracts/final reports were supplied for FY 1998. Chronology of the disposal of all proposals from non-Ph.D.-granting historically black colleges and universities (HBCUs) and predominantly Hispanic institutions for the period FY 1995-FY 1999 and comparative data for non-Ph.D.-granting institutions and the NSF were also made available.

After perusal of the various documentation materials and intrasubgroup discussions, each subgroup was able to record its inputs to assigned topics by accessing a blank template that contained all of the questions via PC. Five PCs, as well as several belonging to COV members, were available for data entry. The COV met as a whole and discussed and supplemented/modified the input of the subgroups. The responses were integrated and the rough draft was made available in hard copy to the COV to permit further refinement of the responses to each of the four categories.

On the morning of the third day, the COV continued to fine-tune the report. A closed session with OIA Director, Dr. Nathaniel Pitts, resulted in frank, positive discussions that extended into the designated open session. No members of the public were present. Dr. Pitts remained until 11:52 a.m., when discussion points had been exhausted. Further refinement of the document continued until the committee adjourned at 12:48 p.m. Finishing touches were to be completed via e-mail.

FY 2000 RESPONSE TEMPLATE FOR
COMMITTEE OF VISITORS (COVs)
MAJOR RESEARCH INSTRUMENTATION PROGRAM
JUNE 14-16, 2000

Integrity and Efficiency of the Program's Processes and Management

1. **Effectiveness of the program's use of merit review procedures:**

   a. Is the overall design, including appropriateness of the review mechanism (panels, ad hoc reviews, site visits), effective? Yes.

      However, the interdisciplinary proposals did put more weight on Criterion 2 than Criterion I, which may indicate a problem with the panel makeup.

   b. Is the review process implemented effectively? **Yes.**

      Most of the proposals reviewed used ad hoc reviews and panels, although according to the histogram data some used ad hoc reviews only, e.g., Databook E2g – Polar Programs and E2d – GEO (mainly ad hoc) while E2c - ENG (mainly panel). Using both ad hoc and panel reviews allows for more consistent overall reviews and helps in eliminating from the review process the "herd mentality" that can pervade pure panel reviews.

c. Is the review process administered in a timely fashion? **Yes.**

The average time from receipt to decision was 5.51 months for MRI compared to 6.18 across the Foundation. (refer to Databook A-6).

d. Are recommendations adequately documented? **Yes.**

e. Are recommendations consistent with priorities and criteria stated in the MRI program solicitations? **Yes.**

Also see sections A-2a and A-4e in this report.

1. **The program's use of the new NSF Merit Review Criteria: The program is successful when reviewers address the elements of both generic review criteria appropriate to the proposal at hand and when Program Officers take the information provided into account in their decisions on awards.**

Is the program successful overall?

a. Did reviewers address the elements of both review criteria appropriate to the proposal at hand? Yes.

All of the sample proposal jackets examined demonstrated a strong commitment to selecting proposals based on scientific merit (Criterion 1). More attention tends to be paid to Part 1 of Criterion 2 ("advances, discovery, teaching...") than the other parts, but this is perhaps natural in a research equipment program. There is also a tendency for reviewers to use Criteria 2 to eliminate proposals that they do not want to fund and to ignore it for the proposals they wish to fund.

b. Did program officers take the information provided into account in their decisions on awards? **Yes.**

c. Based on these criteria, does the program successfully use the new merit review criteria? **Yes.** See also section A-4e below.

d. Identify possible reasons for dissatisfaction with NSF's merit review system.

This issue is addressed throughout the report.

1. **Reviewer selection:**

a. Are proposals evaluated by an adequate number of reviewers with appropriate expertise/qualifications? **Yes.**

The COV did not have access to the information on the reviewers' specific areas of expertise. Some reviewers self-identified themselves in places where they thought that their expertise might be lacking. The general disciplines of the reviewers seemed appropriate to the proposals. The numbers of reviewers ranged from 4 to 14 for the sample proposals that we examined, with the minimum number both from EIA. Why would EIA, which is "integrative," have the smallest number of reviewers and therefore the least diversity of reviewers?

b. Do reviewers reflect balance among characteristics such as geography, type of institution, and underrepresented groups? **Geography, yes; Institution, no; Gender, no; Race/ethnicity, no data available.**

The reviewers were largely from primarily research-oriented institutions based on the sample of proposals examined. At this time, the statistics indicate no adverse consequences in the terms of the success rate for female-generated proposals since it is larger than that for proposals generated by males. The reviewers are overwhelmingly male; for 19 proposals examined, there were 8 with all male reviewers (for example, the two EIA proposals cited immediately above), 3 with only a single female reviewer, and 1 where the gender of three reviewers was unidentified. This phenomenon appears to vary according to directorate. In 1999, sample proposals contained reviewer lists from AST, CTS, EIA, MPS, GEO, OCE, and ENG that were all male or contained at most one female member. BIO was a notable exception, with review panels being one-third to one-half female. In divisions where at least 30 percent of the reviewers are female, there appears to be increased attention paid to Criterion 2.

c. Are apparent conflicts of interest recognized and adequately resolved? **Yes.**

There were few conflicts of interest (COI) that arose in the sample of proposals that we examined. Where they did occur, reviewers appeared to err in the direction of caution when identifying themselves as having COIs, and the resolution seemed appropriate. There is no indication that there is any problem here that needs correction.

1. Resulting portfolio of awards:

a. Is the overall quality of science/engineering high? **Yes.**

a. Are awards appropriate in scope, size, and duration? **Yes.**

The MRI Program Solicitation NSF 99-34 states that the scope of MRI awards should include both instrument acquisition and development. An instrument is considered to be "a single instrument, a large system of instruments, or multiple instruments that share a common or specific research focus." This specification covers the range of possible instruments that might be considered important for research purposes. Furthermore, the specification places the emphasis on the research focus of and goals for the instrument rather than the physical description of the instrument. This specification seems to cover the range of conceivable instrumentation without excluding devices, systems, or collections that, by their proposed use, are important instruments in one scientific context. For example, a proposal to purchase a cluster of computer workstations without a specific scientific focus would not constitute an instrument. However, the same hardware, when used collectively to investigate voting behavior in political science or to carry out computationally intensive calculations for computational fluid dynamics, functions scientifically as an instrument and should therefore be included within the scope of the MRI program.

Of the 1,456 submissions from 1997 to 1999, 22 percent proposed the development of instrumentation whereas the remaining submissions proposed instrument acquisitions. By comparison, 18 percent of the actual awards were made to develop new instrumentation. This indicates that the number of development awards roughly corresponds to the proportion of development submissions. Together with consideration of the types of instruments being funded under the program, the scope of the awards is appropriate.

With respect to size of awards, currently $10 million is set aside for the explicit purpose of guaranteeing funding for large proposals (those greater than $1 million). Without this set aside, it is likely that the volume of smaller proposals would make it difficult to fund the largest requests. Currently, large proposals constitute about 11 percent of the total of MRI proposal submissions. Given the current set-aside, this means that about 8 percent of the awards that are funded are over $1 million. Thus, the proportion of actual awards over $1 million out of the total number of awards is quite similar to the proportion of these proposals submitted. However, it is important to note that there are some discrepancies by directorate: Within ENG, 9.5 percent of the submitted proposals requested $1 million or more, but only 2.7 percent of them received awards. Similarly, within MPS, 7.8 percent of the submissions were for $1 million or more, and only 4.9 percent of them were awarded. By contrast, in OPP 23.1 percent of the submissions were large proposals and 33.3 percent were awarded. Overall though, across the directorates as a whole, it appears that there is a match between the proportion of submissions for $1 million or more and awards. Thus, the MRI program is maintaining a mix of large and small awards that is comparable to the submission rate of these proposals. The strategy of setting aside $10 million as a pool for large instrumentation does seem to produce desirable results.

At the lower end, the program solicitation indicates that proposals requesting under $100,000 should only be funded from non-Ph.D.-granting institutions, from the mathematical sciences community, and from the social, behavioral, and economic sciences community. From 1995 to 1999, 56 awards were made for requests under $100,000. Three of these requests came from SBE, as allowed for in the solicitation, and 13 came from MPS. From 1996 to 1999, 51 awards were made to non-Ph.D.-granting institutions. Therefore, it appears that there is a reasonable correspondence between the limitations on smaller awards as specified by the MRI program solicitation and the award process.

Over the period 1995-99, the average duration requested for MRI proposals that were awarded was 2.24 years; the average duration of the actual effort was 2.27 years. This is just slightly lower than the average duration of NSF research awards, which is 2.49 years. Although there is some variability across this period, MRI awards are typically shorter in duration than overall NSF awards. Among applicants that requested 2 or 3 years for their project, 84 percent were awarded their requested duration. For other requested durations, the agreement between request and award was considerably lower, e.g., around 60 percent for 1- or 4-year durations. For proposals requesting 5 years, only 26 percent were awarded that duration. In general then, it appears that awards are appropriate in duration.

b. Has the program effectively identified and supported emerging opportunities? **Yes.**

While many are being funded, the COV encourages more aggressive solicitation. Three proposals are good examples of innovative, cross-disciplinary science with engineering and instrument development, focus on establishment of ocean floor instrument capability off Hawaii by exploiting retired telephone cable for power and data telemetry, promise enhanced capability in seismology, volcanology, and ocean studies. It will be some time before we see the full payoff from these projects, but they demonstrate a strong program commitment to innovative, cross-disciplinary, development-oriented research.

d. Has appropriate attention been given to maintaining openness in the system, for example, through the support of new investigators? Yes.

The percentage of new PIs is approximately the same in the MRI program as in NSF overall (37-45 percent vs. 41-45 percent). The percentage of awards to new PIs in the MRI program is the same as for NSF overall. The success rate of new PIs in the MRI program is only slightly lower than the success rate of all PIs in the MRI program (26-38 percent vs. 33-44 percent) and may not be statistically significant. Women have been successful at rates higher then the overall rate in the MRI program, but minorities PIs have not been as successful as the overall rate for some years. From 1995 to 1998, the success rate for minorities fluctuated between 32 percent and 8 percent. However, in 1999, the success rate was 52 percent. This fluctuation may represent the small overall number of minority PIs. The percentage of MRI proposals coming from non-Ph.D.-granting institutions has decreased from 13 percent to 1 percent between 1996 and 1999; the percentage submitted to NSF as a whole is in the 5-6 percent range. The funding rate from MRI is higher (~6 percent) than the rate for NSF as a whole (2 percent).

e. Do proposals address the integration of research and education? Yes and No.

It is not possible to give a simple yes/no answer to the question of whether proposals address the integration of research and education. It is certainly not being done uniformly, although some proposers are doing it quite well. There was one example of a proposal in which strong attention was paid to educational impact of the proposed project, which was commented upon favorably by the review panel. The proposal was not funded for other reasons, but it is clear that the message was sent strongly to the PI that this was a positive aspect of the proposal, and that attention paid to this matter would likely pay positive dividends in future efforts submitted to NSF. In contrast, a funded proposal, paid only cursory attention to the participation of students in the process. No attention was paid to the issue in the NSF summary or the panel summary. One reviewer did comment that the laser "could have important aspects on ... the education of participating students," although that was clearly inferred from the notion that the proposed laser surely must have such an impact, rather than any direct statements in the proposal itself. One reviewer commented specifically that "apparently no thought has been given to incorporate the equipment into the curriculum and make it accessible to students/women/minorities." It is a bit distressing that this issue was apparently not addressed in followup discussions with the proposers, or in the NSF comments, or made a condition of award. It seemed to disappear as an issue after a few reviewers made unfavorable comments about this discrepancy, and it did not resurface at appropriate points thereafter. In the sample of proposals to which the COV had access, it appeared that the attention to this issue varied from discipline to discipline, although a larger study involving the entire proposal database would have to be done before coming to any firm conclusions on this issue. Our impression was that those in the biological sciences paid much attention to this issue, while those in the physical sciences and engineering were less likely to do so.

Following is an example in which the review process must have sent mixed, confusing messages to the proposal writer about the quality of the educational component integrated into the proposal. In one proposal, the proposer seems to make a fairly substantial case for the integration of the equipment requested (various materials characterization equipment) into the educational environment of the university. It was mentioned that a new university-wide cross-disciplinary minor had been introduced in materials science and engineering, and specific courses in which the equipment would be used were described (an advanced materials analysis course, a course in electron beam methods, a chemistry course in elemental and surface analysis, a graduate topics lecture course, and other curricular offerings). Considerable detail was given. For example, regarding the graduate surface analysis course, it was said that "A hands-on laboratory portion of the course could be more fully implemented by having the students work on projects that would require use of the XPS/AES/SIMA, TEM, SEM, ellipsometry, and diffraction systems." However, the reviewers sent mixed signals about this component, with one commenting that "the training of graduate students with this instrumentation is quite appealing ... and well thought out," another saying that "the purchase and use of the equipment, of course, (emphasis added) will have an impact on ... student training," and yet another also taking the view that this will necessarily happen (an attitude that should not be encouraged in reviews, and perhaps should be specifically discouraged by language in instructions to reviewers). However, the panel summary states "How would (sic) this facility improve student education is unclear." The PI for this (declined) proposal would be left wondering whether the summary review really reflected the attitude of the panel (or anyone who had read the proposal), or was a wildcat effort by one person. In some important aspect, the review process appeared to break down in this case.

a. Has the number of applications from underrepresented groups increased over years?

No.

The number has remained fairly constant from 1995 through 1999 for both women and minorities. The participation of women has been in the 40s and 50s with fluctuation; the minority participation has been in the 20s.

b. Is there an appropriate balance of projects of the following types? **Yes.**

Overall, the types of equipment funded appear to represent the requests from the community. However, it is clear that in many of the divisions many proposals are received for the same type of equipment, indicating that the program is meeting the needs of the academic community. A large number of awards in several directorates were for mass spectrometers. For many of these, it was not clear if they would be shared-use facilities or primarily for the use of a single PI. NSF could enhance the utilization of these instruments by encouraging more community-wide use of expensive facilities.

One example of an innovative, high-risk proposal supported by the program is a GPS array. Several highly qualified reviewers rated it "excellent" or "very good," but several other highly qualified reviewers rated it only "fair" or "good," raising concerns about high cost, non-uniqueness of the data, and consequent inability to distinguish among hypothesis. One of the nation's leading geophysicists wrote a letter urging funding of this facility. In short, while there is not unanimous support in the community, many bright scientists are strongly supportive. While the jury is still out about the overall impact of this project (it may take 5-10 more years to see results), this seems to be exactly the kind of innovative and somewhat risky (given high cost) infrastructure that the MRI program should support. A high-risk project likely to be funded is support from AST to provide instrumentation for a center that would develop new detectors for astronomy and industry such as Tektonix. Examples of interdisciplinary awards: SBE 9512394 – Laboratory instrumentation for economics and political science; SBE 9871186 – Core equipment for cognitive psychology and neural science; BIO – 9977768 – Protein X-ray crystallographic beam line. Examples of innovative awards: EIA 9871235 – Virtual workbench; DBI 997752l – Magnetic imaging for cognitive neural sciences. Also see section B-5-1.

B. Program Results

GRPA OUTCOME 1: Discoveries at and across the frontier of science and engineering that result from NSF investments: Performance is successful when NSF awards lead to important discoveries; new knowledge and techniques, both expected and unexpected, within and across traditional disciplinary boundaries; and identification of high potential links across these boundaries.

1. **Is the program's performance successful for this goal overall? Yes.**

Indicators for success of MRI program:

- Development of new instrumentation that supports research leading to important discoveries and new knowledge and techniques.

1. The detection of neutrinos through a large volume of natural ice in Antarctica as a Chernkov detection medium. Fifteen institutions and several countries use it. It has public interest because of the Antarctic

environment and astronomy outcomes that boost the interest of the public in science. It has fostered the development of remote distance analysis and reporting of data as well as the development of power supplies that are highly reliable (Polar Programs 9512578). The AMANDA project is an excellent example.

2. Three proposals (GEO 9724491; GEO 9724465; GEO 9512614), representing good examples of innovative, cross-disciplinary science with engineering and instrument development, and focus on establishment of ocean floor instrument capability off Hawaii by exploiting retired telephone cable for power and data telemetry. These projects promise enhanced capability in seismology, volcanology, and ocean studies. It will be some time before we see the full pay-off from these projects, but they demonstrate a strong program commitment to innovative, cross-disciplinary, development-oriented research.

3. The electron microdiffraction instrument that was developed for investigating metal-ceramic interfaces at the molecular level combines both theory and experiment (MPS – 9412146).

- Acquisition and development of instrumentation that fosters shared use across traditional disciplinary boundaries.

  One proposal that struck the members as being particularly innovative combined web based remote analysis using an electron microprobe. This proposal makes innovative use of a web-based interface to enable long-distance use of the machine by many investigators. It allows petrologists and geochemists over a wide geographic area to use this specialized instrument.

  At this point, there may not be sufficient data to measure the impact of the science or engineering proposed when a final report is generated.

<u>GRPA OUTCOME 2</u>: Connections between discoveries and their use in service to society that result from NSF investments: The program is <u>successful</u> when the results of

NSF awards are rapidly and readily available and feed, as appropriate, into education, policy development, or use by other federal agencies or the private sector.

1. **Is the program's performance successful for this goal overall? (Y/N)**

   Insufficient data are available to evaluate this question. There are many projects that are aimed at serving society but at this time there is not sufficient evidence to evaluate the programs on this point. Three programs that have big potential payoffs in this regard are:

   a) The acquisition of a GLC/MS system for bioremediation.

   b) The use of EEG-based imaging system for human-computer interface.

   c) The use of GPS for trying to obtain better understanding of earthquake processes.

   Indicator for success of MRI program:

   Acquisition and development of instrumentation that enhances productivity and effectiveness of the science and engineering workforce. Every instrument in this division does this, but again there has not been enough time to evaluate the overall effectiveness of the program.

   Program Goal 1: Support the acquisition of major state-of-the-art instrumentation for research, research training, and integrated research/education activities.

2. **Is the program's performance successful meeting this goal? Yes, at least for research.**

   Comments and Examples

   It is clear from the funded proposals examined that the program is indeed resulting in state-of-the art instrumentation getting into the hands of persons who will make good use of it for research. For research training and integrated research/education activities, the matter is less clear. In one example of a denied proposal in which a supercomputer was requested that would seem to have obvious applications to the integration of education and research, only one reviewer commented on the obvious lack of attention paid to these issues. The NSF review analysis mentioned that the NSF would "encourage the PI to take into account reviewers' comments and consider resubmitting a thoroughly revised proposal to the next MRI competition or another appropriate program" without pointing out this particular deficiency. The PI would (it would be hoped) be called to account for this deficiency by the next panel to examine this proposal, and would quite likely be concerned that he had not had this problem adequately pointed out by reviewers and NSF staff in the first attempt at funding.

Program Goal 2: Improve access to and increase use of modern research and research training instrumentation by scientists, engineers, and graduate and undergraduate students.

3. Is the program's performance successful for this goal? Yes.

Comments and Examples

Certainly, this program is putting over $50 million worth of modern research equipment into the hands of scientists, engineers, and graduate and undergraduate students each year. The distribution of equipment (and the use thereof) to these various groups is not even (nor, likely, was it intended to be). These are addressed in points 7 and 9 and elsewhere in this report. In two exemplary proposals from BIO (9977187, 9977366), the proposals specifically addressed the use of the new equipment in undergraduate classes (specific courses and lab assignments were named in the proposal).

Program Goal 3: Enable academic departments or cross-departmental units to create well-equipped learning environments.

4. Is the program's performance successful for this goal? Yes, in some cases.

Comments and Examples

While not every proposal addresses this point, some do. One nice example is from ocean sciences, in which the impact on the learning environment at both the undergraduate and graduate level was strong, and specifically cited by the Program Manager as one reason for the funding the proposal. This is also an example of a proposal that builds the scientific infrastructure of an entire region through the acquisition of the requested equipment.

Program Goal 4: Does the program foster the development of the next generation of instrumentation for research and research training.

5. **Is the program's performance successful for this goal? Yes.**

From 1997 to 1999, 323 (22 percent) of the 1,456 proposals submitted were for instrumentation development. By comparison, 18 percent of the 482 awards made during this period were for instrumentation development. Thus, there is good correspondence between development submissions and development awards. However, it is interesting to note that of 23 proposals considered "exemplary" by the Technical Coordinators, 56 percent were development proposals. From discussion with the Technical Coordinators, it is clear that development proposals are typically much more interesting scientifically. It appears that the MRI program is leading to new developments in several areas of instrumentation. Scientific visualization, data manipulation, and analysis will be influenced by the development and enhancement of new instruments at CalTech such as the Virtual Workbench (EIA–9871235) and the third-generation virtual reality device at the University of Illinois at Chicago (EIA–9871058), which will lead to variable resolution desktop/office-sized displays. These instruments provide new methods of graphically displaying data and interacting with these displays. In addition, new measurement devices are being developed including a protein crystallography beamline (BIO– 9977768), a detector for investigating proton structure, a new radiation tracker, and an accelerator mass spectrometer. Other new devices improve fabrication methods including crystalline bonding for ceramics and wafer-level batch packaging methods that will lead to new gigascale integration.

Program Goal 5: Promote partnerships between academic researchers and private sector instrument developers.

6. Is the program's performance successful for this goal? No.

By the very nature of the proposed instruments that are being developed, it may be impractical for such partnerships to be formed. For some instruments, commercial viability may never be feasible; for others, the timeline for commercial delivery may be far too long for the private sector's development/investment planning. There are only a few instances of partnerships between academic researchers and the private sector. Within the exemplary proposals (which constitute a large group of development proposals), only 22 percent of the development proposals mention some form of partnership with the private sector. And in many of these cases, it is an indirect relationship. Sometimes this consists of an equipment donation serving as matching funds. In other cases, this relationship may be projected as possible future licensing arrangements or collaborations resulting from prospective positive developments. These projections are typically cited based on prior experiences, but do not reflect any formal arrangement in respect of the actual proposal. In none of the cases examined were the relationships specifically collaborative in the development of the proposed instrumentation and therefore not reflective of an active development partnership. For example, the University of North Carolina at Chapel Hill requested acquisition of a graphical supercomputer for synthetic environment serving science and engineering to develop software to be licensed in the future. The PIs cited past licensing relationships with industry (e.g., Molecular Simulations, Inc., Division, Ltd., and Hewlett-Packard) as evidence of this prospect. In a proposal from Georgia Tech, the PIs alluded to the relationship between their MRI proposal and another proposal to be submitted jointly with a number of other institutions to MARCO, an industry-funded consortium. Other proposals cited donations of equipment from IBM or other computer manufacturers as evidence of partnership, although the companies were not actively participating in development beyond their donations. These examples indicate that to this point, the MRI program has not actively developed new partnerships between academic researchers and industry. In some cases, this may be a result of the nature of the instruments being developed; it may be too soon for commercial application of instruments such as the Virtual Workbench. In other cases, such as the AMANDA project, commercial application may not be practical. However, whenever academic-industry partnerships or those with federal agencies and international partners are feasible, they should be encouraged.

C. Other Issues

12. Cost-sharing:

Does the 30 percent cost-sharing requirement inhibit minority and undergraduate institutions from applying?

The number of minority and non-Ph.D.-granting institutions participating in the program has declined over the time that the cost share has dropped from 50 percent to 30 percent. The numbers for non-Ph.D. institutions has dropped exponentially. (Director Pitts indicated that a fundamental change in the program goals from facilities and instrumentation to solely instrumentation may have made the program less attractive to these institutions.)

The number of large (> $1M) proposals was very limited; out of 44 proposals, 5 were received from HBCUs, 2 of which were awarded. Both of these proposals had their cost share contributed by a European collaborator.

The average amount of money requested per year by non-Ph.D. institutions has dropped from the $100Ks to the $10Ks from 1995 to 1999. Of the approximately 112 submitted proposals from 1996 to 1999 in this category, 6 were for amounts in excess of $500K, and 2 were awarded. It appears that large grant proposals (> $ 500K) are not as likely to be submitted for minority and non-Ph.D.-granting institutions; one reason may be the cost share.

12a. Submission by FASTLANE

MRI initiated FASTLANE submission in 1997. The number of proposals submitted has increased by approximately 10 percent from the beginning (1996, 423; 1997, 503; 1998, 479; 1999, 472). It is not clear whether the implementation of FASTLANE has generated the increase.

For non-Ph.D.-granting institutions, the number of proposals has decreased exponentially from 1996 to 1999 (1996,53; 1997, 31; 1998, 12; 1999, 6). The onset of FASTLANE correlates with the decrease in submissions; however, the COV was unable to determine that FASTLANE was actually the cause of or related to the decrease in submissions. Although the waiver process for non-FASTLANE submission is explained in the NSF Grant Proposal Guidelines, this information should be included in the MRI program solicitation.

- **Funding Large Requests:**

  Should the program solicitation provide more detailed information on proposal success rates at different request levels? Yes.

At present, in the Background section of the solicitation, it is stated that "The overall proposal funding rate… was approximately 34 percent." In some MRI review panels, it seemed apparent that PIs were adding irrelevant equipment into proposals to bolster the size of the requested amount, given the lack of detailed information about the relationship between requested amount and success rate. Adding one or two sentences to the Background section clarifying this relationship, specifically noting the different success rates for lower requested amounts and higher requested amounts, would aid PIs in preparing more targeted proposals. Additional detailed information showing a breakdown of success rates by amounts requested for specific years could be given on the NSF web site with appropriate citation in the solicitation.

- **Acquisition vs. Development Projects:**

  Do the guidelines for submission of acquisition and development

proposals achieve the goals of broadening institutional participation in the MRI program and encouraging the submission of development proposals? Do the guidelines result in an appropriate balance between development and acquisition awards?

As noted elsewhere, from 1997 to 1999, 22 percent of the submitted MRI proposals were for instrumentation development and the remaining proposals were for instrumentation acquisition. Similarly, 18 percent of the actual awards were made to develop new instrumentation. Although it appears that the success rate for development proposals mirrors the submission rate, it is difficult to know whether the current guidelines are producing an "appropriate" balance of development and acquisition proposals. It is clearly in the best interest of science and technology to support well-formulated development proposals. The fact that institutions can submit a third development proposal to the MRI program may aid currently in promoting submission of development proposals. Since 1997, when this went into effect, there has been a slight increase in development proposals from 100 in 1997 (compared to 409 acquisition proposals) to 118 in 1999 (compared to 363 acquisition proposals). This slight tradeoff between development and acquisition could reflect institutions' making use of the change in guidelines permitting submission of a third MRI proposal if it is a development proposal.

One way to modify the current guidelines to encourage the submission of development proposals would be to eliminate the cost-sharing requirement that is currently imposed on the proposing institution. Real instrument development is closer in nature to research than acquisition and should therefore be treated as such. Given the inherently riskier nature of instrument development, some institutions may be less likely to invest cost sharing in these proposals. Lowering the institutional investment may encourage submission of more instrument development proposals.

- Major Systems vs. Large Instruments:

Are the definitions and distinctions in solicitations clear? Are they appropriate to the needs of the scientific community?

The current definitions of an instrument and systems of instruments are clear. It does not seem possible to change the current language without becoming too restrictive. The current language will clearly differentiate a proposal to purchase a cluster of computers intended to be used to address a coherent set of scientific problems such as computational fluid dynamics as opposed to the same cluster used to run off-the-shelf scientific software for general computation. Under the current solicitation, the first could be considered an instruments, but the second would not.

D. Areas of Emphasis: For each area of emphasis shown below, do the investments and available results demonstrate the likelihood of strong performance in the future? Explain and provide NSF-supported examples that relate to or demonstrate each outcome.

16. **Area:** New types of scientific databases and the tools to use them (a critical component of Knowledge and Distributed Intelligence activity). **No, not to a substantial extent**.

Comments and Examples

There is one example we found of the use of MRI-funded equipment to add to an existing organismal DNA database (9977187) and another (9601571) in which the surface velocity field of southern California was mapped and made available as a web-based database. However, the MRI program has not made a major impact in this area of emphasis, at least as far as can be seen from the example proposals we examined.

17. **Area:** Biocomplexity**. Yes.**

Comments and Examples

Much of the equipment supported by MRI could be useful for studies/projects on biocomplexity or is predicted to be used for this endeavor. For example, 1) chromatography, mass spectrometry, chemical sensors used in analyses of soil or other environmental samples can give some information (detect "signature molecules") about the kind of microorganisms that are present. Molecular genetics instrumentation approaches detect microbes in all kinds of samples. 2) Optical and image analysis – one can scan organisms (microbes, invertebrates, including larvae) into daabases. Then investigators can take samples (in the field anywhere), click on features of the organism, and acquire an idea of the identification and classification of organisms at different locations.

18. Area: Nanoscience and nanoengineering. Yes.

Comments and Examples

Approximately 5 percent of MRI investment is in equipment directly or indirectly related to nanoscience and nanoengineering. It is unclear whether this amount is sufficient to accomplish NSF's goals in this research area.

The one relevant report submitted by FASTLANE indicates that MRI support has provided an effective tool that one would expect to lead to innovation, but it is early in this development.

19. Area: Research on global change. Yes.

Comments and Examples

There is strong evidence of the promise for strong performance in the future. One proposal for a mass spectrometer will insure continued performance and extend a strong track record of innovative research in Holocene climate change and anthropogenic influence on the environment. There are approximately 50 publications in peer reviewed journals related to this work.

A funded proposal from Woods Hole shows promise for strong performance in the future. The proposal for the development of a low cost, stable CTD Measurement Systems for Autonomous Oceanographic Instruments. The technology to be developed will "…address a long standing and growing need for a low-cost, unattended CTD capable of making accurate measurements over periods of years…" This instrumentation is critical for studies of ocean circulation and ocean influence on short-term climate change.

20. Area: Participation of underrepresented groups in integrative research and education activities (Y/N).

Comments and Examples

The results are mixed in terms of the participation of underrepresented groups in the integrative research and education activities of the proposal. Not all awarded (non-exemplary) proposals have explicitly incorporated these activities into their proposals. Reviewers of awarded proposals (non-exemplaries) have not consistently noted the presence or absence of underrepresented groups in integrative research and education activities in proposal.

The exemplary proposals did not consistently address the participation of minorities in the proposals; the presence of minority participation in research and education was the exception and not the rule. Reviewers of exemplary proposals did not consistently address the presence or absence of this participation.

21. Areas needing improvement.

The COV identified a few points that, if addressed, would markedly assist the MRI program in meeting its mandates and aid in evaluating the program in a more definitive manner.

1. For the next COV review, consider enabling detailed technical audit of a random sample of completed projects.
2. Modify the FASTLANE reviewer and PI reporting forms to encourage discussion of the success in addressing both criteria 1 and 2.
3. Update the brochure entitled "*Research Instrumentation: Enabling the Discovery Process."* The current piece is dated 1994.
4. Where possible, determine the ethnicity and gender of the reviewers.
5. Indicate whether the proposal reviewers are new or previous reviewers in the MRI program.
6. Include in the Background section of the MRI solicitation information about the success rates for instruments that cost in the $100-200,000 range and for those costing in excess of $1 million. More detailed information about success rates could be included on the NSF web site.
7. In order to encourage submission of development proposals vis-a-vis acquisition proposals, the level of cost sharing should be reduced for the former to compensate for their riskier nature.
8. Actively encourage resubmission of strong proposals by underrepresented groups and non-Ph.D.-granting institutions.
9. To encourage submission of MRI proposals from non-Ph.D.-granting institutions, the restrictions on what is counted as institutional cost sharing should be relaxed to allow a greater contribution of PI release time and other "in-kind" matching.
10. Increase efforts to increase representation of females in the review process, especially in the areas of ATS, CTS, EIA, OCE, GEO, MPS, and ENG. Increased participation of women in the proposal submission process is also desirable. This goal might be partially achieved by increasing the number of women in the review pool. No specific recommendation concerning minorities is being made at this time because of lack of data.
11. Some effort should be made in reducing the redundancy in the COV template review form.
12. Require final reports to be submitted 2 or more years after grant to determine outcomes. This is especially valid for development proposals. In addition to listing of publications, patent applications filed and patents issued with brief descriptions of the inventions are desirable.
13. Encourage the use of ad hoc reviewers in addition to panels in order to address the concern about "herd mentality" that can pervade pure panel reviews.
14. Statistics with respect to dollars awarded/capita in the states should be provided.

MAJOR RESEARCH INSTRUMENTATION PROGRAM

(MRI)

Committee of Visitors (COV)

June 14-16, 2000

Dr. Jean’ne Shreeve, COV Chair

Professor of Chemistry

University of Idaho

Moscow ID

Dr. Estela Blaisten-Barojas

Professor of Physics, Computational Sciences

George Mason University

Fairfax VA

Dr. Timothy Dixon

Professor of Marine Geology and Geophysics

University of Miami

Miami, FL

Dr. William Jackson

Professor of Chemistry

University of California

Davis CA

Dr. Edna Kaneshiro

Professor of Biological Sciences

University of Cincinnati

Cincinnati OH

Dr. William Lord

Interim Vice-Provost, Research and Advanced Studies

Dean, Graduate School

Palmer Chair, Department of Electrical Engineering

Distinguished Professor of Engineering

Iowa State University

Ames IA

Dr. Michael Leuze

Director, Collaborative Technologies Research Center

Oak Ridge National Laboratory

Associate Professor of Computer Science

University of Tennessee

Knoxville TN

Dr. Cynthia McIntyre

Chief of Staff

Assistant Secretary of the Institute

Rensselaer Polytechnic Institute

Troy NY

Dr. Robert Megginson

Associate Professor of Mathematics

University of Michigan

Ann Arbor MI

Dr. Howard Nusbaum

Chair, Department of Psychology

Associate Professor of Cognitive Neuroscience

University of Chicago

Chicago IL

Dr. Dorothy Pumo

Professor and Chair, Department of Biology

Hofstra University

Hempstead NY

Dr. Pao Wang

Professor of Atmospheric and Oceanic Sciences

University of Wisconsin

Madison WI

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