Executive Summary
for EAR/IF Committee of Visitors Report
September 4, 2007

Finding: The EAR Instrumentation and Facilities (IF) Program supports world-class science across an astonishingly broad range of research and with a remarkable diversity of awards, ranging from temporary support for technical staff to long-standing support for major, national facilities (multi-million dollar per year budgets). The combination of external (mail) reviewers, standing and ad-hoc (special emphasis) panels, and advisory structures provide crucial support to IF Program Officers (POs) in their efforts to maintain balance and responsiveness across the diversity of supported research (e.g., in terms of disciplines, as well as type and size of awards). EAR has been responsive to recommendations of the past COV.

Recommendation: The Instrumentation and Facilities POs should partner with PIs to communicate more effectively to the lay public – not just the scientific community – the excitement, quality and societal impact of the outstanding science coming out of IF-supported facilities and research.

Finding: The IF Program excels in addressing NSF's 4 strategic goals (Discovery, Learning, Research Infrastructure and Stewardship), and plays a special role in fulfilling NSF's support of research having Broader Impacts, notably by sustaining – even creating – the equipment, databases, technical support and facilities infrastructure essential to education and research in modern society.

Recommendation: EAR should partner with its PIs and advisory bodies to communicate more widely throughout the scientific community the effectiveness of its programs in terms of Broader Impacts.

Finding: With major, multi-user national facilities (FS) having grown to the multi-million dollar per year funding level, and these facilities accounting for a large fraction (> 75%) of the IF budget, successful management (e.g., clearly defined goals and performance metrics; alignment of responsibility and authority; succession planning) has become a core issue for the Program, to the point that in some cases community-based governance structures may need significant revision or replacement to ensure effectiveness and sustainability of FS in delivering science.

Recommendation: EAR should more explicitly include evaluation of management in its panel and advisory structures, and partner with the research community to identify and disseminate best management practices for large scientific projects.

Finding: The COV is gravely concerned about the sharp decline in the level of funding (in real dollars) over the past 15 years for IF equipment acquisition (EA) and the decline of proposal success rates to levels of 20% or less. The combined impact of these factors undermines the program's effectiveness in realizing NSF's strategic goals (in particular Research Infrastructure and Stewardship) and Broader-Impacts objectives. Based on analysis of the past 3-years' proposal jackets, the COV's concerns include a potential loss of balance across the active research community resulting from different institutional levels of cost sharing for instrumentation (EA): specifically, favoring "wealthy" institutions that can readily volunteer cost sharing.

Recommendation: The COV reluctantly concludes that – among other possible solutions – a uniform policy of requiring a specific amount of cost sharing (e.g., 30%), whether from the PI's institution or from other funding sources, would result in a larger and more balanced community receiving funds.

FY 2007 REPORT TEMPLATE FOR
NSF COMMITTEES OF VISITORS (COVs)

The table below should be completed by program staff.

Date of COV: August 22-24, 2007
Program/Cluster/Section: Instrumentation and Facilities (IF)
Division: Earth Sciences (EAR)
Directorate: Geosciences (GEO)
Number of actions reviewed: Awards: > 60 Declinations: > 60 Other:
Total number of actions within Program/Cluster/Division during period under review: Awards: ~ 200 Declinations: ~ 351 Other: ~ 150
Manner in which reviewed actions were selected: **See A.2.4**

PART A. INTEGRITY AND EFFICIENCY OF THE PROGRAM'S PROCESSES AND MANAGEMENT

Briefly discuss and provide comments for *each* relevant aspect of the program's review process and management. Comments should be based on a review of proposal actions (awards, declinations, and withdrawals) that were *completed within the past three fiscal years*. Provide comments for *each* program being reviewed and for those questions that are relevant to the program under review. Quantitative information may be required for some questions. Constructive comments noting areas in need of improvement are encouraged.

A.1 Questions about the quality and effectiveness of the program's use of merit review procedures.

Provide comments in the space below the question. Discuss areas of concern in the space provided.

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCEDURES	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE[1]
1. Is the review mechanism appropriate? (panels, ad hoc reviews, site visits) Comments: The approach used is summarized at the end of A.2 (A.2.4). The review process for IF proposals includes some combination of two or more of the following processes: program officer review, mail review, panel review and site visit review. Given the diversity of proposals funded by the IF program, this variety of review mechanisms is appropriate. The COV systematically examined 81 proposal jackets (as described below). In all cases, program officer's review of proposals was well documented and was deemed to be outstanding by the COV. We discuss mail, panel, site review and PO	Yes

[1] If "Not Applicable" please explain why in the "Comments" section.

decision in the following sections.

Mail Reviews: The average number of mail reviews for an IF proposal over the past 3 years was 5.5 with an average of 4.6 for the reviews meeting both criteria (intellectual merit and broader impacts). The number of mail reviews is impressive, given the difficulty of getting reviews from an increasingly over committed community. The COV was encouraged by the number of mail reviews that mention broader impacts compared to previous years. In most cases the mail reviews provided helpful comments about the proposal for the PI and the program officers.

Panel Reviews: In most cases the panel reviews were consistent with the criteria, and provided useful information to the PI. There were only a few examples of panel summaries that did not provide adequate information to the PI. The panel makeup represents the diversity of proposals in the IF program, and has the appropriate expertise necessary. It is weighted to geochemistry, but this is a conscious effort because the largest number of proposals come from this area. However, with the large fraction of the IF budget going to facilities the program officers should consider panel members with management experience to help evaluate the management review of the large facilities. The POs have included more panel members with expertise in hydrology and low temperature geochemistry in the past few years.

Site Visits: Site visits of major facilities by the program officers and the panel are important, and should be continued given the large investment by IF. Site visits provide an excellent mechanism for fully understanding how a facility operates, and the impact the facility is having on the community. The IF panel and program officers made seven site visits to facilities during the 3 year period between 2004-2006. The COV recognizes the importance of site visits and encourages the program to continue the practice. The program officers have followed the recommendation of the last COV report and are documenting the site visits. Site visits for 2004-2006 are summarized in Table 1.

TABLE 1 Site visits 2004-2006

FY	Round or SEP	Institutional Venue	City and State	Purpose	Proposal No.
2004	1	University of Texas	Austin, TX	NSF/EAR/IF Proposal Review Panel and Site Visit to the Univ. of Texas X-ray Computed Tomography Facility (UTCT)	EAR-0345710
2004	2	University of California, Los Angeles	Los Angeles, CA	NSF/EAR/IF Proposal Review Panel and Site Visit to the UCLA National Ion Microprobe Facility	EAR-0421795
2005	1	University of Arizona	Tucson, AZ	NSF/EAR/IF Proposal Review Panel and Site Visit to the University of Arizona AMS Facility	EAR-0446861
2005	2	Scripps Institution of Oceanography	La Jolla, CA	NSF/EAR/IF Proposal Review Panel and Site Visit to Project IDA Network Operations [NCALM review]	EAR-0518962
2006	SEP	IRIS PASSCAL Instrument Center	Socorro, NM	NSF/EAR/IF IRIS Special Emphasis Panel	EAR-0552316
2006	1	IRIS Data Management Center	Seattle, WA	NSF/EAR/IF Proposal Review Panel and Site Visit to the IRIS Data Management Center (DMC)	EAR-0552316
2006	2	Argonne National Lab	Argonne, IL	NSF/EAR/IF Proposal Review Panel and Site Visit to GSECARS/Advanced Photon Source	EAR-0622171

Program Officers decisions. The COV was impressed with the program officers' review analysis, and the decision making process. For most of the set of 81 proposals this COV examined, the panel, the mail reviewers and the Program Officers all agreed on the proposal ratings. The COV was thus satisfied that the decisions made by program officers were largely driven by the panel and mail reviewers. The COV did observe a small number of proposals when program officer's decisions were incongruent with panel and/or *mail* reviews. However, in all cases there was documentation for the decisions.	
2. Is the review process efficient and effective? Comments: After three days of discussions and examination of more than 81 proposal jackets, the COV developed the strong impression that the IF program is a diverse portfolio of projects that serves the EAR community well and is managed by a professional, efficient, and hard-working pair of program officers. The program officers handled 551 proposals during the three-year period between 2004 and 2006. There was a major jump in the number of proposals submitted in 2006 (272 proposals, compared to 144 in 2005 and 135 in 2004). The COV was impressed with the review analysis written by the program officers for such a large number of proposals. This large increase in proposals could have a major negative impact on how proposals are handled because the workload has increased enough to have to be compensated in other areas, such as processing efficiency and long-term planning. It is important that the IF program continues to function in a fair and efficient manner, and have appropriate staff to help with this task. One problem (inefficiency) is the number of mail reviewers asked to review proposals who decline to do so. In most cases, 2 to even 4 times the number of scientists are asked than the number of reviews that are returned. The COV is really not sure what to do about this, but simply makes the case that it is an inefficiency that it would be desirable to reduce.	Yes
3. Do the individual reviews (either mail or panel) provide sufficient information for the principal investigator(s) to understand the basis for the reviewer's recommendation? Comments: The COV found that many mail reviews provided adequate information to assess the basis for the reviewer's recommendation. In general, the review community takes the review responsibility seriously. Numerous examples were found where reviewers provided very helpful comments to young PIs to help improve future proposal writing. Given the large decline in funding available, there are increasing examples of reviews that are very positive (e.g., 5 Excellents) but the proposal is not funded (due to limited funds) leaving the PI uncertain with what to do to improve the proposal. This is a difficult situation for PIs, program officers and reviewers. We are pleased to see that in the examples evaluated by the COV, the "Review Analysis" section of the proposal jackets contained sufficient documentation to understand the difficult decisions made on the proposal. However, it is clear that many highly reviewed proposals are not being funded simply due to the small amount of available funding, and they are so good that there is not much to fix with panel or mail input. Thus it is critically important to get the funding rate up.	Yes

4. Do the panel summaries provide sufficient information for the principal investigator(s) to understand the basis for the panel recommendation? Comments: In general, about 70% of the panel summaries provided sufficient information for the PIs to understand the panel recommendation. In 30% of the cases, the panel summaries were extremely short and did not provide enough information for the PIs. The program officers should continue to encourage the panel summaries to be as thorough as possible, especially in cases that panel and mail reviews differ significantly.	Yes
5. Is the documentation for recommendations complete, and does the program officer provide sufficient information and justification for her/his recommendation? Comments: The program officers impressed the COV with the documentation and completeness of the proposal jackets, especially with respect to the "Review Analysis" provided. The documentation for recommendations on almost all proposals was outstanding. The decisions made by the Program Officers, whether consistent with or contrary to the panel and mail reviews, were thoroughly documented. We applaud the program officers for their diligent work in documenting the peer review and decision-making process	Yes
6. Is the time to decision appropriate? Comments: Most proposals are reviewed, and decisions are reached and communicated to the PI within 6 months, although the full processing at NSF may take longer. When the processing time has gone beyond 6 months, we found documentation that justified the delay. But, as pointed out above in the answer to question 2, the PO's are at the breaking-point of the number of jackets that they can handle. Therefore, it would not be a surprise if the next COV saw that the time to decision had increased.	Yes
7. Additional comments on the quality and effectiveness of the program's use of merit review procedures: The COV was impressed with the program officers, and the quality and effectiveness of the program's use of merit-review procedures. It is clear that the program officers spend a large amount of time writing and documenting the review analysis. As the number of proposals increases, this diligence may be difficult to maintain with 2 only program officers.	

A.2 Questions concerning the implementation of the NSF Merit Review Criteria (intellectual merit and broader impacts) by reviewers and program officers.

Provide comments in the space below the question. Discuss issues or concerns in the space provided.

IMPLEMENTATION OF NSF MERIT REVIEW CRITERIA	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE[2]
1. Have the individual reviews (either mail or panel) addressed both merit review criteria? Comments: The approach used by the COV in addressing this issue is summarized at the end of A.2 (A.2.4). It should be noted that for the 81 jackets in our sample, few, if any, contained reviews by individual panelists. Thus the findings for this question apply solely to the mail reviews. *Intellectual merit (IM) criterion*: All of the reviewers do a reasonable to excellent job of evaluating the proposals based on the IM of the proposals. They defend their assessments by addressing most or all aspects of intellectual merit (importance of work, PI qualifications, quality of writing, access to resources, etc.). *Broader impacts (BI) criterion*: Mail reviews almost always addressed the BI criteria, but it was rare to see the BI criteria discussion be as lengthy and detailed as the IM criteria discussion. In 11% of the jackets considered, we deemed the comments on BI to be poorly enough discussed as to be inadequate. As noted above, the FY2006 jackets had the better BI discussions. It should be noted that I&F proposals are somewhat unique in that they ALL should have high intrinsic BI value because by definition they *"enhance the infrastructure for research and education such as facilities, instrumentation, networks, and partnerships".* A difficulty still remains with the BI criteria for some mail reviewers, but it appears to be getting less problematic for this 2004-2006 period as compared with the previous period discussed in the 2004 COV report. Where problems still exist with the BI interpretation, BI are either completely ignored or simply interpreted in terms of extending the science, as opposed to the intended interpretation of the criterion regarding societal impacts of the proposal (i.e. dissemination, teaching, training, benefits to society, underrepresented groups) as pointed out by the 2004 COV. Assessing BI of IF proposals should actually be easier than other proposals, particularly since infrastructure is a BI criterion. Proposals receiving the highest ranking were exceptional in the area of BI, and more mail reviewers of these proposals addressed the BI criterion, probably because it	Yes

[2] In "Not Applicable" please explain why in the "Comments" section.

stood out as an important part of the value of the proposal. The 2005 and 2006 Responses to the 2004 COV Report by Jim Whitcomb specifically point to written materials on the website, and workshops, that have attempted to clarify and expand the use of the BI criteria in judgements of proposals. The language there is good, helpful and relevant. This information may be having an impact, but it is too hidden within a footnote of the GPG to be consulted carefully in the rush to write and review proposals.	
2. Have the panel summaries addressed both merit review criteria? Comments: *Intellectual merit criterion*: The panel reviews always addressed the IM of every proposal reviewed. *Broader impacts criterion*: From our proposal sample, 31% of the panel summaries included a discussion of how the proposal treated the BI criteria, for 21% of the panel summaries this was not an applicable question (no panel summary), and for 48% the panel summary included no discussion of the BI. Thus, while this is a significant improvement over the 2004 COV report (none of the panel summaries analyzed included discussion of BI criteria) there can be more effort in the future to make this a part of all panel summaries.	Yes
3. Have the *review analyses* (Form 7s) addressed both merit review criteria? Comments: *Intellectual merit criterion*: In every case that we reviewed, the POs very carefully documented most or all aspects of intellectual merit based on all available mail and panel reviews. The COV was especially impressed with the care used by IF officers in preparing these review assessments. The assessments generally were insightful, well-organized, thorough and thoughtful. In terms of PI understanding of the actions taken on a proposal, these are the single most important pieces of communication received from NSF. *Broader impacts criterion*: In 25% of the jackets examined, the PO-prepared review analysis did not include discussion of the BI. No doubt this was because the proposal itself did not address the BI. We note that unlike the 2004 COV, which concentrated on the best proposals, our sample included more than 40% declines. Thus, our findings may look different from the 2004 COV – showing less attention to the BI in the review analysis – but may really mask an improvement in this area since the 2004 COV sample includes few declined proposals.	Yes
4. Additional comments with respect to implementation of NSF's merit review criteria: There seem to be NO issues with the meaning of the intellectual merit statement, its interpretation and use in proposal evaluation. But concerns seem to exist for the BI statement and its use. 1) The BI criterion is not uniformly applied, and is often misunderstood by the mail reviewers: the POs could tailor the review request letter to clarify how a reviewer should evaluate BI (including linking to relevant NSF documents), especially with respect to infrastructure proposals. 2) About half of the Panel Summary Reports we analyzed did not contain information on the BI of proposal merit. Especially for the border-line proposals, we would suggest that the	

results of the BI merit of the proposal be included in the summary. This could also be improved for the review analyses prepared by the POs.

3) Beefing up the BI component of a proposal should be easiest for IF proposals because improvement of infrastructure for research and education is a BI goal. Perhaps this needs to mentioned more to PIs by the POs.

Approach used by the 2007 COV

To answer the questions relating to the use of Merit Review in evaluating the 551+ IF proposals from 2004-2006, the COV sampled the proposal jackets by looking at 80 jackets, divided in the following way: all of the 15 Facilities Support proposals, plus 65 proposals distributed by year and kind from the other IF proposal types (Equipment Acquisition, Technician Support, Geoinformatics, Instrumentation & Technique Development). Fifteen proposals were selected at random from the highest-scoring awards, equally distributed among FY2004, 2005 and 2006. Fifteen of the lowest-scoring declines were similarly chosen. From the approximately 180 proposals in the grey area that were comprised of low-scoring awards and high-scoring declines, 35 proposals were selected at random across the four types roughly in proportion to the number of proposals in each grouping. In this way, the COV has seen a subset of winners, losers and the in-between from all years, and including all five groupings. For each proposal we read all the mail reviews, the PO review assessments, and the panel summaries when they existed.

Additionally, COV members were free to look at any other proposal jackets, and typically read from 4-20 additional files to address specific questions (e.g. early career awards or specific types of infrastructure support).

Discussion between the COV and IF program officers over 2.5 days, their detailed presentation of the proposal evaluation process, and the consistency of the considerations of the review criteria across years and proposal types gives confidence our sampling accurately reflects the Program's full treatment of all the proposals.

As noted in the 2004 COV report, the Broader Impacts (BI) criterion historically has not been as fully considered as the Intellectual Merit (IM) criterion in proposal evaluation. We noticed a trend toward improved consideration of the BI criterion for the proposals from the more recent fiscal years (e.g., FY2006 as compared to FY2005 or FY2004).

A.3 Questions concerning the selection of reviewers. Provide comments in the space below the question. Discuss areas of concern in the space provided.

SELECTION OF REVIEWERS	YES , NO, DATA NOT AVAILABLE, or NOT APPLICABLE[3]
1. Did the program make use of an adequate number of reviewers? Comments: The COV endorses the combination of independent mail peer-reviews and panel review sessions as the best working model for IF proposal review, and we encourage continuation of this process. Overall, a conscious effort is made by the POs to assign a sufficiently large number of reviewers per proposal to achieve an effective assessment of the proposed research. Despite a marked increase in the number of proposals submitted over the past 3 years (2004-2006), compared with the prior three years (2001-2003), the average number of reviewers for competitive individual proposals remains nearly constant and high. Note that 396 proposals were reviewed in the period 2001-2003 (COV 2004 report, p.3) versus 551 for the period for 2004-2006.	Yes

Table 2: IF Average Number of Reviews per Proposal and Average Review

Fiscal Year		AWARDS	DECLINES	Total
2004	Number of Proposals	68	67	135
	Average of Number of Reviews	5.4	5.7	5.5
2005	Number of Proposals	74	70	144
	Average of Number of Reviews	6.0	5.7	5.8
2006	Number of Proposals	58	214	272
	Average of Number of Reviews	5.7	5.6	5.6
Total	Number of Proposals	200	351	551
	Average of Number of Reviews	5.7	5.6	5.6

*This table shows funding rates for the competitive proposals only and counts individual proposals.

Thus, for the period 2004-2006, the increase in proposal load has not impacted adversely the quality or goals of the review process, though the Program may be

[3] If "Not Applicable" please explain why in the "Comments" section.

at risk of this becoming a problem. The POs are to be commended for this remarkable achievement. The number of reviews per proposal should continue to be monitored over the coming three-year period. For the period 2003-2006, Table 2 (below) indicates a total of 551 (out of 721 submitted) competitive proposals with an average of 5.6 reviews per proposal. These data imply over 2500 reviews for competitive grants. In the period 2001-2003, an almost similar number of reviews (2,345; 2004 COV report) covered about 150 fewer proposals. A review of the documentation for a small percentage of accepted and declined proposals verifies the data in the table for the 2004-2006 period. The minimum number of mandatory reviews (3) is far exceeded, which represents a healthy process.	
2. Did the program make use of reviewers having appropriate expertise and/or qualifications? Comments: Thorough electronic and hardcopy documentation is maintained by the POs for the complete review process. Such documentation facilitates greatly the task of the COV, and is essential for the evaluation of all items relating to selection and appropriateness of proposal reviewer expertise and qualification. First, regarding mail reviewers of IF proposals, the expertise is appropriate but it is readily foreseeable that the recent trend in the increase of proposal submissions will undoubtedly place a strain on the maintenance of adequate numbers and breadth of expertise of reviewers. It would be useful in future to maintain a database item on the expertise of the mail reviewers. An existant, and well-kept database by the POs contains a record of the scientific expertise of the panel members that characterizes well their broad expertise in geophysics, geochemistry, cyberinfrastructure, and is also representative of the number of proposals in each different field.	Yes
3. Did the program make appropriate use of reviewers to reflect balance among characteristics such as geography, type of institution, and underrepresented groups?[4] Comments: It is very clear that the POs need to be applauded in their efforts to faithfully reflect the geoscience community among the body of selected mail reviewers as well as panel members. Reviewer workload and representation among states seems distributed fairly in proportion to the number of submittals from each state. There exists, in general, a ratio of 3:1 between reviewers per state and the number of proposals submitted by each state. Although two states did not submit proposals, all states did participate in the review process; this can be seen as a strong national commitment among the research community to support the review process. There is, unfortunately, a lack of representative statistical data with which to	Yes

[4] Please note that less than 35 percent of reviewers report their demographics last fiscal year, so the data may be limited.

evaluate confidently the degree of representation of underrepresented groups and minorities as mail reviewers in the process. In the three-year period (2004-2006), ~95% of reviewers did not respond to gender questions and ~75-80% did not respond to minority classification questions. If, however, we do consider the responses available, which may not be statistically significant, only about 4% of the reviewers are women, as compared to the current estimated proportion of women on geosciences faculty (~ 14% according to Jordan, F and Patino, L. , 2007 NSF Internal Report). If we only consider the greater number of respondent reviewers (20-25%) who did choose to participate in the minority survey, it appears that ~2-4 % of these reviewers are of minority status, a range which lies within the estimated proportion of geoscience faculty (Jordan, F and Patino, L. , 2007 NSF Internal Report). In the 2004 COV report, similar constraints were placed on the task of evaluating reviewer participation as a function of gender and minority status because of overall poor response to these surveys. The same holds true during this COV review, and the same is expected to stay true in the future unless community demographics are more effectively assessed. For the IF COV committee, a database was readily made available by the POs which shows a consistent and strong representation of the female/male gender ratio (~1:1) and among underrepresented minority groups on the IF Panel. One out of each 8 panel members is African-American, approximately in agreement with the national statistics on minority faculty ethnicity distribution in geosciences faculty (~3%: Jordan, F and Patino, L. , 2007 NSF Internal Report). Within the few data available over the past three years, more reliable interpretations are not warranted at this time. Because of the few numbers of people on each of the panel (typically 8), each serving each 3 years, a representative national geographic distribution can not be achieved quickly. More geographic diversity among panel members over a short, say 3 year, period panel members might be achieved by shortening the periods of time panel members serve. However, given the extra demand of researcher time that would be required, coupled with the increase in the number of proposals sent to IF over the past few years (increase of ~150 proposals since the COV 2004 report), we do not expect this suggestion to be feasible. Also, there is merit to corporate memory associated with longer terms. A positive suggestion may be made regarding the need to engage more panel review members from the community. Although we recognize many implicit pitfalls in this idea, we suggest IF consider experimenting with greater use of tele-conferencing technology and/or other means of electronic interaction to maximize panel member interaction prior to panel meetings in order to shorten face-to-face panel meetings but keep them productive. In summary, despite a workload increase over the past three-year period, the POs continue to maintain a fair balance of expertise and ethnic representation from the geoscience scientific community in its body of reviewers.	
4. Did the program recognize and resolve conflicts of interest when appropriate?	Yes

Comments: Proposal review numbers for multi-institutional facility proposals are commensurate with the greater portion of the IF budget they affect. The recent renewal of support for IRIS provides a good example that also shows the importance placed on removing conflicts of interest in the review process. Because IRIS comprises over 100 members, it was difficult to find US seismologists for review. Some reviewers came from IRIS member institutions, although it appears that these were carefully selected so that none had previous involvement with the IRIS organization or its facilities. Mail reviews were requested from 17 such scientists; 15 responded (4 seismologists and 11 non-seismologists). In addition, a special external panel comprised of 2 international seismologists, 1 national seismologist and other scientists experienced in science policy, education, cyberinfrastructure and geophysics evaluated the proposal and performed a site visit to the PASSCAL Instrument Center. We emphasize continued vigilance with respect to conflicts of interest, especially with regard with to multi-user facilities. But, it is very evident that POs hold this as a high priority. In conclusion, this issue is a well-managed and documented aspect of the program.	
5. Additional comments on reviewer selection: More proposals that were rated highly in mail reviews (4-5 range) were declined during this three-year period (17 for 2004-2006) as compared to only two in the 2004 COV review. However, declinations were justified and well documented. This increasing trend correlates with an increase in the number of overall proposal submittals.	

A.4 Questions concerning the resulting portfolio of awards under review. Provide comments in the space below the question. Discuss areas of concern in the space provided.

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE[5], OR DATA NOT AVAILABLE
1. Overall quality of the research and/or education projects supported by the program. Comments: Based on 1) analysis of project jackets, including mail reviews, panel reviews, and the expertise and review analysis of the POs; and 2) recognition of the large portfolio of project results published in leading scientific outlets such as *Nature* and *Science*, the COV panel views the research projects as high quality. The major facilities, which are guided by the scientific community, provide valuable data that can be used by a wide range of investigators. The individual instrument awards are leading to important science. Moreover, the projects provide opportunities for both graduate and undergraduate students to participate in cutting-edge science that can lead to scientific presentations at meetings, publications, and theses.	Appropriate
2. Are awards appropriate in size and duration for the scope of the projects? Comments: Awards made by the IF program are of variable, but appropriate, size and duration. GPRA targets cannot be applied, given the fact that instrumentation needs vary in size and cost over a very large range. Typical instrumentation awards are for a two-year period, allowing sufficient time for the PI to complete purchase and installation of the instrument. Awards for technician support have a longer window (3-5 years), as is appropriate for efforts involving employment and training. Smaller, 12 mo. awards for equipment (< $50 K), split-funded with research programs, are no longer handled on an individual basis by the POs, but are handled by "block grants" to the programs from IF; this seems appropriate. Awards for Facilities (FS) are negotiated case by case, and have a 3-5 yr duration as continuing grants or cooperative agreements. The complexity of these agreements, and the desired stability for observational stations and data warrant the extended grant periods. The POs have made a concerted effort to increase the average award size for individual competitive awards in FY2004-2006, with the average size increased from $100K to $159K to $510K in FY 04, 05 and 06, respectively. The FY06 value is skewed by a relatively high proportion of FS awards, compared to equipment acquisitions (EA), and the accounting change for split-funded acquisitions < $50K, which are now passed to research programs as discretionary block grants for equipment. It was also affected by "mortgages" for previous proposals. As emphasized in the IPAMM Report, larger awards during a time of constant budgets inevitably leads to sharply	Appropriate

[5] If "Not Appropriate" please explain why in the "Comments" section.

decreased success rates. Several facilities are now in sunset or operating under decreased funding, after difficult considerations of their value to the larger community and pressure for additional funds to maintain other facilities and parts of the IF program. FS funding is closely evaluated at multiple administrative levels, and by groups with different degrees of self-interest in maintenance and/or growth of the facilities. The COV is satisfied that the review process considers the impacts of the funding decisions across the spectrum of the EAR research community.	
3. Does the program portfolio have an appropriate balance of: • Innovative/high-risk projects?[6] Comments: Innovation in the program portfolio derives from a number of sources, as illustrated by the following select examples. **(1) Providing infrastructural needs for innovative scientific applications** • At the heart of the major facilities, such as IRIS, UNAVCO and COMPRES, whose support constitute the lion's share of the program's portfolio, is the generation of unparalleled, open-access data or beamlines and other facilities available to a broad range of researchers**.** The conceptual designs of these facilities are recognized internationally and much-emulated. Evidence of the innovative application of these resources can be seen in numerous recent studies published in *Science* and *Nature.* **(2) Investment in instrumentation and technique development** • The project EAR 0004077/0331484/0413899/0549639 sought optimization of the electron microprobe for geochronology (the "UltraChron"). The entrepreneurial actions of the PI leveraged resources from the manufacturer, Cameca. • EAR 0550040 involves development of techniques for the production of very large diamond single crystals by chemical vapor deposition. These materials will support development of much larger volume experimental cells to examine material behavior at core pressures. **(3) Innovative use of basic instrumentation** • Using an ion microprobe supported by EAR-0319230, oxygen isotopic analyses of zircon suggested the presence of oceans much earlier in Earth's history than previously thought. • EAR-0236489 supported microscopes and sample preparation equipment enabling examination of Paleocene flora to demonstrate abrupt biodiversity changes and a severely disrupted food web across the K/T boundary. **(4) Innovation in design of the IF program** • The EAR-IF program is unique in GEO. Many scientists need advanced tools to make discoveries, and recognition of this by EAR with an IF program that is both separate, yet integrated closely with research in the same division, has created a valuable resource to the EAR community.	Appropriate

[6] For examples and concepts of high risk and innovation, please see Appendix III, p. 66 of the Report of the Advisory Committee for GPRA Performance Assessment, available at <www.nsf.gov/about/performance/acgpa/reports.jsp>.

4. Does the program portfolio have an appropriate balance of: • Multidisciplinary projects? Comments: The program contains a variety of multidisciplinary projects, because many of the instruments have multiple applications and the data from large facilities can often be used in a wide variety of applications.	Appropriate
5. Does the program portfolio have an appropriate balance of: • Funding for centers, groups and awards to individuals? Comments: The appropriate balance of funding between multi-user facilities, which benefit a large community of researchers, and awards to individuals, which typically benefit a local or regional group of users, is a perennial challenge. During the review period, the IF program has maintained a balance of approximately 75% facilities and 25% others uses (equipment acquisition, technician support, …). Over the same period, the program has seen an overall decrease in budget of about 10%, and redirection of some funds to technician Support. As a result, there has been considerable erosion in the EA budget, from 17 to 11% of the portfolio and a sharp decline in the number of EA awards. This erosion impacts resources widely distributed at individual institutions, and preferentially for some types of research, leading to negative consequences for Learning, Discovery and Training of the scientific workforce in these locations. In tight budgetary periods, the IF program must hold facility funding at "maintenance levels", to protect the significant investment in these resources and prevent irreversible loss of capabilities. FS funding is closely evaluated at multiple administrative levels, and by groups with different degrees of self-interest in maintenance and/or growth of the facilities. The COV is satisfied that the review process considers the impacts of the funding decisions across the spectrum of the EAR research community. Nevertheless, continued budgetary pressures cannot be sustained without irreparable harm to the EAR community. The COV is appreciative of the efforts of the POs to leverage their ability to support these other programs. Leveraged funds added an average of $12.3 M/yr over the review period, including NSF's MRI and ITR Programs external to IF. In particular, $3.9M per year is leveraged from the MRI program, and benefited non-PhD granting institutions. The COV sees the value to the EAR community of assessing the potential role of additional multi-user facilities in support of geochemical research. There is no implication that such facilities can wholly replace the need for instrumentation at individual institutions, in particular for the development of new techniques and analytical protocols, but it may be possible to achieve enhanced access to facilities or equipment.	Appropriate
6. Does the program portfolio have an appropriate balance of: • Awards to new investigators? Comments: During the previous COV period (FY01-03), ~25% of awards were given to new investigators. The funding rate was more variable	Appropriate

for the present evaluation, ranging from a high of 51% in FY 04 to a low of 7% in 2006, with a caveat that overall funding rate was about 20% in the FY06 round. Evaluation of the portfolio suggests there is no single reason for the overall low rate of success of new investigators in recent rounds; reasons included lack of EAR funding, modest intellectual merit, poor management plans for maintenance of the instrument, and insufficient program funds to award all deserving proposals. These statistics belie the considerable efforts of the POs to encourage and support the most deserving young investigators. But perhaps performace would have even been worse without their efforts. During the award period, two young investigators (EAR0521266) and (EAR0723151) received significant early career awards combining instrumentation with technician support. The COV views technician support as extremely important for the long-term viability and broad usage of laboratories. Also, it creates crucial opportunity for young investigators to focus on advancement of their research profile, rather than to be tied to the daily mechanics of operating and maintaining an instrument. Support was also provided for a new experimental fluid dynamics lab for another young investigator (EAR0236799). Thus, the program has appropriately and significantly invested in new investigators of very high potential.	
7. Does the program portfolio have an appropriate balance of: • Geographical distribution of Principal Investigators? Comments: Over the period FY 04-06, EAR/IF funds were awarded to PIs from 34 different states. Of the 18 states and territories unrepresented in the awards list, ≤ 2 proposals had been submitted from 11 states. The POs are carefully managing the portfolio for geographical representation, but cannot make awards where they are not requested.	Appropriate
8. Does the program portfolio have an appropriate balance of: • Institutional types? Comments: The IF program portfolio served all sectors of higher education, except for two-year institutions, during the review period. Research-intensive universities received the majority of total funds (51%), and submitted most of the competitive proposals (58%), with graduate-serving institutions awarded much of the balance. These statistics largely reflect proposal pressure, as the funding rates across all types of institutions has remained roughly the same. Thus, the portfolio is well-balanced with requests made by the community. MRI funding reached the greatest diversity of institutions, including 4 year colleges, minority and minority-serving institutions, Epscor states, and institutions serving a large percentage of first-generation college students. This appears to reflect allocation of MRI funds for institutions whose primary mission is undergraduate education, and a healthy and competitive response of the earth science educational community to the availability of those funds. The recent removal of cost-sharing requirements has resulted in approximately a doubling of all proposals, including from bachelor- and master's granting institutions. Despite the change in overall submissions, there was no change in the proportion of the total proposals submitted by non-PhD granting institutions (20% of the total proposals), or in the relative	Appropriate

percentage of awards to this group as a whole. In the case of FY 2006, when the effects of this policy change can be measured, all institutional types saw their funding rate decrease to about 20%. Thus, the effect of this policy has impacted the proposal load, without significantly changing the balance of institutions served by the program.	
9. Does the program portfolio have an appropriate balance of: • Projects that integrate research and education? Comments: The vast majority of the projects integrate research and education nicely. The IF Panel is explicitly charged to consider balance across the IF portfolio, including in the integration of research and education, and advise the POs accordingly.	Appropriate
10. Does the program portfolio have an appropriate balance: ▲ Across disciplines and subdisciplines of the activity and of emerging opportunities? Comments: The portfolio balance is generally appropriate among subdisciplines in each class of awards. The relative balance between a small number of multi-user facillities, which have grown steadily in size and number and now make up 75% of the budget, and the much larger number of individual-institution (EA) awards, which have been level funded in nominal dollars for 15 years, poses complex issues. It is crucial to bear in mind that deriving scientific results from the data products from large facilities often requires EA awards to individual institutions. There is a healthy mix between traditional "core" science and some new opportunities.	Appropriate
11. Does the program portfolio have appropriate participation of underrepresented groups? Comments: The proportion of FY 04-06 awards with women PIs and Co-PIs held at about 35%. This value compares favorably with the demographics of women faculty in geoscience. Based on 2005 data *("Where are the Women Geoscience Professors?"*, NSF-AWG workshop report), women hold ~26% of assistant professor (13% in PhD-granting institutions) and ~8% of full professor positions. Given the predominance of awards to PhD-granting institutions, there are significant opportunities for women in this program. The participation of underrepresented minorities in geosciences is so small that statistics are of questionable reliability. Three self-identified underrepresented minorities hold active EAR/IF awards.	Appropriate
12. Is the program relevant to national priorities, agency mission, relevant fields and other customer needs? Include citations of relevant external reports. Comments: The program priorities of EAR/IF align well with the NSF strategic goals of Dicovery, Learning, Research Infrastructure and Stewardship. • Discovery: Many scientists need advanced tools to make discoveries. The IF program is the steward of world-recognized resources and instrument networks (IRIS, UNAVCO, COMPRES, IRM, and others)	Appropriate

which *promote transformational, multidisciplinary research* in Earth science. For example, in addition to fundamental advances in our understanding of Earth's interior and materials under extreme conditions, these networks yield deeper understanding of earthquakes that place communities at grave risk. • Learning: IF supported facilities and instrumentation provide opportunities for undergraduate and graduate students to participate in cutting-edge science, enhancing the technological and scientific literacy of the workforce. The POs, panel and community reviews encourage PIs and institutions to consider how broadly an instrument can be used, effectively building an "intellectual infrastructure" around the instrumentation. This approach encourages community appreciation of new tools, and helps to guarantee their longevity and institutional support for the new equipment. • Research Infrastructure: The contributions of EAR-IF to research infrastructure are dramatic. It also supports a remarkable breadth of the Earth science research enterprise, from an individual researcher working on a microscope to a global seismographic network, with significance to studies of everything from early Earth environments to modern tectonic activity, from biological evolution to support for the global nuclear test ban treaty monitoring. • Stewardship: The COV concludes that the POs have taken careful and well-considered steps in managing a very diverse portfolio faced with challenges brought about by resources that have not kept up with the needs of the community. They have sought to support young investigators and have an impressive record of support for underrepresented groups.	
13. Additional comments on the quality of the projects or the balance of the portfolio:	

A.5 Management of the program under review. Please comment on:

1. Management of the program.

Comments: During the FY04-06 COV evaluation period, the EAR/IF program has faced increased proposal pressure (new proposals: FY04 – 146, FY06 - 221) along with flat or declining budgets. Despite the increase in workload, the IF POs have maintained a high-quality program. To reduce the workload associated with the significant number of small, matching grants, and enhance integration of IF and core research-program funding, the POs transferred equipment and IT funds (< $50K) to associated research programs, which are then responsible for their management and reporting. Streamlining of the review process could also decrease the PO workload, but the COV concurs with the IF decision to continue with both mail and panel reviews of proposals. The mail reviews are detailed, and the panel helps interpret mail reviews and provide feedback for the PO (particularly important for high-risk or innovative projects). The whole process of archiving and tracking the proposals appears to have been improved through migration to the eJacket database system.

The recent rapid decrease in the percentage of funded proposals is a serious concern for the IF program, which historically has had a success rate around 50%. Several NSF goals (access to the necessary tools, globally competitive research in the Earth sciences, foster training through access to analytical instruments) could be compromised if these trends continue. Further, the steep decline in funding rate from ~50 to ~20 percent portends a heavier proposal load in the future, and loss of potential and capacity as young investigators become discouraged by the proposal process.

The COV investigated a management review of one of the facilities that resulted in a personnel action at the facility. We found a detailed paper trail of the escalating response of the NSF to identified deficiencies. The COV recognizes that the management of large facilities is a demanding task; further discussion and suggestions are offered in Part C of this report.

We note that the NSF as a whole was rated "effective" in three Program Assessment Rating Tool (PART) Evaluations, which is the highest rating possible. A key metric is the time to decision, with a goal of decision for 70% of proposals within 6 months of the later of the deadline, target date, or receipt date. The NSF has met these goals during the COV review period. We assume that the IF program met this metric. The IF program responds to PIs electronically with the expected action on their proposal, but the dwell time of proposals is typically close to 8 months. Thus, the POs meet the intent of the metric, even though it has become difficult for them to handle the proposal load without delay in formalizing the actions decided upon.

The EAR/IF program has carefully considered the specific recommendations of the previous COV, and has responded appropriately. Some of these recommendations, however, remain important issues. In particular, with an increasing number of proposals, and flat or declining budgets, how can POs find the proper balance between funds for facilities and for individual instruments while not undermining the success of IF's mission?

2. Responsiveness of the program to emerging research and education opportunities.

Comments: The COV examined IF actions on proposals from recent PhDs, and proposals concerned with the development of new instruments and techniques (IDT) to assess how well the Program responded to emerging research. A relatively large percentage of IDT proposals (perhaps 35%) were funded, and we note ongoing support of several innovative proposals initiated before 2004. A smaller percentage (~25%) of proposals from recent PhD's were funded, in part due to budget constraints. To address some of the difficulties experienced by new faculty in experimental science, IF has bundled EA (instrument) and TS (technician) support for the establishment of two new laboratories for qualified young investigators since 2004.

The new category of *Geoinfomatics* was established in 2006 to provide transformative cyberinfrastructure for the Earth sciences with interactive databases and software tools to integrate diverse forms of information. Open access to high-quality data and tools to operate on these data provide new research opportunities for students and educators.

Sustained education and outreach (E&O) efforts are supported at several national facilities (e.g., IRIS, UNAVCO). The MREFC Earthscope program has greatly expanded the geographic distribution of geophysical instrumentation, providing unique outreach and education opportunities. UNAVCO and IRIS are the primary sub-contractors tasked to build the PBO (Plate Boundary Observatory) and US Array components of Earthscope, and their E&O components complement those of Earthscope. The success of these E&O efforts is difficult to judge, and the COV suggests cost-benefit analysis, user canvassing, or some other type of community feedback to guide future E&O efforts by the IF supported facilities. This issue may not be unique to IF, but may also apply to other facilities and infrastructure programs throughout EAR, GEO or even NSF.

These examples demonstrate that the EAR/IF program is responding well to emerging research and education trends, with IF's standing panel providing oversight on the balance of effort. Overall, the COV is encouraged by the continued support for high-risk research, young faculty and carefully targeted E&O.

3. Program planning and prioritization process (internal and external) that guided the development of the portfolio.

Comments: Three criteria drive NSF planning and prioritization: Relevance, quality, and performance. In the IF program, quality and performance are assessed through a careful review process (intellectual merit and broader impacts), and performance is assessed by feedback from the user community and scientific outcomes from the researchers. Priority is given to new proposals that develop partnerships within NSF, and with other domestic and international agencies, as well as to previously-unfunded but well-justified proposals. The Program seeks to maintain baseline capabilities of the facilities, even during times of tight budgets.

Many notable IF scientific successes are a result of this significant investment in past years. Most recently, UNAVCO and IRIS have been key agencies in building components of EarthScope. As the build-out phase of PBO nears completion in 2008 and US Array continues its march across the country, new scientific developments are expected. We commend IF managers for their foresight in recognizing and developing facilities that support these key emerging user communities.

The large budgets of IF facilities, which serve a proportionately large and growing user community, are balanced against smaller acquisitions of equipment for analytical laboratories, computational resources, technician support and software development that are of fundamental importance to maintaining capabilities and infrastructure supporting research across many EAR programs. The IF Program is charged with maintaining baseline capabilities of existing facilities, even during times of tight budgets. Thus, tight budgets have required a difficult balancing between the needs of the various research communities served by IF, and the distribution of program resources between FS and other components of the program (e.g., EA, TS, …). The POs, guided by mail reviews and panel recommendations, must carefully consider funding levels and project accountability for valuable resources. The COV finds that IF recognizes that both multi-user and smaller-scale facilities contribute to their scientific communities and deserve support, and the Program has mechanisms for evaluating and maintaining a balanced and diversified portfolio. The POs' ability to strike this balance is especially challenged when resources continue to be flat to declining, and the very low funding rates of ~20% in FY 2006 suggest that a crossover point may have been reached in their ability to do this.

A special emphasis panel (SEP) is often used to review proposals from large facilities. These SEP would benefit from the addition of panelists with experience in managing large scientific programs, as described in section C. Although Facilities proposals are typically more complex in structure, the work of shepherding a few facilities through the proposal process every few years is compounded by the POs' need to process a large number of smaller (e.g., EA, ITD, TS) proposals. The review needs of the latter proposals are well met by the process described above, of combined mail and panel reviews.

4. Additional comments on program management: IF is supporting outstanding science, and should continue many of their current practices. The Program has adapted as well as could be expected to the difficult and changing budgetary conditions experienced in FY04-06. Additional program expertise to help resolve potential management issues with the large facilities is discussed in Part C of this report.

PART B. RESULTS OF NSF INVESTMENTS

.
The NSF mission is to:

- promote the progress of science;
- advance national health, prosperity, and welfare; and
- secure the national defense.

To fulfill this mission, NSF has identified four strategic outcome goals: Discovery, Learning, Research Infrastructure, and Stewardship. The COV should look carefully at and comment on (1) noteworthy achievements based on NSF awards; (2) ways in which funded projects have collectively affected progress toward NSF's mission and strategic outcome goals; and (3) expectations for future performance based on the current set of awards.

NSF investments produce results that appear over time. Consequently, the COV review may include consideration of significant impacts and advances that have developed since the previous COV review and are demonstrably linked to NSF investments, regardless of when the investments were made.

To assist the COV, NSF staff will provide award "highlights" as well as information about the program and its award portfolio. Since relevant aspects of the Stewardship goal are included in Part A, the COV is not asked to respond to that goal in Part B.

B. Please provide comments on the activity as it relates to NSF's Strategic Outcome Goals. Provide examples of outcomes ("highlights") as appropriate. Examples should reference the NSF award number, the Principal Investigator(s) names, and their institutions.

B.1 OUTCOME GOAL for Discovery: "*Foster research that will advance the frontier of knowledge, emphasizing areas of greatest opportunity and potential benefit and establishing the nation as a global leader in fundamental and transformational science and engineering."*

Comments: To develop new understanding about Earth materials, structure, processes and history, new measurements are often necessary, whether in the field or the laboratory, as are new capabilities in computational simulation. Toward this end, most of the IF funding, while generally expended for tools or tool development, creates the environment necessary to enable discovery across the many frontier regions of science and engineering. The POs actively manage a huge diversity of project types, ensuring that significant progress is being made across a wide range of cutting-edge research programs in Earth science.

The COV is impressed with the number of high-profile discoveries resulting from projects supported fully or in part by the IF program. Numerous reports of IF-supported research have appeared in leading international journals, such as *Science* and *Nature*, in many cases being featured on the cover of the journal. Much of IF-supported research is directly relevant to major social and economic issues facing today's world. These include projects providing fundamental knowledge about global warming, natural hazards, energy and resource supplies, and a host of similar issues.

The COV notes that the EAR IF program has set the world standard for the support of major

research facilities in Earth sciences. No other country can boast of a greater diversity of highly successful, cutting-edge science from such facilities.

The focused program to fabricate very large (>10 carat) diamond single crystals using chemical vapor deposition by R. Hemley and D. Mao (EAR-0544943 and EAR-0550040) is an excellent example of world-leading transformative science supported by the IF program. The PIs will use these crystals to construct diamond-anvil cells with sample volumes up to 100 times larger than existing apparatus for ultrahigh-pressure (megabar) research. These large, high quality diamonds will not only transform the nature of ultrahigh-pressure research, but they will find applications in a wide range of other revolutionary scientific and commercial endeavors.

B.2 OUTCOME GOAL for Learning: "*Cultivate a world-class, broadly inclusive science and engineering workforce, and expand the scientific literacy of all citizens.*"

Comments: The IF program plays an important role toward attainment of a diverse, competitive and globally engaged workforce. The B.S., M.S., and Ph.D. students trained on IF-funded equipment are critical to maintaining a world-class technical workforce in the U.S. In addition, some of these students will become the next generation of research scientists. The COV observed that the POs are aware of this opportunity, and actively seek to provide infrastructure funding to a diverse group of people at a diverse range of institutions. However, as noted, the low success rate of EA proposals is notable and poses a challenge in this effort.

The COV notes that the large, publicly-accessible databases provided by many of the facilities are now available to support undergraduate research as well as graduate-student research projects. Progress in developing web-based data-visualization products, such as the IRIS earthquake browser [http://www.iris.washington.edu/servlet/eventserver/map.do;jsessionid=90468B389CB3BC4E42AA55CB815EE118], make these data available for use by the general public and for K-12 education. These databases provide a new and extremely valuable resource that will continue to support education well into the future.

The EA program provides instruments that are used to educate students about the fundamental scientific activity of data acquisition. Without being mandated, this learning component is an organic part of the IF program. This data-gathering experience is critical to the success of science and engineering education and the COV suggests that the value added to university education by this program is one of several reasons that may justify mandating cost sharing by most universities to support the acquisition of IF equipment. In addition, a cost-sharing mandate would increase the funds available to the IF program, thereby potentially benefiting a larger and more diverse group of students.

The IRIS program (EAR-0552316) provides an excellent example of how a traveling museum exhibit, a teacher development program, a summer internship program, web pages including web-based data viewers, posters, educational affiliates, distinguished lecturers and even video products are being used to deliver a wide range of learning experiences to a broad audience, ranging from K-12 and university students to the general public.

B.3 OUTCOME GOAL for Research Infrastructure: "*Build the nation's research capability through critical investments in advanced instrumentation, facilities, cyberinfrastructure and experimental tools.*"

Comments: This COV concludes that careful management of the EAR/IF program has played a

pivotal role in placing EAR-supported research and education at the forefront, worldwide. Funding of new equipment and development of new techniques and instruments are essential for maintaining long-term research capacity in the Earth sciences.

The POs are applauded for maintaining a consistent influx of research and education tools into the EAR community (e.g., EA, ITD, and FS proposals), providing valuable research tools to the next generation of researchers, as well as promoting the continued building of a solid infrastructure (e.g., ECR and TS proposals). However, the recent decline of proposal success rates to near 20% concerns the COV because it is likely to lead to an irreversible loss of research capacity. This loss significantly diminishes the ability to gather and analyze data acquired through IF-funded facilities, and directly impacts the IF program's ability to satisfy NSF strategic goals as well as its Broader-Impact objectives (see discussion in B2, above). The COV supports the POs' recent efforts to develope strategies for rebalancing the portfolio. In addition, the COV urges consideration of a range of possible strategies to redress this problem. One such strategy could include reinstituting a cost-sharing requirement on proposals in order to improve overall proposal success rates.

Strategic development of multi-user facilities throughout the country has given a larger portion of the community access to cutting-edge research data and education opportunities. The innovative leveraging of funds (e.g., through the MRI program, cost-sharing with other NSF programs and with other agencies) has been exemplary, and has increased the effectiveness of the EAR/IF Program.

The IF Program recognizes scientists' needs for tools and, by providing those tools, it has an extraordinary impact on the entire field of Earth sciences. Thus, the IF program plays an absolutely critical role in the immediate and long-term success of Earth-science research, including in domains within other divisions of the GEO Directorate or the NSF. This, along with the its contributions to education, makes the IF program a major factor in NSF meeting its Broader Impacts goals.

A good example of a project that significantly enhanced the U.S.'s research infrastructure is the multi-collector Secondary Ion Mass-Spectrometer (SIMS) acquired under EAR-0319230. This instrument pushes the limits of precision and accuracy for high spatial resolution of stable-isotope analysis of geological and biological samples. Analysis of oxygen isotopes in ancient zircons using this instrument produced results that have revolutionized thinking about the evolution of the early Earth.

PART C. OTHER TOPICS

C.1 Please comment on any program areas in need of improvement or gaps (if any) within program areas.

The 2004 EAR/IF COV report noted that colated statistics from project reports (e.g., indicators of "results of investments" that might include information such as number of facility/instrument users, publications, number of graduate or undergraduate users) were not readily accessible, a situation that remains largely unchanged during the 2007 EAR/IF COV review. Whereas long-term impacts to the Intellectual Merit criterion might be estimated from publication data extracted from literature reviews, these reviews are difficult and time consuming to perform. Information about the Broader Impacts criterion are more difficult to gather. Examination of some project reports by the 2007 COV underscore the difficulty in extracting this type of information from project reports (in the current online submission format). Difficulty in collating statistical measures is compounded because annual and final reports for EAR/IF projects often do not contain much information about impacts; these reports are often submitted during, or soon after the installation of instrumentation or the development of facilities and techniques. Thus, it is often the case that the results of investments through IF awards are not realized until several years after the end of the award period, and may therefore be poorly documented by current reporting and accounting procedures.

Recommendation: NSF should develop a mechanism by which PIs' final reports could be exported into a database, and could be amended up to several years after the end of the grant. This would greatly facilitate Program Officers' abilities to collect, document and showcase the long-term impacts of IF awards.

C.2 Please provide comments as appropriate on the program's performance in meeting program-specific goals and objectives that are not covered by the above questions.

Management of Large Facilities

National, multi-user facilities (FS) that serve broad scientific communities have grown to account for approximately 75% of the IF budget. These facilities are highly successful, and have provided data leading to important scientific results. Several are admired worldwide as the leaders in their fields, setting standards to be emulated. They are operated by groups of researchers, melding scientific leadership from their research communities with high technical skills.

FS not only account for the bulk of IF's funding, but individual facilities have grown to considerable size, with multi-million dollar annual budgets. Such growth has introduced new management challenges, beyond those typical in academic science, raising questions about the effectiveness of facilities as they grow in size and number. There is a potential for management inadequacies to seriously undermine the scientific effectiveness of FS. Unless explicitly recognized by the facilities, and addressed by NSF, management can become the Achilles heel of a technically excellent program. Some of these issues are illustrated by recent developments that resulted in changes of leadership at UNAVCO. However, the potential for difficulties exists in other facilities, especially when a field is growing rapidly. The relatively informal and *ad hoc* arrangements typical in academia can lead to ineffective governance and management. Moreover, the present interface with NSF, primarily via proposal submission and review, is not well suited to identifying and avoiding potential management problems. The COV notes that even SEP typically do not necessarily include panelists

experienced in management of large, scientific facilities and programs.

The panel thus recommends that NSF work in partnership with the research community to improve management of large facilities, addressing a range of sound-governance issues including: clearly defined goals and performance metrics; alignment of responsibility and authority; succession plans; and long-term planning. Such partnership could take a variety of forms, but should focus on the twin elements of i) evaluating management effectiveness of current and proposed facilities, and ii) identifying and communicating best practices, lessons learned and other aspects of sound management.

Specific actions that might be considered include: 1) Adding expertise to the program staff in areas of science management, either by adding POs with this specific expertise or by including management as part of the background expected of POs (and providing adequate training, as needed); and 2) Adding expertise in scientific management to the standing IF panel, which could also take an ongoing role in facility oversight and mentoring beyond proposal review. The advantage to this approach is that it would maintain the IF Panel's role in balancing large facilities with the rest of the program. Alternatively, EAR or GEO might organize an advisory committee to specifically assist in overseeing both management and science of large facilities. This approach would have the advantage of being able to transfer knowledge about management practices across many facilities and disciplines (though with the potential risk of making it more difficult to balance a portfolio of small and large awards). However organized, management review and oversight could provide valuable insights from comparing different facilities, raising important issues before they undermine effectiveness, and helping share best practices and lessons learned. Expertise could be drawn not only from the traditional EAR community, but from other communities and agencies having deep experience in management of large scientific projects, such as in space science, in certain areas of physics and in many high-technology groups from the private sector.

C.3 Please identify agency-wide issues that should be addressed by NSF to help improve the program's performance.

The COV had neither the time nor the information to address the issue, but has the impression based on several (anecdotal) examples that the concerns about large-facility management in IF has parallels in other programs at NSF. There may be opportunities to share knowledge about best practices more widely or effectively across the Foundation.

C.4 Please provide comments on any other issues the COV feels are relevant.

C.5 NSF would appreciate your comments on how to improve the COV review process, format and report template.

SIGNATURE BLOCK:

_____

For the EAR/*Instrumentation & Facilities Program* COV
Raymond Jeanloz, Chair

EAR/IF COV MEMBERS (August 22-24, 2007)

NAME	Expertise
Dr. Susan Beck Department of Geosciences University of Arizona Tucson, AZ 85721 Email: beck@geo.arizona.edu	Seismology/tectonics
Dr. Raymond Jeanloz (Chair) Department of Earth & Planetary Science University of California, Berkeley Berkeley, CA Email: jeanloz@berkeley.edu	Mineral physics [AC/GEO member]
Dr. Michael Lisowski U. S. Geological Survey Vancouver, WA 98683 Email: mlisowski@usgs.gov	Volcanology/geophysics
Dr. Juan Lorenzo Department of Geology & Geophysics Louisiana State University Baton Rouge, LA 70803-4101 Email: jlorenzo@geol.lsu.edu	Crustal seismology
Dr. Claudia Mora Department of Earth & Planetary Sciences University of Tennessee Knoxville, TN 37996-1410 Email: cmora@utk.edu	Stable isotope geochemistry
Dr. Donald Rimstidt Department of Geosciences Virginia Tech Blacksburg, VA 24061 Email: jdr02@vt.edu	Low-T geochemistry
Dr. Steven Shirey Department of Terrestrial Magnetism Carnegie Institution of Washington Washington, DC 20015-1305 Email: shirey@dtm.ciw.edu	Radiogenic isotope geochemistry
Dr. Seth Stein Department of Earth & Planetary Sciences Northwestern University Evanston, IL 60208 Email: seth@earth.northwestern.edu	Geodesy/tectonics
Dr. Karl Wirth Department of Geology Macalester College St. Paul, MN 55105 Email: wirth@macalester.edu	Igneous petrology/geochemistry