December 16, 2005

Dr. Alfred Aho
Chair, CISE Advisory Committee
National Science Foundation
4201 Wilson Boulevard
Arlington, Virginia 22230

Dear Dr. Alfred Aho:

The Committee of Visitors (COV) for the Information and Intelligent Systems (IIS) Division for the National Science Foundation (NSF) Directorate of Computer & Information Science & Engineering (CISE) met December (Dec) 12-14 at NSF to review the performance of IIS for Fiscal Years (FY) 2003 – 2005 in two primary areas:

A. Assess the quality and integrity of operations, including technical and managerial matters pertaining to proposal recommendations; and

B. Comment on how the outputs and outcomes generated by awardees have contributed to the attainment of NSF's mission and strategic goals.

We additionally addressed three questions posed by CISE staff:

1. What are the most exciting research outcomes that are a direct result of IIS funding?

2. Which areas of research seem to have the most potential in terms of growth and/or promising new results?

3. What are the fields (or subfields) in IIS that might profit from increased integration within IIS, across CISE and the entire NSF?

The above items, together with other findings are in the attached report.

Will you please forward the report to Peter Freeman? Marti Hearst and I will coordinate who will present the findings at the spring CISE Advisory Committee meeting. Please feel free to contact any of us on the IIS COV with any questions or comments.

With best regards,

Rosalind W. Picard
Chair, IIS Committee of Visitors

Enclosures

Cc: Members of the 2006 IIS COV (w/enclos.)

FY 2006 REPORT TEMPLATE FOR
NSF COMMITTEES OF VISITORS (COVs)

Date of COV: December 12-14, 2005
Program/Cluster/Section:
Division: Information & Intelligent Systems
Directorate: Computers & Information Science & Engineering
Number of actions reviewed: 150 Projects Awards: 75 Declinations: 75 Other:
Total number of actions within Program/Cluster/Division during period under review: Awards: 830 Declinations: 4636 Other: 94
Manner in which reviewed actions were selected: **Stratified Random sample, representative of all actions, except heavily biased toward "accepts" (50% of actions instead of the average acceptance rate over 3 years of 15%). Note that 2003 ITRs were omitted from this sample because they had their own COV in March 2005.**

EXECUTIVE SUMMARY

COV Members: *M. Brian Blake (Georgetown Univ), Paul Dourish (UC Irvine), Tim Finin (U Maryland Baltimore County), Lise Getoor (U Maryland College Park), Jonathan Grudin (Microsoft), Yannis E. Ioannidis (Athens), Marti Hearst (UC Berkeley), Janet Kolodner (Georgia Tech), Colette Maloney (EU Information Society Technologies), Rada Mihalcea (U of North Texas), Rosalind Picard (MIT), Jordan Pollack (Brandeis Univ), Charles Rothwell (CDC National Center for Health Services), Neil Rowe (US Naval Postgrad School), Matthew Turk (UC Santa Barbara)*

The COV met for an intense 2.5 days to review the performance of the Information and Intelligent Systems (IIS) Division for the National Science Foundation (NSF) Directorate of Computer & Information Science & Engineering (CISE). In making the detailed study, we used laptops, software, databases, and web tools, which it may be noted, are all technologies that were enabled by fundamental research supported by NSF. We examined nearly 150 jackets of proposals with associated reviewer materials (a stratified sample of half declined and half awarded, chosen with a strong statistical bias toward accepts), dozens of two-page Area Reports aimed at future directions and innovations, three IIS Annual Reports, hundreds of Research Nuggets, the previous IIS COV 2003 report, and many more reports of IIS-funded workshops and meetings, together with content from presentations of IIS Program Directors. We also analyzed various collections of numeric data, and computed statistics to assess trends in funding, especially with an eye toward assessing how NSF IIS is able to support the current and prepare the next generation of innovators.

The last three years have brought the strongest budget pressure to date on IIS, co-occurring with the highest number of proposals to process in history (5,574). Despite this challenging situation, we

observed a team that is constantly improving their processes, is open to questions, is willing to take risks, actually implements new ideas using their own technologies, performs evaluations, accepts change routinely, and is overall a pleasure to work with. We found integrity, ingenuity, intelligence, and excellence in the program's processes and management. IIS outcomes are products of research that include new enabling technologies, fundamental theoretical advances and new capabilities that expand people's abilities to learn, make decisions, communicate, and achieve goals. We identified outcomes that affect users of information technologies – personal computers, educational technologies, health informatics, web-based search and information retrieval, digital libraries, robotics, and more – with worldwide impact, and detailed many of these in Section C of the report. We found that there is an enormous amount to commend in this corner of NSF, which is a genuine goldmine of innovation.

The United States can be proud of the hard work and dedication shown by this community in bringing the highest standards of science and engineering, together with great creativity and ingenuity, in addressing so many of the important technological challenges facing the world. IIS research, because of its focus on fundamental technologies that support integration, adaptability and multidisciplinary research, is uniquely poised to contribute to a broad range of national concerns. These concerns include new technologies for helping elderly live safely in their homes longer, new approaches to personalized education, and new innovations in information inference and machine learning that support national security, such as information integration from multiple sources for detecting bioterrorism, flu epidemics, or other large-scale changes affecting the American people. IIS is also well positioned to address societal concerns such as privacy, information access and sharing, as well as usability and adoption of new technologies.

While brainstorming how IIS could continue to improve, we considered several pressing national needs, and wish to highlight how IIS funding can address one of them. This concern relates to the expected significant changes in demographics in the coming years. The national projection is for a severe decline in the number of US scientists and engineers as the number of underrepresented minorities grows, and as these minorities have not traditionally moved into the science and engineering fields. NSF and the NSB recognize this problem and we wish to highlight how IIS funding can help address its solution in the paragraphs below.

Like many communities in NSF, IIS has suffered from an inability to fund an adequate number of highly competitive proposals. The last several years have exacerbated the problem for IIS because of an enormous growth in national interest in the basic research supported by IIS. In FY 2003 submissions to IIS grew 73% and in FY 2004 they grew an additional 18%. The lack of appropriate budget increase meant that acceptance rates for research proposals would drop significantly below the NSF average funding rates, while IIS staff workloads were growing enormously. IIS was asked to find a way to reduce the number of submissions. The possible sources of growth were identified as (1) Innovation and increasing national interest in IIS research, (2) New contributions from smaller schools, from EPSCOR states, and from faculty increases in IIS areas, and (3) Researchers sending in multiple submissions.

IIS took several actions to reduce the submission rate (and thus to try to increase the acceptance rate): First, they limited the number of submissions for each PI to two per solicitation. Second, IIS cut in half the number of solicitations for new proposals, holding solicitations once per year instead of twice per year. The result was a significant decline in submissions for FY 2005, with a drop of over 20%

from FY 2004. The resulting FY 2005 submission numbers were thus only 62% over the FY 2002 level. To take further action to reduce the number of submissions, IIS is slowing the solicitation for FY 2006 by an additional 6 months, so that there is an 18-month gap between solicitations. These measures were taken not only to reduce submissions, but also to try to increase funding rates from what was going to be a mere 6% if such actions were not taken.

We performed a careful analysis to see to what extent multiple submissions were still affecting IIS funding rates. We found that IIS applicants submitted on average from 1.2 to 1.3 proposals during FYs 2002-2005, which was in the middle of the ranges of the other CISE divisions, where applicants submitted from 1.1 to 1.4 proposals per person. Thus, it is not the case that IIS applicants were submitting a larger number of individual proposals. We also asked how many unique Principle Investigators there were from year to year, and we found growth in the number of unique PI's applying to IIS that was significantly higher than in the other divisions. In particular, the number of unique PI's applying to IIS doubled from 2002 to 2004 (from 933 to 1838). With all the changes being made in the last couple years, we advocate that these statistics about new PI's be watched across CISE, as they relate to opportunities for growing diversity and for understanding how to allocate future CISE funds to match future needs.

While the many changes IIS made did decrease submissions and increase their rates of funding, IIS funding rates for research awards (regular, ITR, Career, and REU Awards) still fell far below those of the other CISE divisions. (We emphasize research awards instead of travel and workshop awards, since the latter are of a different nature. We did also examine the percent of funding of non-research awards, and found IIS to be in the middle of the other CISE divisions with respect to those rates.) Thus, IIS is able to fund significantly fewer of the research proposals it receives than are other parts of CISE, even with the great steps taken to decrease the number of proposals that get submitted.

Research Award Funding Rates across CISE Divisions

Year/Division	FY 03	FY 04	FY 05
CCF	**22%**	**17%**	**23%**
CNS	**22%**	**15%**	**19%**
IIS	**16%**	**10%**	**11%**

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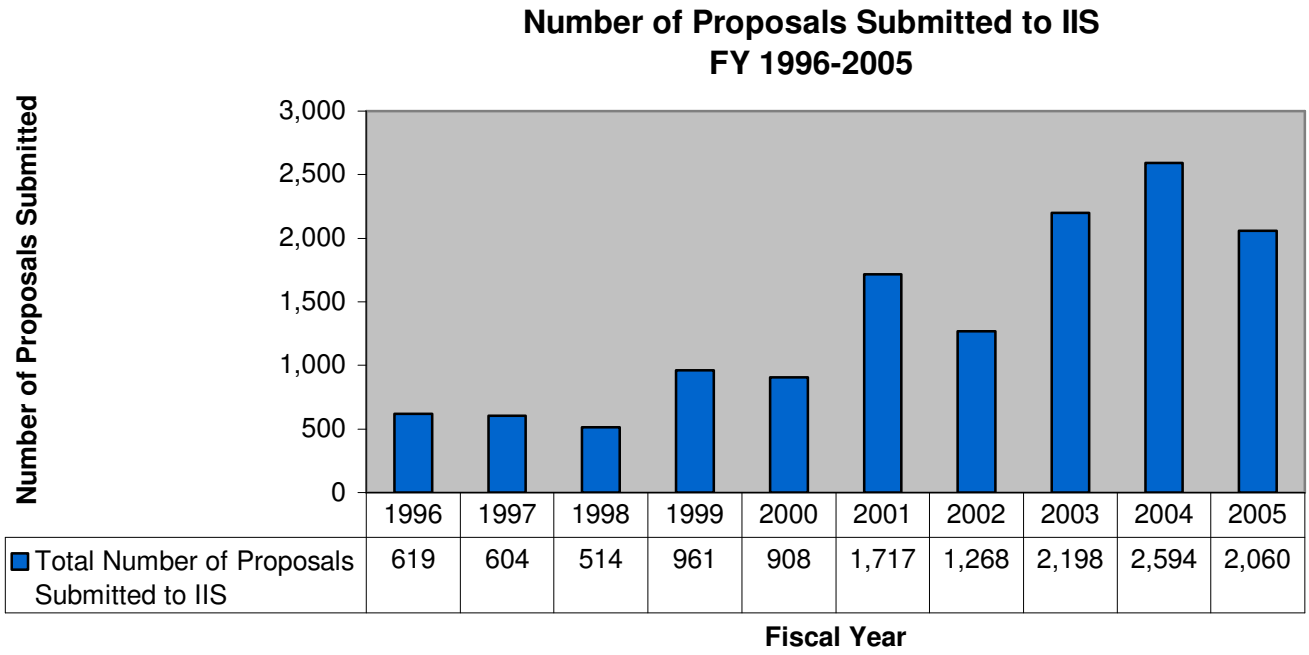
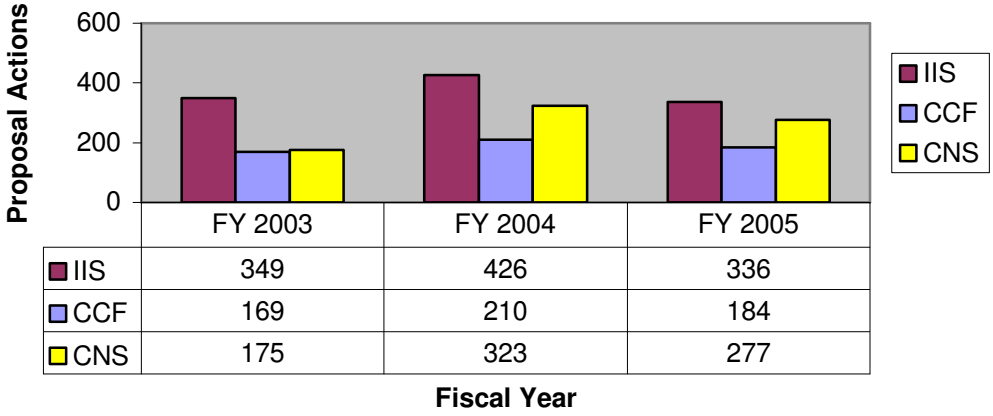


The lower rate of funding research proposals was found for all three years: Even after dramatically reducing the number of solicitations and restricting proposals, IIS funding capacity was not able to keep up with the rates of other CISE divisions. Moreover, we examined the dollar amounts allocated to the funded proposals, and found that they ran on average at around 80% of the requested budgets. Thus, not only is IIS inhibited in the rate that they can fund incoming highest quality proposals, but they are also handicapping the ones that they do fund, by reducing the requested amounts.

While the demands on IIS can be seen as a sign of the widely recognized importance of this area, and one can argue that everybody across NSF has suffered with the dearth of funds, we think there is an additional *opportunity cost* incurred by the squeeze on IIS. We found this when we took a closer look at where the cuts were. We noticed two things in particular, which we highlight here because of their impact on the national demographic concern.

1. IIS attracts significantly more women and underrepresented minorities than all other divisions of CISE. (Note CNS had a special program to attract more minorities in 05, bringing their numbers into alignment with the natural numbers of IIS for that one year.)

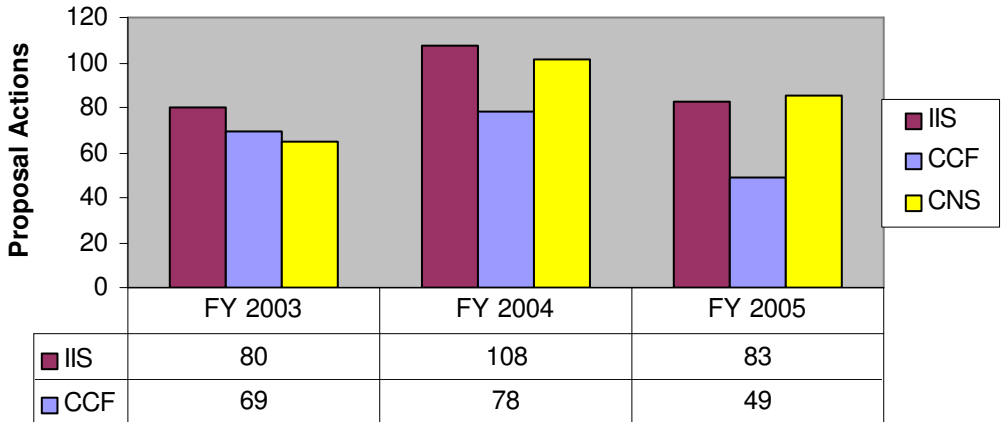
Number of Proposal Actions (awards + declines) for Female PIs FY 2003-2005 by CISE Division



	FY 2003	FY 2004	FY 2005
IIS	349	426	336
CCF	169	210	184
CNS	175	323	277

Fiscal Year

Number of Proposal Actions (awards + declines) for Minority PIs FY 2003-2005 by CISE Division



	FY 2003	FY 2004	FY 2005
IIS	80	108	83
CCF	69	78	49
CNS	65	101	85

Fiscal Year

2. While rates of funding for experienced PI's were constant, rates for New PI's dropped during the time of budget pressure. In reading reviews, we observed that several panelists pointed out that less experienced PI's were "a greater risk to fund", and used this as an excuse to rate their proposals less competitively, while others pointed out that some PI's "had a great track record" so "even if the proposal wasn't top notch, they should be funded." While we found evidence that program directors sometimes overrode these biases, it does not erase the fact that these biases are in the community, and that they can hurt efforts to bring in new investigators.

The above two observations suggest that the dramatically reduced funding rates may be disproportionately hurting NSF's efforts to grow the number of women and minorities in science and engineering. IIS is an important growth area and the youth know this and are attracted to it. They also are attracted naturally through their experiences with "cool technologies" like the web, robotics,

new educational, health, and multimedia technologies, and more. These youth include a *proportionately large* number of bright young women and underrepresented minorities. We would like to propose that increasing IIS funding could significantly impact the number of women and minorities in science and engineering, while also enabling a continuation of the innovation that has given the USA its current worldwide lead in technology.

In summary, we applaud the extraordinary quality and integrity of the work conducted by IIS during the past three years. The IIS Division Director, Program Directors, and staff have implemented tremendous changes and improvements despite enormous budget pressures and unprecedented growth. We additionally recognize a large number of IIS scientific and technological outcomes that have contributed to significant innovations in technology worldwide, impacting education, health, science, business, and everyday computing experiences. We encourage NSF to act on our findings and especially to look for future opportunities to increase funding rates for IIS. In so doing, they will not only support the outstanding work that IIS is doing to fuel the Nation's future innovation, but also the diverse and growing number of researchers who are naturally attracted to this important area.

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:	Yes.

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

Yes. The review mechanism has been outstanding. Supplementing panel reviews with solicited ad hoc reviews is an excellent way to obtain clarifications and bring in people who could not make the panel meeting or who had special expertise for particular proposals.	
2. Is the review process efficient and effective? Comments: Yes. The review process is efficient, and is exemplary in comparison to other agencies. The process has served NSF extremely well. We are particularly impressed with IIS's responsiveness to concerns raised by the previous COV concerning dwell times and process efficiency. This is laudable. We noted that it is more challenging to manage an effective process in the case of broad, multidisciplinary initiatives such as Digital Libraries and new initiatives such as Advanced Learning Technologies. The move to annual solicitations and university pressure for grant funding may increase the difficulty of assembling panels with appropriate expertise, as many are excluded due to their participation in the submissions. We worry that the move towards clustering in IIS solicitations could exacerbate the problem of assembling appropriate panels, if not carefully managed. Reviewer expertise is particularly an issue when proposals draw on application areas not traditionally encompassed by CISE. The review process may have to be adjusted to compensate for the rise in percentage of proposals rejected. Why this is occurring (growth in faculty outpacing growth in funding, etc.) and possible outcomes (loss of young or outstanding researchers to Europe, Asia, etc.) are not in our scope. Extreme competition for resources can work against risk-taking and innovation. We saw brilliant, innovative, high-risk proposals that seemed extremely promising, but which were ultimately unfunded. We advocate that IIS panels and reviewers explicitly address proposals on innovation/risk criteria in order to check the natural tendency towards caution when resources are less plentiful. We recommend that all panels be made aware of the possibilities for SGER awards.	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: Yes. We read many excellent reviews. It is clear that reviewers frequently put	Yes.

considerable effort into writing reviews that support not only an effective decision-making process but also appropriate communication back to investigators. However, there are some cases of "skimpy" reviews that merely summarize the proposal (rather than assessing benefits) and make broad statements about research programs rather than evincing critical engagement. This is particularly problematic in cases where proposals are declined, and in responses to investigators early in their careers, where guidance is most crucial and negative responses most demoralizing. Furthermore, in the face of rising competition pressure, and the need to distinguish between several equally high-quality proposals, it is difficult to ensure that reviews report on the intrinsic merits or flaws of research proposals, rather than only providing reasons to reject them. We would encourage program officers to ensure that panelists understand that their role is to identify promising research rather than to seek reasons to reject proposals for funding. The merits of a proposal should be stressed at least as much as its shortcomings (despite computer scientists' natural tendency to focus on the latter.) NSF could take steps to help ensure that reviews provide information that investigators can use effectively in revising and resubmitting proposals. Making exemplary reviews available to reviewers in advance of the review process might help to raise overall quality. Program managers might also encourage other panel members to comment upon the quality of reviews overall.	
4. Do the panel summaries provide sufficient information for the principal investigator(s) to understand the basis for the panel recommendation? Comments: Yes. Most panel summaries we examined are outstanding. Certainly, there is some variability. Our sense and experience is that program officers can push scribes to include more useful detail – perhaps even encourage a minimum word count for the summary. In some cases the review analysis compensated for weaker panel summaries, but since these are not returned to investigators, they cannot be used to improve future submissions. Again, more guidance for scribes on how to write effective summaries might be of use. Providing exemplars may be one useful way of providing guidance.	Yes.
5. Is the documentation for recommendations complete, and does the program officer provide sufficient information and justification for her/his recommendation? Comments:	Yes.

Yes. Review analyses were very strong overall and provide valuable documentation of recommendations and rationales. Of course, there are lapses in particular instances. For example, in one proposal, the panel summary stated that a "key suggestion includes revising the proposal to…" and the review analysis listed several problems and concluded "I recommend that this proposal be declined because of one or more of the above factors" – a vague explanation for a recommended revision. For SGERs and Workshops, we encountered cases in which no review analysis was available. This makes it difficult to assess recommendation decisions overall.	
6. Is the time to decision appropriate? Comments: Yes. IIS has worked to address the dwell time concerns raised by the previous COV. IIS has improved responsiveness and has successfully met or exceeded its targets for responses within six months. We strongly applaud this. The dedication of IIS officers to addressing this issue is very impressive and a great boon to the research community. We also appreciate that, while frustrating, delays in responding to proposals often work to the advantage of investigators and programs by enabling more flexible fund allocations.	Yes.
7. Additional comments on the quality and effectiveness of the program's use of merit review procedures: We understand that the huge number of proposals submitted to IIS risks overwhelming program officers. We recognize, too, that recent changes in IIS programs have started to address this. We discussed the possibility of limiting number of proposals per institution to increase the percentage of proposals accepted and increase geographic and institutional diversity. However, we do not recommend this as a change; it could lead to more conservatism by university research offices that take responsibility for controlling submissions and work against young researchers in favor of established researchers. Perhaps balancing mechanisms to favor original or young researchers can be found, such as higher funding of CAREER grants and SGERs. We believe that the increase in submissions in recent years is a good sign rather than a bad one. It is a consequence of the rising importance of IT and IIS-related research, resulting in more researchers being drawn to the discipline and major growth in IIS-related faculty throughout the country, including EPSCOR states. While it creates process difficulties, it is a sign of the success and vibrancy of IIS's research areas.	

One topic of discussion was a comparison between NSF review processes and those employed by other agencies. Quick responses for inadequate proposals, multi-layered review processes and similar mechanisms might help address both dwell times and workloads on reviewers and on 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: Yes. Reviews certainly address both merit criteria. Individual reviews were structured so that both merit review criteria were considered by reviewers. In some cases, the two criteria are treated unevenly. It appears that some reviewers don't understand what the "broader impact" criterion designates. Again, exemplars might help to make the use of review criteria more even and consistent. Another area in which we noted variability was the degree to which reviewers, under the category of broader impacts, considered commercial interest in the research activities. Solicitations might provide further guidance.	Yes.
2. Have the panel summaries addressed both merit review criteria? Comments: The majority of summaries include evaluations with respect to both criteria. Again, however, variation was found. Our sample showed less attention to broader impacts than seemed to appear in the statistics. Our experience was	Yes.

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

that this might vary considerably with program officer.	
3. Have the *review analyses* (Form 7s) addressed both merit review criteria? Comments: Yes. Review analyses by program officers were often impressive, going beyond the summary provided by the panel scribe. However, the 100% statistical success rate in addressing broader impacts was at times achieved by cutting and pasting boilerplate — the phrase "taking into consideration both the intellectual merit and the potential broader impacts, I recommend that the proposal be funded" appeared in multiple review analyses in our sample as the only reference to broader impacts. We noted two areas in which review analyses could provide a more detailed audit trail. One area is the justification for continuing support of previously funded research projects. A second is the rationale for budget reductions, when they are imposed.	Yes.
4. Additional comments with respect to implementation of NSF's merit review criteria: The merit criteria structure the review process effectively. There are always, of course, variations in their application. Where the criterion of intellectual merit is ill used in reviews, it tends to be as a summary of the proposal activities rather than a critical evaluation of merits. Where the criterion of broader impacts is ill used – a more common occurrence both in proposals and reviews – it tends to assume, rather than articulate, a benefit for work in some broad area, often described in terms of "societal" benefits at a very high level. Investigators and reviewers should be encouraged to more clearly articulate how the broader impact criterion ties to the specific goals of the project and how they provide specific benefits to specific groups.	

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]**

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

1. Did the program make use of an adequate number of reviewers? Comments: Yes. We strongly commend IIS for increasing the numbers of reviewers in the face of an increase in proposal submissions.	Yes.
2. Did the program make use of reviewers having appropriate expertise and/or qualifications? Comments: Yes. Overall, this is adequate and appropriate. Panels clearly need to balance a range of areas of expertise and experience, so IIS should be commended for its efforts here. One consequence both of the increased competition for funds, and of the single deadline per year, is that it is increasingly difficult to put together panels of qualified reviewers. Examination of reviews certainly shows examples of reviews from reviewers lacking in domain expertise. IIS has increased the expertise of review panels by recruiting reviewers from industry and from abroad, both of which have helped considerably, but panel expertise is an ongoing concern. The quality of the review process is of the utmost importance not merely to ensure the appropriate use of NSF funds but also to ensure that young investigators receive adequate and helpful feedback on unsuccessful proposals. As IIS moves to cluster-based solicitations (perhaps increasing multidisciplinary proposals), assembling qualified panels can become more difficult unless care is taken. Ad hoc (mail) reviews may supplement panel reviews to add expertise in particular areas. Overall, IIS staff are aware of these issues; we recommend vigilance and close attention to the impact of these changes on the review process.	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: As far as we can tell, demographics seem to be ok. IIS seems to be short of data on this through no fault of their own. However they do take the issue of underrepresented groups seriously.	Yes.

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

4. Did the program recognize and resolve conflicts of interest when appropriate? Comments: The program procedures for identifying and managing conflicts appear exemplary.	Yes.
5. Additional comments on reviewer selection: We applaud the continued development of "recommender" technology to aid in project and reviewer classification and matching.	

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: A genuine effort seems to be made to support research that pushes the boundaries.	Appropriate
2. Are awards appropriate in size and duration for the scope of the projects? Comments: We are impressed that the IIS management is attentive to the considerations of size and duration for projects, and explicitly addressed this in their comments. Statistics suggest that the size and duration of projects depend overall on funds available. In good years, longer projects are funded, and more generously; in lean years, both size and duration are smaller. The real question here is what size cuts have been made to requests. Budget constraints may be placing an upper limit on the size of each grant and as a	Appropriate

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

consequence also on their scope. Given the trend towards increased integration of disciplines, the reduction in size evident in FY 2005 is worrying.	
3. Does the program portfolio have an appropriate balance of: • Innovative/high-risk projects?[6] Comments: IIS management are very focused on the degree of innovation reflected in the programs, and are responsive to concerns in this area. This question is difficult to evaluate since no information is provided that directly speaks to this. Nor, interestingly, is any such information requested, either of proposal authors or proposal reviewers. If this were an explicit criterion by which IIS would like to evaluate its proposals, it would seem appropriate to make this explicit throughout the process, and to gather data accordingly. The statistics provided to us measure innovative/high-risk projects through the indirect metric of SGER awards. While the last COV noted the relatively low numbers of SGER awards through IIS, we were pleased to see that these had been expanded. We were pleased, also, to see that several panels explicitly chose to recommend funding for proposals that were clearly exciting but clearly high-risk. It might be a good idea for solicitations to explicitly mention that both "transformative" (often high-risk, high-payoff) and more traditional research proposals are being solicited and to give some guidelines for what discussions of transformative research should include. It would be a good idea to ask IIS reviewers to designate specifically if they think a proposal is for truly transformative work, and if so, to comment on the degree of potential payoff and on what reviewers think the proposers might realistically be expected to achieve. Of course, low-risk high-payoff proposals are also important to fund, but we don't see these as having the same difficulty achieving "highly competitive" ratings through the panel process.	Appropriate
4. Does the program portfolio have an appropriate balance of: • Multidisciplinary projects? Comments: We applaud NSF's support for multidisciplinary work, and note that IIS is particularly strong in this regard. At the same time, we would advocate that CISE consider both how to better define and how to measure such support. Many research programs within IIS incorporate multidisciplinary approaches and expertise. Indeed, these approaches are a hallmark of IIS research, and we were impressed with the degree to which the division actively encourages	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/acpga/reports.jsp>.

multidisciplinary partnerships in research areas such as Digital Society and Technology, Digital Government, and others. However, NSF procedures do not allow for accurate statistical analysis in this area. In particular, we would note the distinction between projects that are co-funded by multiple programs, projects that include investigators with different disciplinary affiliations or backgrounds, and projects that blend disciplinary approaches in more tightly-integrated teams (or even in single investigator awards). One would expect that many proposals submitted to the newly defined areas such as robust intelligence will be multidisciplinary (e.g. combining CS and bio-sciences); the same goes for those in areas such as digital government (e.g. combining CS and social science, geo-science, etc.) Increasingly researchers are mastering multiple domains and are seeing themselves as multidisciplinary, and it will become increasingly important to ensure that students are educated in this way too (broader impact). The IGERT program has provided one such excellent opportunity for multidisciplinary training.	
5. Does the program portfolio have an appropriate balance of: • Funding for centers, groups and awards to individuals? Comments: With the end of ITR as a priority area, IIS funding for large groups has declined somewhat, in favor of small group or individual funding. As new priority areas grow, we would expect to see this balance change.	Appropriate
6. Does the program portfolio have an appropriate balance of: • Awards to new investigators? Comments: IIS has done an outstanding job of supporting new investigators through career grants and awards to first-time investigators. It is encouraging that despite the lower success rate, first-time award winners typically succeed after an average of 2.2 submissions. Continued vigilance is encouraged: The number of first-time submissions declined leading to the highest ratio in favor of prior PIs in 2005 (the first year that the new IIS rules restricting submissions would have had impact, and the year following record low rates of acceptance.). With overall success rates down and solicitations more spread out, there is a risk of discouraging promising new investigators.	Appropriate
7. Does the program portfolio have an appropriate balance of: • Geographical distribution of Principal Investigators? Comments: Statistics suggest a good distribution of investigators relative to centers of population and institutions of higher education.	Appropriate

8. Does the program portfolio have an appropriate balance of: • Institutional types? Comments: Diversity of institutional types has risen.	Appropriate
9. Does the program portfolio have an appropriate balance of: • Projects that integrate research and education? Comments: The variety of types of awards looks appropriate for this purpose; it is particularly appropriate that CAREER awards address this.	Appropriate
10. Does the program portfolio have an appropriate balance: • Across disciplines and subdisciplines of the activity and of emerging opportunities? Comments: IIS has undergone considerable reorganization over the last few years, most particularly with the emergence of a cluster arrangement of program areas. We are not yet able to assess the impact of this reorganization, since the project funding in response to the first "cluster-based" solicitations is outside of the review period. This reorganization has the potential to position IIS to be more responsive to emerging opportunities. At the same time, it also has the potential to obscure the balance of funding between disciplines and subdisciplines. It is important that data be gathered to allow this balance to be monitored. Further comments, with respect to particular areas, are made under C.1.	Appropriate
11. Does the program portfolio have appropriate participation of underrepresented groups? Comments: The participation of women is outstanding, with slightly better acceptance rates than men, which is encouraging for this group of underrepresented researchers in science and engineering. The committee notes, however, that the acceptance rate of proposals sent by other minorities is rather low, with smaller or at most equal acceptance rates as compared to non-minorities. This, on top of the already low rates of acceptance, can be discouraging for this group of underrepresented PIs, and can have negative influence on society in the long run, given the continuous increase in minority populations. We'd like to see some programming put in place that will help those who are at institutions where it is hard to get research mentoring have access to	Appropriate

mentors who can help them grow their research and proposal-writing skills.	
12. Is the program relevant to national priorities, agency mission, relevant fields and other customer needs? Include citations of relevant external reports. Comments: Yes, scientific research is increasingly relevant to solving engineering problems which themselves are characterized by burgeoning interdisciplinary demands. The priorities set by IIS appear to be addressing the right issues in an appropriate way (see solicitation 05-551).	Appropriate
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:

Program Officers clearly make extensive and effective use of the IT and statistical data support available to them to make appropriate decisions in the face of increasingly stretched budgets.

IIS has initiated considerable reorganization in order to better manage funds and respond to new directions. Program officers are proactive in routing proposals appropriately and seeking opportunities for co-funding when appropriate, in order to make the best use of funds available. The emergence of cluster-based solicitations is an organizational innovation in support of these needs. We are not yet able to assess the impact of this change although we are supportive of the attempt to respond flexibly and effectively to the broad needs of the research community.

We are particularly impressed with the degree to which IIS management have been responsive to the issues raised by the last COV, and the seriousness with which the report was taken.

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

Engagement between NSF and the broader research community is critically important to ensuring responsiveness to emerging trends. We note that Program Officers are actively engaged with the research community beyond the review and program management activity itself. Support for workshops and conference activities maintain a strong coupling between NSF and emerging areas for research and education. We particularly applaud IIS program officers attending academic conferences and meetings, participating on panels, etc.

There may be opportunities to expand NSF's presence and participation at the scientific meetings of contributing disciplines, in order to maintain a vibrant connection with the many rapidly growing important areas being addressed by IIS research.

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

The organizational structure of IIS reflects appropriate prioritization of areas of research need. For example, one place where the planning and prioritization process did guide the development is in what has happened in recent years with the Robotics and Computer Vision programs, and the separation of a single program into different areas with different program officers responsible. Another example is the Advanced Learning Technologies program; the focus on learning technologies that was previously part of ITR is now a focus in IIS. Overall, organizational changes in IIS suggest that the division is very attentive to steady development of the portfolio.

4. Additional comments on program management:

PART B. RESULTS OF NSF INVESTMENTS

NSF investments produce results that appear over time. The answers to the first three (People, Ideas and Tools) questions in this section are to be based on the COV's study of award results, which are direct and indirect accomplishments of projects supported by the program. These projects may be currently active or closed out during the previous three fiscal years. The COV review may also 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. Incremental progress made on results reported in prior fiscal years may also be considered.

The following questions are developed using the NSF outcome goals in the NSF Strategic Plan. The COV should look carefully at and comment on (1) noteworthy achievements of the year based on NSF awards; (2) the ways in which funded projects have collectively affected progress toward NSF's mission and strategic outcomes; and (3) expectations for future performance based on the current

set of awards. NSF asks the COV to provide comments on the degree to which past investments in research and education have contributed to NSF's progress towards its annual strategic outcome goals and to its mission:

- To promote the progress of science.
- To advance national health, prosperity, and welfare.
- To secure the national defense.
- And for other purposes.

Excellence in managing NSF underpins all of the agency's activities. For the response to the Outcome Goal for Organizational Excellence, the COV should comment, where appropriate, on NSF providing an agile, innovative organization. Critical indicators in this area include (1) operation of a credible, efficient merit review system; (2) utilizing and sustaining broad access to new and emerging technologies for business application; (3) developing a diverse, capable, motivated staff that operates with efficiency and integrity; and (4) developing and using performance assessment tools and measures to provide an environment of continuous improvement in NSF's intellectual investments as well as its management effectiveness.

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

B.1 <u>OUTCOME GOAL for PEOPLE</u>: Developing "a diverse, competitive and globally engaged workforce of scientists, engineers, technologists and well-prepared citizens."

Comments:

IIS programs are a critical source of support for developing human resources within the research community. Of particular note are CAREER grants intended to support young researchers, support for graduate and undergraduate student research, funding for workshops exploring innovative new ideas, support for doctoral consortia, and travel grants. IIS programs also contribute significantly to the development of ideas, infrastructure, and software that help produce a diverse, competitive and globally engaged workforce in the general population. In summary, IIS's programs have been extremely positive factors in the development of the workforce in the computer and information sciences.

CAREER grants continue to have a higher funding rate than other research grants. However, the last few years has seen an increase in the number of CAREER submissions (143, 188, 220 in each of 2003, 2004 and 2005) and a decrease in the funding rate (25%, 23%, 17%). The declining funding rate poses serious problems for junior faculty whose prospects for promotion and tenure depend on obtaining external support for their research. We have several anecdotal reports that because CAREER awards are becoming more difficult to obtain, some University departments discourage new faculty from submitting a proposal in their first or second year in order to maximize their chance of receiving an award prior to being reviewed for promotion and tenure. We recommend that NSF take a careful look at the impact of the funding squeeze on the development of new researchers in the sciences.

First-time PIs in general have been hit harder than prior PIs by the decreasing IIS funding rates. Between 2004 and 2005, the funding rate for prior PIs remained constant at 19% while that for new PIs decreased from 15% to 11%. This may be explained by the fact that while submissions from

PI's who had never received NSF funding remained at about the same level, submissions increased from PIs who had previously received some funding from NSF. [Note: we do not have separate funding rates for "research awards" vs. "non-research awards" in this particular category at this time, but recommend that such distinctions be carefully monitored. The rates here combine the categories.]

IIS projects are an important source of support for graduate and undergraduate students. The number of graduate students supported by IIS programs increased almost 60%, from 2002 to 2005 (from 948 to 1488). This is good news. However, the current trend is still down from a high of 1532 in 2004 to 1488 in 2005. The number of undergraduate students supported shows a similar trend. This may be due to the fact that some ITR projects, a large source of support for graduate students, are ending. If so, we expect the effect to continue over the next few years, causing a further decrease in the number of graduate and undergraduate students supported unless offset by an increase in funding of other IIS programs.

IIS continues to work toward increasing the number of researchers drawn from under-represented groups. While all groups are experiencing a decline in funding rates, overall the trends are very similar. The funding rate for minority PIs appears to have declined somewhat faster than that for non-minority PIs between 2004 and 2005. The COV notes that many PI's do not report their ethnicity, so there is additional unknown information hidden in the category of those who do not report this data.

IIS programs support increasing diversity in the research community through projects that support students drawn from under-represented groups. For example, the project "Computational Neurobiology Graduate Program" (#9987614, T. Sejnowski, UC San Diego) supports an IGERT graduate program that focuses on under-represented communities. Some IIS programs have technologies and systems that help people with disabilities engage more fully in society (e.g., #9910607, A. Sears, U. Maryland, Baltimore County).

Many of the IIS projects contribute ideas and tools that engage the broader public in using, studying or choosing a career in an IIS related area. Others produce results that directly support portions of the general public in using information technology. The digital libraries program has produced several large libraries that developed into publicly accessible educational resources. An award (#0205082, A. Druin, U. Maryland College Park) to the University of Maryland and the Internet Archive produced a library and easy interface technologies for children (ages 3-13) to access an international collection of digitized children's books (see http://www.icdlbooks.org). As another example, a team at Maryland and Michigan (#0219492, B. Bederson, U. Maryland College Park) produced an easy to use web-based tool for interacting with a zoological tree of over 200,000 animal names as well as pictures and recordings (see http://animaldiversity.org/).

Robotics technology funded by IIS has an enormous public appeal, and can attract young students into careers in science and engineering, as witnessed by the growth in competitions such as FIRST and ROBOCUP. Researchers at Dartmouth (#9912193, D. Rus, Dartmouth) pioneered the first reconfigurable robot made of identical modules. Dr. Rus went on to win a McArthur Foundation award. Grant #9900322 (M. Mason, CMU) resulted in an undergraduate student being able to design a robot using the generally available Palm Pilot as the control computer, becoming a valuable teaching tool.

B.2 OUTCOME GOAL for IDEAS: Enabling "discovery across the frontier of science and engineering, connected to learning, innovation, and service to society."

Comments:

During the past three years, the IIS program has funded a number of projects implementing innovative research ideas, which resulted in significant advances in science and engineering, as well as connections with other fields of study, education, and society. The committee highlighted what was believed to be some of the most noteworthy achievements in terms of research accomplishments and impact on the strategic goals of NSF:

1. Innovative applications of machine learning in IIS areas, including applications for improving the behavior of robots (#0413335, R. Rao, U. Washington), or for taking steps toward "how the mind works" through a better understanding of brain activities during cognitive tasks (#0423070, T. Mitchell, CMU)

2. Cross-disciplinary projects, including projects targeting the education of students for cross-disciplinary environments (#9987614, T. Sejnowski, UC San Diego) (#9787588, D. Touretzky, CMU). Examples of projects under this area include biologically-inspired technologies to improve robotics applications (#9984954 C. Liu, U Illinois Urbana-Champaign), or natural language processing methods to model biological sequences (#0205456, A. Joshi, U. Pennsylvania)

3. Human computer interaction for direct brain-computer interfaces (#0118917, M. Moore, GSU), functional near infrared imaging for brain-computer interfaces (#0512003, D. Proffitt, U Virginia); IIS also supported student participation in the international brain-computer interface conference (#0534128, M. Moore, Georgia State U).

4. Trust, reputation, and social computing, which are increasingly important given the growing integration of technology in everyday life. An example is the project on the evaluation of trust among users of e-commerce systems (#9977999, P. Resnick, U. Michigan).

5. Context-aware systems, including work on making computers aware of human-centered ways of describing locations (#0308018, Jones, NJIT and #0307459, L. Terveen, U. Minnesota), and on integrating information displays into the everyday environment through personalized art (#0118685, Stasko, Georgia Tech).

6. Multilingual processing, with the goal of increasing the communication across language barriers, which can have an impact on national security, as well as enable the current trends toward globalization. Example projects include the work on building tools for Arabic dialect modeling (#0329163, O. Rambow, Columbia U.), or the information sharing project on transnational digital government, targeting the integration of information technologies across different countries (#0131886, J. Fortes, U. Florida)

7. Statistical models and Bayesian analysis of patterns and processes that are widely used in several areas of research, including computer vision, data mining, speech and language processing, robotics, and neuroscience. Example projects include statistical models of the primate neocortex (#0534858, T. Dean, Brown U.), improved speech interfaces for the general public (#0208835, M. Eskanazi, CMU), learning rich statistical models of the visual world for robust perception (#0535075, M. Black, Brown U.), and stochastic modeling and computing of visual patterns (#0244763, S. Zhu, UCLA).

8. Multimodal systems, integrating novel and multiple modalities in human-centered systems. Example projects include multimodal learning for assistive aids (#0083032, D. Roy, MIT), haptic texture perception and rendering (#0087443, H. Tan, Purdue), and using eye gaze to model salience for spoken language understanding (#0535112, J. Chai, Michigan State U).

B.3 <u>OUTCOME GOAL for TOOLS:</u> Providing "broadly accessible, state-of-the-art S&E facilities, tools and other infrastructure that enable discovery, learning and innovation."

Comments:

Considering the open accessibility of the web and other open-source dissemination approaches, it is much easier to make software tools, modules and data available to the wider research community. The NSF-funded projects have both nurtured the development of these approaches and have enabled sponsored projects to use such sharing paradigms. Within the period of this COV, several projects have supported this area of sharing information management tools and data.

This idea of sharing tools and modules has done a great deal for the idea of technology transfer of research applications. Collaboration has created a synergistic effect where researchers that share their tools via the web and open-source approaches tend to spark the interest of related researchers. As a result, more general-purpose tools are being created that apply across multiple domains. Of particular note, the Protégé ontology management tool (a NSF-funded development effort) has been widely used in the COV period in multiple domains (e.g. bioinformatics, neuroscience, logistics, e-commerce)

There were several tool outcomes that the committee thought were particularly notable and useful.

1. The COV was encouraged by the significant number of tools that promote learning in target communities, such as under-represented researchers, K-12, and broader communities). For example, "Meaningful Feedback for Student Writers" is an Natural Language Processing tool (using LSA) that gives feedback to student writers from grades 6 to 12, helps them with reading comprehension while providing content feedback on written summaries.

2. Information management tools supported by the NSF have greatly enhanced the ability for searching large information sources including but not limited to the web. In the past, funding has led to popular web searching tools (i.e., Google), however new approaches help users personalize their searches in addition to linguistic and semantic tools to facilitate representation of text and information (i.e., "A Linguist's Search Engine" (#0113641, P. Resnik, U. Maryland) and "Semantic Web Workshop " (#0211606, A. Sheth, Georgia Research Foundation, and later 2004 ITR Funding "Profile-Aware Web: Rules, Proofs, and Trust on the Semantic Web").

3. Other tools arose from projects that assembled and shared data collections or provided services to generate data. Datasets on social networks, biological food webs and Semantic Web documents are published by the SPIRE project (#9912193, T. Finin, U. Maryland, Baltimore County). The Animal Diversity project (#0219492, B. Bederson, U. Maryland, College Park) has made its underlying data available to other researchers in several forms. Many of the other projects described above have also produced useful tools as byproducts.

B.4 OUTCOME GOAL for ORGANIZATIONAL EXCELLENCE: Providing "an agile, innovative organization that fulfills its mission through leadership in state-of-the-art business practices."[7]

Comments:

Because of the focus of IIS on providing enabling algorithms and software for developing intelligent systems, many of its projects contribute to organizational efficiency. The development of Web-based tools for finding information efficiently, sharing information with minimal overhead, and answering unstructured questions will impact many processes in organizations, and NSF has provided more funding for this than any other U.S. funding agency. Examples projects are the Wisconsin land information system (#0091489, I. Cruz, U. of Illinois at Chicago, N. Wiegand, U. Wisconsin) that pulls together a wide range of information to provide a useful government system for many purposes, and the project developing transnational digital government for the Organization of American States (#0131886, J. Florez, U.Florida).

PART C. OTHER TOPICS

CISE would also like your advice about the promise and potential of various areas of research and education in IIS. Please comment on the following division-specific questions:

1. What are the most exciting research outcomes that are a direct result of IIS funding?

The most exciting research outcomes resulting from IIS funding can be stratified in four extremely important areas. These areas are information technologies that support (1) ***collaboration***, (2) ***recruitment and learning of future scientists***, (3) ***projects of important national interest***, and (4) ***cross-disciplinary projects that integrate many scientific domains***.

a. **Collaboration techniques and tools-** Of emerging importance are tools and techniques that enable distributed sets of organizations and individuals to improve the way that they work collaboratively on common problems. Such collaboration environments require tools to help entities locate and share data efficiently and effectively. IIS has supported leading efforts in development of tools that categorize entities (names of people, locations, organizations) while recognizing relations between them (Brown, Columbia, Illinois, MIT and Oregon (0085836)). These tools are revolutionizing the way that information is organized and managed in a sharing context. In addition, recommender systems are used to suggest highly relevant information to specific users. One project (9978717, Univ. of Minnesota Twin-Cities) provides effective interfaces

[7] For examples and further detail on the Organizational Excellence Goal, please refer to pp. 19-21 of NSF's Strategic Plan, FY 2003-2008, at <http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf04201>.

for users to provide ratings (more than just “thumbs up” or “thumbs down”) for shared information. New peer-to-peer technologies (0205635, A. Halevy, University of Washington) supported by IIS enable full communities to collaborate and effectively share data. Innovations in this area will have far-reaching impact in government, education, business, and in a diverse variety of community groups.

b. **Recruitment and training approaches-** Several projects and tools serve to attract a future workforce of engineers and to make learning more accessible and more effective. Research integrating technology and pedagogy at Florida State (0218692) has shown that the design of pedagogical agent images (making them more realistic or making them represent non-traditional roles) is important in facilitating learning and motivation. Pioneering research on robotics, such as the tiny reconfigurable robots developed at Dartmouth (9912193), the Palm Pilot Robot Kit (9900332, CMU), and investigations on how we interact with robot pets (0102558 University of Washington,) can attract young students into the engineering disciplines. Research in the area of digital libraries has brought educational material online for citizens of all walks of live. The International Children's Digital Library for example has significantly advanced interfaces available for children to access digital materials online and made available a collection of 10,000 digital children's books (see http://www.icdlbooks.org).

c. Technologies supporting public interest topics- Several exciting projects have investigated approaches that support current needs within national interest. In particular, the work in support of tools for Arabic dialect modeling (0329163, O. Rambow, Columbia) will help professionals supporting efforts in the Middle East. This is particularly important considering a limited workforce of native speakers and current restoration efforts in Iraq. The transnational digital government work (0131886, J. Fortes, University of Florida) will facilitate the ability for information technologies to be integrated across different countries considering political and cultural differences. Another important project (9800696, H. Chen, University of Arizona) supports crime analyst and detectives in sharing enforcement data with their new tool called COPLINK. This is important to mitigating the threat of terrorism. A more recent, multi-university project investigates search and rescue techniques in response to natural disasters (0331707, S. Mehrotra, UC Irvine) such as tornados, hurricanes, and floods.

d. Integrating sciences via cross-disciplinary projects- Cross-disciplinary projects are particularly exciting because IIS-based research can have broad impact across the sciences as a whole. A number of advances in biological approaches and medical interventions rely on advances in intelligent information systems as proposed and performed within the IIS directorate. One project (0205456, A. Joshi, University of Pennsylvania) uses natural language processing methods to model biological sequences generally supporting the identification of medical problems. A project directed toward cardiovascular informatics (0335578, I. Kakadiaris, Univ. of Houston)

combines the areas of computer vision, data mining, medical and surgical domains. This is an extremely important area to impact considering that heart disease kills more than three times all cancers combined. Another project, 9984954, L. Chang, from University of Illinois at Urbana-Champaign impacts the areas of biology, robotics, and networks in the investigation of biologically inspired-sensors for robotic applications. Human characteristics can be broadly used to create intelligent machines that adapt to their environment, and IIS has been a leader in funding research that integrates understanding of humans with future development of information and intelligent systems.

2. Which areas of research seem to have the most potential in terms of growth and/or promising new results?

Contemporary technical developments hold both risks and challenges, making IIS research ever more relevant in key areas. There are many large societal issues that benefit from research in information technology, but we have identified four to frame the use-driven nature of fundamental IIS research. Industry is not expected to address these issues before return on investment can be guaranteed.

1. **Technology-enhanced quality of life**: As our society ages, fewer young people will be able to physically and financially support their elders. Intelligent information systems are central to modern medical technology, and important emerging opportunities for the graying society focus on how to maintain quality of life, social relationships and autonomy through the use of robots and intelligent agents as companions, minders, and cognitive prostheses.

2. **Education and lifelong learning**: The public education system is critical to developing our next generation of citizens, and it is under constant pressure. But learning does not stop upon graduation, as people constantly need to expand their knowledge and training in a fast-moving world economy. IIS technology supports the development of new kinds of pedagogical systems to meet these needs, including software for aiding personal learning, and the development of new kinds of learning communities that can enhance lifelong education and training for all citizens.

3. **Advancing new kinds of scientific research**: Science has become more and more engaged with computers and software for modeling and analysis. As scientific projects gain the ability and infrastructure to acquire and share huge amounts of digital information, more intelligent tools for analysis -- such as pattern recognition and data mining -- become critical. Intelligent Informatics, as sponsored by IIS, is not only useful for biological and geographical work, but is the foundation for future advances across all scientific fields, from astrophysics through zoology.

4. **Advancement of human culture**: The Internet has emerged not only as an efficient communication mechanism, but also as an archive and expanding experiment in making all human knowledge and culture available. However, there is a large frontier in making the knowledge usable by and accessible to all people, regardless of age, location, background, or infirmity.

Cutting across all of these areas are a number of **integrative challenges**, issues that need to be addressed to seamlessly integrate technological advances into human-centric socio-technical systems. **IIS is uniquely positioned to broaden the focus of research beyond computing techniques to tightly-coupled systems of people, technology, and the physical, social, and cultural environment**.

1. **Balancing privacy and information sharing**

   As advanced technologies for information processing, data mining, and statistical learning are increasingly deployed and applied across a wide number of domains, questions of information privacy will continue to grow and should become a major focus of IIS research. One major question is the relationship between privacy and sharing, which must be addressed from a multi-disciplinary approach, embracing technological concerns, social considerations, and policy issues. For example, data mining over large medical data sets must preserve privacy in support of data sharing and integration; indeed, greater data sharing (and therefore more effective medical research) is enabled by adequate privacy provisions. IIS has a crucial role to play in a holistic approach to privacy research and education, for example helping to educate the public in recognizing privacy threats such as "spyware" software which tracks internet activities. While privacy research is currently distributed across a range of programs in CISE, we recognize the existence of much strength within IIS to lead in its advancement.

2. **Improved governance and shared security**

   Information technologies can bring enormous new efficiencies to management and government. The revolution in digital government has only begun. Yet the usability and security of systems that touch a broad segment of the public, from automobile license renewal, to voting, to response in disaster situations, require a sensitivity, openness, and auditability that is often at odds with private enterprises, which are focused on their own intellectual property concerns. We recommend that IIS provide leadership in investigating how technology can lead to a safer and more secure nation while preserving freedom and accountability.

3. **Usability and Accessibility**

   The high-speed multi-media broadband-connected "desktop" workstation is only one modality for the use of intelligent systems. Mobile devices pose different interface constraints, and attempts to bridge the gap between desktop and mobile have had mixed success. People with constraints in vision, hearing, or movement, or who have limited access to resources (e.g., in developing regions and disaster areas) require better methods of accessing communications than the current defaults. We recommend that IIS continue and expand its research in universal access, IT under limited resources, and ecologically-aware computing.

Technological directions

Fundamental science directed to meet social goals runs the risk of watering down the fundamental science. However, because basic research in computing synthesizes new mechanisms and exploits opportunities afforded by Moore's law, it can be supportive of

broad societal needs such as those above. In this spirit, after studying the IIS grants portfolio from 2003-2005, we have identified a range of activities in IIS that we believe will have the most impact on those integrative challenges.

Data/Information processing and management

As the web expands and penetrates more activities of our lives, we will increasingly need to access information sources that are widely distributed and widely diverse in format. Novel integration and fusion techniques will be important in the sharing of information across governmental agencies. Furthermore interactions between individual users, their environments, and their social situations affect the dynamics of large-scale system behavior, while different agency's demands lead to conflicts over privacy concerns and interoperability. Several classical information-processing problems need to be investigated in the context of new systems and applications to new domains of human endeavor, leading to challenges in traditional IIS areas such as search and retrieval, optimized processing, adaptibility, and dealing with uncertainty. We recommend that IIS prepare to recognize and exploit these challenges and opportunities to traditional research areas as they arise.

Knowledge systems

New advances are required to bring human-machine interaction closer to human-to-human practice. In that direction, novel common sense reasoning methods are required, as well as combinations of approaches into multi-modal inference systems. Advances in knowledge extraction and summarization will create new "knowledge commons" that will address a variety of societal needs, from cultural heritage preservation to electronic health.

Intelligent technologies

Intelligent technologies, such as robots and software systems that learn, collaborate with humans, and interact more naturally (e.g., using language and gesture, as well as taking into account both cognitive and affective models of the people with whom they interact), are areas of historic progress and tremendous future growth, especially in future elder care, through the use of automated companions and intelligent prostheses. New meta-learning structures, like boosting, co-evolution, and swarm optimization, which can apply to many basic algorithms from statistical, inductive, neural, and evolutionary learning, promise breakthroughs while adding intelligence to distributed, collaborative and multilingual communities. Growth areas also include the issues of hybrid (human/machine) control over many machines. IIS's traditional strengths in machine learning can be most useful here; coupled with development of more sophisticated visualization techniques, they will be critical to building flexible, adaptive robust systems in support of digital government, health, and scientific discovery.

Interactive Systems

As computation and computers become interactive partners rather than simply tools, interaction styles and personalization need to become richer. Intelligent and interactive technologies hold promise for development of cognitive, social and

emotional prostheses. An emotional prosthesis could help someone with Aspberger's syndrome read body language and facial expressions using a wearable computer vision system. A cognitive prosthesis could aid someone suffering from memory loss or impaired vision. In turn, richer intelligence and interaction styles provide increased opportunities for computational support for a variety of needs.

Educational Systems

IIS technologies have much to offer education and life-long learning, in the classroom and beyond. IIS research can lead to enhancements in peer-to-peer and teacher-to-student collaboration approaches that promote learning, to simulation, modeling, and visualization systems that help learners understand and use abstract science concepts, and to systems that aid young learners as they engage in, for example, attempting to reason scientifically and learning to learn. New social technologies, such as blogs, wikis, massively multi-player on-line games, and social network systems show the promise of technology for promoting learning and engagement. We recommend that IIS should promote research in using such new media forms for educational purposes, as educational purposes are not as profitable for industry as are purely entertainment purposes.

3. What are the fields (or subfields) in IIS that might profit from increased integration within IIS, across CISE and the entire NSF?

Artificial intelligence and cognitive science, collaborative systems, HCI, and other IIC fields are now connected to Education and Human Services (EHR) through the new Advanced Learning Technologies (ALT) program. We applaud this endeavor and believe that this will become an even more important connection in the future as technologies grow in their affordances for promoting learning, as we learn more about social and cultural influences on learning, and as we learn more about pedagogical methods that promote learning. It is important as this endeavor proceeds, to make sure that these projects have both the needed technology and learning expertise and that the program address not only issues in promoting learning in school but also informal education and education and training through life. It is possible that researchers from the social sciences should also contribute to this endeavor with contributions from the social sciences directorate.

Research in ubiquitous technology is currently scattered across CISE. Within IIS, it's funded under HCI, agents, and database areas; within the rest of CISE, it is funded under networking. We believe this area would benefit from both a cross-CISE thrust and a joint endeavor with Engineering, where researchers are working on sensor networks.

A similar endeavor, we think, would promote multi-disciplinary research aimed at enhancing quality of life and health as our population ages. Researchers across robotics, agents, universal access, HCI, and perhaps other areas are already working individually on issues in this area. NIH does not currently support the technical innovations needed to make great strides in this area. The time is right for promoting a more systematic multi-disciplinary approach – within IIS, within CISE (bringing networking and other computing technologies

into the endeavor), and across NSF (bringing mechanical engineering, for example, into the mix). This is an area that has critical time importance, as the population boom is aging fast. This growth area is also one that is well poised to attract many new scientists and engineers who are women and underrepresented minorities.

Overall, we'd like to see robotics and artificial intelligence better connected to each other, and we applaud the IIS program officers who have clustered them in the new Robust Intelligence category of the FY-05 IIS solicitation so as to encourage those connections.

It is confusing for some researchers that human-computer interaction areas of research are funded across several different programs –HCI, human language and communication, universal access, and so on. We applaud the IIS program officers for supporting and encouraging more connections across these areas in the new Collaborative Systems category of the FY-05 IIS solicitation.

Cognitive science, psychology, and cognitive neuroscience should be integrated with artificial intelligence and agents, and this is already encouraged in the Robust Intelligence part of the new IIS solicitation.

Biomedical informatics would benefit from collaboration with NIH. NLM funds medical informatics at NIH, but it is difficult for the stars of information systems that get their funding from NSF to contribute and share their findings in the most productive ways. Nor do those working in information systems get to easily identify the nitty-gritty issues in real-world information management. Important here is that NIH should contribute funds to the effort along with NSF.

It should be easy for robotics researchers in IIS and those in Engineering to get funding together.

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

We applaud the aspect of the IIS mission to "Develop new knowledge about human-system interaction and co-evolution; understand design, use, implications, and feedback into next design." This is largely resonant with the HCI focus, and we hope to see growth in this increasingly important area. We reexamined the HCI example from the 2003 COV, where there was a question about alignment between the NSF HCI funding and the current HCI research community. The HCI program during the past three years still largely missed the computer science HCI focus as developed by ACM. Of 12 proposals in our sample, 3 were submitted by researchers among the 750+ with 10+ papers in the HCI Bibliography of 30,000+ titles and the only one awarded was a conference doctoral workshop. 30% of HCI awards went to human language. (Human language is also funded under Universal Access, IKM, AI, and other programs; with HCI and Human Language in different clusters, overlap seems likely to persist.) Some funding decisions in our sample did not seem well matched to the program at hand. Some awards in broad programs seemed outside even the broad scope. Vibrotactile feedback in rescue robots was funded in Universal Access despite at best secondary relevance. Terrain sensors for wheelchair access, though it seemed an

excellent proposal, was mostly funded in the HCI program. Many HCI awards seemed more relevant to AI. HCI is a dynamic area with an unusually diverse representation of researchers (especially women) and with the greatest opportunity of all the IIS areas for impacting the everyday experience of people. We encourage NSF to continue to find ways to grow and support this vital influential area.

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.

[No additional comments.]

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

The following points should be considered for NSF-wide improvements. No priority is implied by the order of the paragraphs.

The electronic jackets seemed to work well. We do not recommend any major changes to the system. A minor change that would be nice would be for COV participants to have a way to mark which ones different members of the team are looking at.

A justification should be written to support every funding decision. The COV did not receive one for all workshop and travel-money grants, so we don't know if justifications are always available or not. In a time of decreasing or flat budgets, fairness requires better care in documenting grant decisions.

The wording of the "broader impacts" criteria was confusing to a number of panels, so wording improvement on the NSF Web site is recommended. The criteria should make it clear that a panel should consider whether industry will do the work anyway using the same approach regardless of NSF funding, thus significantly affecting the broader research impact of the proposed NSF project. The criteria also need to clarify more how a proposal could represent more of a contribution to education and personal development than another proposal.

The proposer's track record was considered inconsistently by panels, and it would be helpful if the instructions could clarify this (though we're not sure whether even attempting to provide guidelines conflicts with NSF policy or not). At one extreme were panels that seemed to give awards based on the researcher's reputation, and at the other extreme were panels that did not even have access to data on the number of proposals submitted previously by the PI. This COV is in favor of NSF providing more data on PI track record to panels.

Could reviews be made accessible in Fastlane before the panels meet? Such a change would emphasize the importance of writing reviews earlier than the last minute before the

meeting, as well as give panelists time to consider issues before the meeting, perhaps allowing them to structure discussion and time better once they are all co-located. The goals of such a change could also be targeted at ensuring that good feedback to the proposer is provided on all proposals).

Big proposals (over $500K) should have more reviewers than small ones. Proposals for $1M or more should have something like six reviewers.

Fastlane should be developed to calculate the average rating of proposals by reviewer over all time, since this is not hard to do and is an issue that comes up in panel assessments. Some reviewers give chronically high or low scores, and it would be helpful to know this. It is particularly helpful with solicited outside reviews where the reviewer "toughness" cannot now be compared.

Final reports of NSF projects should be available on NSF's Web site. Nuggets help publicize work but details of research should be made available too once the work is done. Public display will provide an incentive to write better reports. Reporting of negative results should not be discouraged in these reports since this can be an important contribution to science and engineering too.

Some mechanism is needed for Program Directors to post on the NSF Web site things like announcements of NSF-sponsored workshops, additional background related to solicitations, and other minimal-graphics documents. Program Directors complained to us about the difficulty of doing this due to issues like providing captions on images and other Federal standards for Web pages.

A mechanism needs to be created to link NSF Web pages to papers written by sponsored researchers. This issue was raised in the last COV but nothing has been done.

More could be done to get Web search engines like Google to index NSF Web pages (particularly if some of the above ideas are implemented that will put more content in the NSF Web site). Increased Web visibility has many potential benefits to NSF. Could NSF take active steps to encourage indexing of its sites by contacting Google or other search engines (Yahoo used to actively encourage indexing recommendations)? Could NSF IT send Google its meta-data to enable better indexing? Google's "Scholar" subindex would seem particularly important to target since it covers academic pages.

There are a number of character errors on the NSF Web site in displaying documents (e.g. double quotation marks are displayed as squares). NSF should fix this because it looks unprofessional.

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

The 2003 COV encouraged the reporting of negative results. The collective benefit to the field could be immense if subsequent researchers can learn from such experiences and avoid repeating unproductive experiments. Across science and industry, reporting of

negative outcomes is seen as desirable in theory but is difficult to organize in practice. The Director's response to the 2003 COV emphasized this recommendation and suggested that NSF could take measures to encourage this, requiring annual reports to include such coverage, and brainstorming some way to make these (or parts of these) accessible to the public. We would like to see serious consideration given to making NSF reports public. We expect that IP issues may occasionally require special attention, but the majority of the information would be of great public benefit if made available online.

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

Collaborative editing of the COV report could be facilitated by investing in some collaboration software that would enable all committee members to simultaneously edit documents. This would have helped us do more in the crunched time we had.

A COV should have for every grant a description of why it was awarded. For competitive awards, this can be the Panel Summary, but for workshops and travel money this was sometimes lacking. A COV cannot decide if money is being spent properly without information on each grant from the program officer.

The 2.5 days did not seem adequate for the COV meeting under the new constraint that a report be finished on the last day. Most members of the COV invested from a half of a day to a full day of personal time before the meeting began in reading advance materials, and many more materials were added to the COV IIS web site when the meeting began. In addition to the 150 jackets to review, there were dozens of relevant workshop reports and other documents on the COV web site and more that were requested for examination by the committee in addressing the area reports on future directions. Another half day of reading and becoming acquainted with the enormous amount of information that we did not have access to, or time to access, before the meeting would have been very useful. While discussing findings and writing the report, we realized that we were lacking important details of much of the data we were given, especially where incommensurate numbers were reported because of differing standards (e.g., reporting number of proposal "actions" vs. number of proposal "submissions," and in some cases using different ways of separating out research awards from travel, workshops, supplements, REU, etc.) We advise that NSF track the statistics we gathered for this report, especially with respect to how programmatic changes impact research participation by new PI's, minorities, and women. Systematic tracking of this information will speed up the efforts of future COV's to assess progress in these areas. Additionally, it would have been nice to have time for the whole group to come together after the report was drafted, to read it and discuss it, and to address one more round of changes before the meeting ended. (Most of the writing took place in subgroups, so that the full talent of the group's insights was not brought to bear on the final form of the report.) While we joked under the strong winds, sub-freezing temperatures, and intensely packed work sessions that a COV should be organized as a weeklong retreat on a Carribean island, the reality is that it was great to have all the NSF staff and their resources at hand to answer detailed questions. However, we do recommend that the length of the process be adjusted to include more time for fact-finding and for editing the report, especially when the COV is asked to address more than the standard form items.

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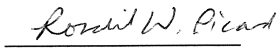

For the Information and Intelligent Systems Committee of Visitors
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Chair

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TO: Deborah Crawford
Acting AD/CISE

FROM: Haym Hirsh
Division Director, Information and Intelligent Systems Division

DATE: March 20, 2007

SUBJECT: Report on Diversity, Independence, Balance, and Resolution of Conflicts for the IIS Committee of Visitors

This is my report to you on the diversity, independence, balance, and resolution of conflicts of the Committee of Visitors (COV) for the Division of Information and Intelligent Systems (IIS) held from December 12 to December 14, 2005.

The COV, which was assembled to review the IIS Division, and whose report was presented to the CISE Advisory Committee on April 24, 2006, consisted of fifteen (15) members, of whom nine (9) are male and six (6) are female. One of the members of the committee is African American, and one member is mobility impaired.

Twelve (12) of the COV members are from academia, one (1) is from industry, one (1) is from a federal agency, and one (1) is from the European Commission. The members' expertise reflects the research areas of IIS's thematic areas, i.e., Collaborative Systems and Universal Access, Robust Intelligence, Science and Engineering Information Integration and Informatics, Digital Government, and Digital Libraries and Archives. All invited COV members attended the meeting.

The Chair of the COV, Rosalind Picard, is the Director of Affective Computing Research at the Massachusetts Institute of Technology Media Laboratory. Ten (10) of the committee members from academia are full or associate professors, and two (2) are assistant professors. One (1) member is a Unit Head, one (1) is a Director, one (1) is an Associate Director, one (1) is a Regent's Professor, one (1) is a Graduate Program Chair, and one (1) is a Department Chair. The industry member's title is: Senior Researcher.

Four (4) of the COV members are individuals who at the time of the meeting had not been applicants to CISE in the past five years and did not at the time of the meeting serve on any NSF Advisory Committee. Most COV members are familiar with IIS from having served on the CISE Advisory Committee or review panels, or are former or

current grantees. None had proposals pending with IIS during the COV meeting. A conflict of interest briefing was held on the first day of the COV meeting. All COV members were required to complete the NSF Conflict of Interest form.

All academic members of the COV were barred from seeing proposals from their home institutions, and all noted conflicts were resolved by barring members from seeing specific proposals with which they had conflicts. No real or apparent conflicts arose during the course of the meeting.