REPORT TO THE NATIONAL SCIENCE FOUNDATION

COMMITTEE OF VISITORS
FOR THE
DIVISION OF DESIGN AND MANUFACTURING INNOVATION
ACADEMIC PROGRAMS
FOR FY 2003, 2004, AND 2005

Submitted to

Dr. Gary May
Chair
Directorate for Engineering Advisory Committee
National Science Foundation

March 21, 2006

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

The table below should be completed by program staff.

Date of COV: March 7-9, 2006
Program/Cluster/Section: All DMI Programs
Division: Design and Manufacturing Innovation (DMI)
Directorate: Engineering (ENG)
Number of actions reviewed: Awards: 80 Declinations: 238 Other: none
Total number of actions within Program/Cluster/Division during period under review: Awards: 596 Declinations: 2589 Other: none
Manner in which reviewed actions were selected: Prior to the COV meeting, information on all DMI actions for the period from FY03 through FY05 was collected and separated into two categories: awards and declinations. From the 3185 listings, every 11th jacket was made available for the COV to review, resulting in 47 awards and 216 declinations. An additional 55 jackets (33 awards, 22 declinations) were provided to the COV by the DMI staff.

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) The National Science Foundation is highly recognized as having a peer review process that is perhaps the most highly developed, peer-oriented, and inherently fair of any federal agency that supports engineering research. There was strong evidence that this was indeed the case for DMI during 2003-2005.	Yes
2. Is the review process efficient and effective? The review process was efficient and effective. DMI Program Directors (PDs) solicited panelists, convened panels, processed recommendations on proposals, documented actions and informed PIs in an efficient and effective manner.	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? Overall individual reviews appear to provide sufficient information to principal investigators. Nevertheless, there were several instances where detailed reviewer comments were lacking, even in the case of apparent experienced reviewers.	Yes

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

Recommendation: • The COV encourages PDs to assure that the individual reviewers provide quality comments and sufficient information to PIs as feedback. This is particularly important to those whose proposals have been rated "good" so that they can understand what changes are needed to achieve a higher level of competitiveness with their proposal.	
4. Do the panel summaries provide sufficient information for the principal investigator(s) to understand the basis for the panel recommendation? Overall the panel summaries provide sufficient information to principal investigators, particularly on proposals at either extreme of the spectrum – excellent/very good or fair/poor. The COV feels that the feedback for PIs with proposals ranked in the middle of the range could be improved. Recommendation: • The COV encourages PDs to assure that panel summaries provide sufficient quality and quantity of information to PIs, especially to PIs whose proposals are ranked as "good".	Yes
5. Is the documentation for recommendations complete, and does the program officer provide sufficient information and justification for her/his recommendation? The Program Directors, in general, did a very good job of providing sufficient information and justifications. In examining jackets, the COV paid particular attention to evaluating the documentation of the proposals which were exceptionally high-ranking proposals that were declined or inordinately low-ranking proposals that were awarded. The COV found a few cases of DNC proposals which were funded which lacked documentation explaining the action and a few cases where highly ranked proposals were not funded and documentation was not as detailed as the COV would have liked. Recommendation: • Program Directors should pay particular attention to documenting proposals where the recommendation for funding does not match the panel recommendation. Also, the Division Director should pay particular attention to check for careful documentation of these decisions when she/he signs off on the action.	Yes
6. Is the time to decision appropriate? Since 2000, DMI has increased the percentage of proposals processed in six months. The time to decision on declined proposals was reduced significantly during this time period. In 2005, DMI processed 80% of declined proposals within six months, where in 2000, only 55% were processed within six months. The process time for awards showed more variability, with improvements from 2000 to 2002, reaching 80%, and then declines from 2002 to 2005. In 2005 only 60% of the awarded proposals were processed within the six month time period. The COV found significant differences in process time between programs. During the period of 2003-05 DMI received and reviewed between 860 and 940 proposals per year. In one program there was a decrease of 35% in proposals submitted, yet the percentage of proposals processed within six months also decreased from 85% to 53%. In contrast, in another program, there was a decrease in proposals of almost 20% accompanied by an increase of proposals processed within six months, from 38% to 89%. Two other programs show a decrease in the percentage of proposals processed within six months (from 82% to 32% and from 65% to 25%). Both programs saw an increase in proposal submission of 68% and 20%. The data did not support a consistent correlation between increased dwell time caused by increased submissions. In general, the dwell time that proposals remained in DMI was adequate, but there is room for improvement. The COV felt that a dwell time of more than 6 months for proposals that	Yes

are clearly not fundable is unacceptable. It appears that the increases in dwell time coincide with various factors such as: reduction of staff support, transition to electronic jacket processing and overall program management. It is unclear which causes are most influential. Recommendations: • DMI is encouraged to carefully examine the proposal evaluation process to determine where bottlenecks occur and take necessary steps to eliminate them to be able to systematically reduce the dwell time. • A more active approach to bringing awareness to the need to reduce dwell time could involve using color-coded files (by month instead of year) to bring attention to long dwell time jackets.	
7. Additional comments on the quality and effectiveness of the program's use of merit review procedures:	

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? The Panel members' comments pertaining to the merit criteria of intellectual merit were situational. The comments appeared to be driven by the topical areas and the composition of the associated panel members. The comments ranged from detailed (quantitative) comments to (broad) general comments. The narrowly defined modeling based proposals defined intellectual merit as an extension to the problem area On the other hand; the more general proposals and interactive simulation based proposals described intellectual merit as affecting students or society. Examples from the proposal jackets are given below: **Intellectual Merit (narrowly defined)** 1. Development of a multi period hierarchical decision model for multi-model logistics system that can be scaled down to solve part routing problems in a discrete manufacturing facility. 2. The study will lead to better decision making for complex systems. 3. The optimal location of facilities 4. The study will lead to a complex algorithm to in an environment with multiple risk factors. **Intellectual Merit (broadly defined)** 1. The study will lead to improved service through improved logistics. 2. The results of this study will lead to higher immunization policies and requirements for health care decision makers. 3. The results will lead to an innovative way to teach OR courses. 4. The results will leads to more opportunities for undergraduate students.	Yes

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

Broader Impacts The broader impact criteria outlined in the proposals was confounded with the intellectual merit criteria. The panel members were fluid, sketchy and diverse in their response to these criteria. Program Managers uniformly identify and define broader impacts to the panels; however, broader impacts are by definition non-specific and are open to individual interpretation. Some reviewers seem to interpret broader issues as only involving outreach activities. Reviewers uniformly direct their primary attention to intellectual impact and appear to use broader impacts as a "swing" issue. Funded proposals, in addition to strong intellectual merit, tend to have broad impacts that identify society benefits in addition to outreach. Examples from the proposal jackets are given below; 1. The results of this study may lead to improvements in health care for society. 2. The results of this proposal may lead to technology transfers. 3. Undergraduate students will be involved in research as a result of this proposal. 4. Poisson Disorder problem can be used in detecting infectious disease, such as AIDS and SARS Recommendation: • Broader Impacts: From the COV's experience on panels and from reading jackets, the appropriate inclusion in a proposal and review of broader impacts could be improved. For example, it was not clear that all the reviewers understood the definition of broader impacts before arriving at their panel. In order to help reviewers, the definition and examples of broader impacts should be linked to RFPs on Fastlane.	
2. Have the panel summaries addressed both merit review criteria? The panel summaries reflected the individual reviews on both criteria. There was some evidence that the panel discussions had input on the reviewers and their understanding of broader impacts.	Yes
3. Have the *review analyses* (Form 7s) addressed both merit review criteria? The review analysis addressed both review criteria.	Yes
4. Additional comments with respect to implementation of NSF's merit review criteria: This remains an issue in the research community that is not specific to DMI. The PIs and reviewers do not understand the rationale behind the requirement for broader impacts and therefore remain confused on the definition even though examples are provided. Recommendations: • Discussions between Program Directors in DMI pertaining to the meaning of the broader impact criteria and the use of the criteria in the proposal evaluation process would be helpful. Many PIs and reviewers are guided in their thinking by discussions of ideas with Program Directors. If PDs understand and are consistent in the definition and application of this criterion, this will positively impact PIs and reviewers, resulting in less confusion in the community. • Instructions should be included in the information that is sent to reviewers to encourage them to read the NSF document that defines broader impacts and to make it clear to the reviewers that a proposal does not need to accomplish all of the types of broader impacts given in the examples.	

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? The COV feels that the number of reviewers is adequate with most proposals being reviewed by three, four, or five reviewers. The COV noted that a significant percentage of the proposals reviewed (12%) had the minimum number of three reviews. The panels appeared to be adequately staffed with eight reviewers being the average for one-day panels and more reviewers for multi-day panels. On average each panel member reviewed approximately eight to ten proposals prior to the panel meeting. The COV feels that this is a reasonable review load for individual panelist. In several cases, however, it was observed that panels reviewed more than 20 proposals in a single day. This is a large number of proposals for a panel to fully discuss in one day. Recommendations: • Maintain an average of not more than ten proposals per panel member for review prior to the panel meeting. • Establish a target of no more than 15 proposals per day to be reviewed by a panel. • Refresh the reviewer list on a consistent basis involving successful recent awardees on new panels to add to the pool of reviewers.	Yes
2. Did the program make use of reviewers having appropriate expertise and/or qualifications? In a general, the COV finds that the reviewers chosen in DMI possess the necessary expertise and qualifications to perform high quality focused reviews. There was considerable discussion over what the balance should be between the number of new panelists and the number of senior panelists on a review panel. While it is important to bring new panelists into the system, the PD should assure that the panel composition contains panelists with the depth of expertise needed to evaluate the proposals. The COV has noted in some cases that PDs relied heavily on a core set of reviewers and suggests that a thorough examination of the reviewer base by each division be conducted. Such a review will insure that there is diversity in the panel reviews and that the focus is broad based insuring that the breath and mission of each division is adequately addressed. Recommendations: • Seek out potential reviewers in other directorates to bring a diverse expertise, as needed. • Strive for a panel composition that includes both new panelists and senior panelists, with a heavier weighting on senior panelists. • Consideration of panel expertise should reflect any anticipated changes brought about by the reorganization with regard to the review process. • Panels should be composed so as to provide opportunities to mentor qualified junior	Yes

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

faculty members in the NSF review process while assuring that panelists have adequate experience in the review process to maintain high quality review outcomes.	
3. Did the program make appropriate use of reviewers to reflect balance among characteristics such as geography, type of institution, and underrepresented groups?[4] The reviewer base is broad coming from a variety of different institutions and geographical areas. The COV does note that over forty percent of the total division reviewer base comes from states along the Atlantic coast. The COV found that the program made appropriate use of reviewers to reflect a balance among characteristics such as geography and type of institution. The program engaged reviewers from 42 states (plus the District of Columbia and Puerto Rico), including a few with particular expertise from universities in Canada, India, China and France. Nearly one-third of the reviewers came from states with large research institutions such as Massachusetts, California, New York, Pennsylvania, and Michigan. Forty percent of the reviewers came from the I-95 corridor which runs along the east coast. Realizing that reviewers from western states are asked to commit more time to the panel because of the large travel times, the COV brainstormed ideas on how to take the panel to the reviewers. DMI could pilot web-cam panels or expand the use of panels held in conjunction with existing national meetings such as the NSF Grantees Conference or the ASME IMECE. The program directors included a balance of reviewers from academia, industry, and other federal research and development organizations (174 universities, 57 corporations, and 13 other agencies). With respect to underrepresented groups, the program data shows a significant increase in the percentage of female reviewers (17% compared to less than 10% in the 2003 review), with a low of around 13% for Manufacturing Machines and Equipment and a high of 22% for Operations Research. We found insufficient data to comment on the participation of reviewers from other underrepresented groups. A small number of reviewers came from a few historically black institutions, and one reviewer came from the University of Puerto Rico. The lack of data may be attributable to the voluntary nature of reporting personal characteristics. Fortunately, anecdotal information on participation by underrepresented groups in panels was often provided by the program directors in the review analyses or minutes.	Data not available
4. Did the program recognize and resolve conflicts of interest when appropriate? The COV found that the program directors recognized and resolved conflicts of interest when appropriate. The review of the program jackets revealed consistent documentation of COI briefings to panel members and, when conflicts were found, the program directors documented such conflicts and their resolution. With respect to conflicts of interest among program directors with proposals submitted to their programs, the COV identified two instances in which the program director selected and implemented a panel to review proposals in which he/she had a conflict of interest. The COV recommends that the division review COI policies with program directors and assure that such policies are followed.	Yes
5. Additional comments on reviewer selection: • Insure that proper methodologies and data collection processes are in place to prevent panel or external reviewer bias (i.e., heavy reliance on certain institutions, individuals, or narrow core competencies).	

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

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 Based on the material in the Nuggets and the Grantees Conference proceedings, the overall quality of funded research projects is very high. Since most awards involve both faculty and their graduate students, there is also positive impact on graduate education at the awarded universities. The CAREER awards also include significant educational components. A number of REU awards were made, and a small portion of the DMI budget was used to support workshops. Tracking the impact of educational programs would be useful in preparing a case for increased investment aligned with the overall competitiveness initiative.	Appropriate
2. Are awards appropriate in size and duration for the scope of the projects? A large percentage of the awards are for approximately 3 years. Obvious exceptions include workshop funding (3% of awards, insignificant % of funding) and CAREER awards (5 years). Approximately 50% of the awards (and 50% of the funding) are to single PIs. Another 30% of the awards are to small groups at a single university. The remaining 20% of the awards are for cross university collaborations. Of the sample awarded jackets examined, the proposed work was consistent across those jackets with the (renegotiated) size and duration of the award. Given the increasing stipends for graduate students and overall increased costs, the funding rate (per faculty month) is insufficient and should be increased. Average award size is flat to decreasing over the past 3 years. Also, most awards include only a single graduate student, rather than one graduate student per faculty PI. It appears that in the interest of funding more proposals, the effective funding per proposal has decreased. Some COV members expressed the opinion that the funding for a CAREER award is high in comparison to funding for specific research proposals, and suggested that making fewer CAREER awards and funding more research proposals. Others were in strong support of the current program. Recommendation: • It was the sense of the COV members that additional funding per PI is required to achieve the desired level of scientific impact.	Not Appropriate
3. Does the program portfolio have an appropriate balance of: • Innovative/high-risk projects?[6] One mechanism for encouraging high risk and innovative research is the SGER program. For this program the engineering funding target is 4-5% of total budget; currently it comprises 1.4% of the budget (33 of the 510 awards were SGER). Most COV members felt that the 5% target was appropriate.	Not Appropriate

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

[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>.

Members of unsolicited proposal panels and program directors seem to be somewhat averse to funding high risk projects, where the perceived and commented upon risk could be based on scope of proposal, novelty, or track record of PI. Some program directors redirect high risk proposals to the SGER program. This policy was supported by the COV. A lack of a definition for risk, results in inconsistency in supporting high risk efforts. It is important that NSF support high risk with high potential proposals. This is an on-going issue with DMI and was highlighted in the last COV report. This is not unique to DMI but is a Foundation-wide issue that has recently been brought to the attention of the National Science Board which has charged the Committee on Programs and Plans Task Force on Transformative Research (www.nsf.gov/nsb/committees/cpptrcharge.htm) with studying this issue and making recommendations. It's not clear how program directors can support high risk proposals in any way other than funding SGER grants. The COV anticipates that the planned Office of Emerging Frontiers will encourage innovation in targeted areas and encourages members of that office to participate in discussions with the Task Force on Transformative Research. Recommendation: • DMI should seek to fund high risk/high potential proposals through the use of SGER grants and the Office of Emerging Frontiers.	
4. Does the program portfolio have an appropriate balance of: • Multidisciplinary projects? DMI received a small number of multidisciplinary proposals and made correspondingly few awards for 2003 and 2004. The COV felt that the funding model of DMI (small awards to small groups) effectively precluded multidisciplinary activities. In 2005 DMI received a larger number of multidisciplinary proposals and made a correspondingly larger number of multidisciplinary awards. The July 2005 conference on "Opportunities for Innovative, Multidisciplinary Research in Manufacturing, Machines and Processes," sponsored by DMI, MME and MPM, is expected to result in additional multidisciplinary proposals. The proposed reorganization should further increase the number of multidisciplinary proposals and awards. However, if the new directorate sees multidisciplinary activity as a priority, then some form of special funding program of targeted incentive would be necessary to generate proposals.	Appropriate
5. Does the program portfolio have an appropriate balance of: • Funding for centers, groups and awards to individuals? The sense of the COV is that this division should not be using its budget for the support of centers, but should support the research of individuals and small groups.	Appropriate
6. Does the program portfolio have an appropriate balance of: • Awards to new investigators? Statistics provided by DMI indicated that, adjusting for a few outliers, the percent of awards given to new PIs has been relatively stable at approximately 20-30% for the past three years. The COV felt that this was commendable, and encourages DMI to strive to maintain such rates. A significant number of proposals included junior faculty as co-PIs, along with experienced researchers as PI. However, in some jackets the reviewer's comments indicated that they were reluctant to fund someone without a history of successfully funded NSF grants. CAREER (37 awards, 14% success rate) awards are targeted at relatively young	Appropriate

researchers, and serve to bring new researchers under NSF support. These awards have been given to very promising, but for the most part not yet proven, researchers.	
7. Does the program portfolio have an appropriate balance of: • Geographical distribution of Principal Investigators? There is no noticeable bias to any particular state, and therefore the COV has no reason to believe that the balance is inappropriate. However, in order to more accurately determine if the balance is appropriate, the number of proposals and awards from a state or geographic region should be compared and contrasted with the number of proposals and awards that is deemed appropriate from that state or region. The tabular and the graphical data provided to the COV on geographic distribution of DMI proposal submissions and success rates per state contain valuable information regarding submissions and the awards, however, the material did not contain any demographics to judge the appropriateness of the distributions. Without demographic information, the issue of balance posed by this question is based on subjective judgment and is very speculative in nature. Recommendation: • Additional information should be provided to future COVs that will enable them to make a more informed judgment on the appropriateness of the geographical distribution of submissions and awards. Suggested additional information per state includes: (1) population, (2) college enrollment, (3) undergraduate engineering enrollment, (4) graduate engineering enrollment, and (5) number of engineering faculty members. This additional information would allow for the estimation of reasonable target numbers per state.	Appropriate
8. Does the program portfolio have an appropriate balance of: • Institutional types? The tabular and graphical data provided to the COV on the number of proposals from undergraduate institutions 2003-2005, contain information regarding submissions and the awards from/to undergraduate institutions; namely 15 and 2, respectively. From the presentation provided by the DMI Division Director, the number of proposals and awards during this time period was approximately 3000 and 530, respectively. Therefore, the acceptance rate of 13% is close to the DMI average.	Appropriate
9. Does the program portfolio have an appropriate balance of: • Projects that integrate research and education? Most funded jackets examined included some aspect of integrating research and education. Some of the plans as written in the proposals appeared general, however there were many examples of funding of REUs, and some work included unpaid undergraduate student participation.	Appropriate
10. Does the program portfolio have an appropriate balance: • Across disciplines and subdisciplines of the activity and of emerging opportunities? The COV felt that DMI awards represented a reasonable balance across disciplines and subdisciplines. This is promoted by the wide spectrum of programs within the DMI Division. The data for the number of submissions to various cross-cutting programs indicates the large interest in research projects which are multi-disciplinary and in emerging areas. Some of the programs however, show rather low funding rates, presumably because of budgetary reasons. There appears to be good use of funding sources from outside DMI to co-fund worthy proposals. This is commendable and should be expanded. Perhaps further outreach to Divisions like DMR or other Directorates with overlapping interest with DMI research could be explored.	Appropriate

Emerging opportunities are fundamental to the Crosscutting Programs at the NSF. Therefore, one measure of this balance is the fraction of the overall portfolio that is in Crosscutting Programs. The programs that have been identified by DMI as crosscutting are... • Major Research Instrumentation Program (MRI) • Materials Use: Science, Engineering, and Society (MUSES) • Nanoscale Science and Engineering Centers (NSEC) • Nanoscale Interdisciplinary Research Teams (NIRT) • Nanoscale Exploratory Research (NER) • Information Technology Research (ITR) • Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers. The total number of proposals submitted to these programs and reviewed by DMI during 2003, 2004, and 2005 was 164, 203, and 487; respectively. This equates to approximately 5, 6, and 16 percent of all proposals received by DMI during these years. It is noteworthy that this reflects a 24% and 140% increase in proposals from 2003 to 2004 and from 2004 to 2005, respectively. Clearly, this increasing trend in the number of proposals reviewed by DMI is an indicator that there is growing potential for increasing the fraction of the DMI portfolio that can be characterized as emerging opportunities.	
11. Does the program portfolio have appropriate participation of underrepresented groups? In order to determine if the balance is appropriate, the number of proposals and awards from an underrepresented group should be compared and contrasted with the number of proposals and awards that is reasonable from that group. Clearly, the tabular and the graphical data on the number of DMI proposal submissions and the success rates for male and female researchers provided to the COV contain valuable information regarding submissions and the awards. However, the material provided to the COV did not contain target numbers for any of the other underrepresented groups. Without award data and target numbers for all of the underrepresented groups, the issue of balance posed by this question will be a subjective judgment and very speculative in nature. Recommendation: • Additional information should be provided to future COVs to enable them to make a more informed judgment. Suggested additional information includes: (1) award data for each of the underrepresented groups, and (2) number of engineering faculty members per each of the underrepresented groups from which reasonable target numbers can be inferred.	Data Not Available
12. Is the program relevant to national priorities, agency mission, relevant fields and other customer needs? Include citations of relevant external reports. The program shows connections to a variety of national priorities including environmental issues and the rapidly emerging area of nanotechnology. The Division should be commended for a broad variety of funded work in areas of national priorities. The committee believes that the submission of these proposals (especially those relating to health care and energy issues) should be continued to be encouraged and funded where appropriate.	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.

The managerial practices and procedures in DMI are excellent. The work of the Division Director, PDs and support staff is highly commendable. The documentations available in the jackets were adequate and demonstrated integrity. In 2005 the SBIR program moved out of the Division, resulting in a reduction of several program support staff. Faced with a decrease in program and administrative support and staff and a steady increase in proposal actions from 1188 in 2003 to 1258 in 2005, the dwell time for most of the programs increased somewhat during this time period. However, the COV found that in spite of the increased workload, the quality of the program documentation remained high.

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

The Division's management practices in this regard are highly commendable and can be exemplified through several actions:

- PDs continuously seek collaborations and interactions within NSF. DMI has demonstrated leadership in crosscutting initiatives as evidenced by its leading position in the Nanoscale initiatives, MUSES, ADVANCE and ITR.
- The committee found a high level of PDs commitment to seek collaboration with other Divisions and external organizations and agencies (e.g., NASA, SRC, and Sandia Labs) in reviewing and funding high quality proposals.
- The Committee found several examples of seeking international awareness and collaboration through funding of various workshops in the USA and abroad.
- The Committee commends the good intermix of permanent PDs and rotators.
- The Division has a practice of making a high percentage of standard awards, which enables it to be very flexible in responding to new initiatives.

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

The Division has been very effective in supporting its core programs, which enable cutting edge research in Engineering Decision Systems and Manufacturing Processes and Equipment. It has been a leader in Nanoscale Science and Engineering and Biocomplexity and the Environment, two NSF wide priority areas. Its future strategies include a focus on Manufacturing Frontiers and Complexity in Engineered and Natural Systems. The Committee commends the support of core programs and the visionary thinking demonstrated by the research portfolio and the Innovation's Plan for the Future.

4. Additional comments on program management:

The Committee expresses concern with regard to the future DMI core programs and future initiatives in light of the announced reorganization. A number of program directors are scheduled to leave NSF in the next year. The Committee strongly suggests that these program directors be replaced, and the balance of approximately two thirds rotators and one third permanent NSF staff be maintained. If submissions continue to increase, the Division will need to consider adding program staff. The COV is also concerned with the limited travel support for permanent program staff.

The Division has done an admirable job in wisely managing its funding base for future development. In view of the announced reorganization, the strategic planning for the new Division should insure that these programs and practices continue to be supported.

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.

The COV notes that the benefits of most of the research undertaken by DMI programs will take many years to fully mature and deploy. As such, the assessment of outcomes was limited to an investigation of interim results, e.g. work closed out since the last COV, and a general assessment of the current program and its alignment to NSF goals. An exhaustive trace of investments made prior to 2002 was beyond the scope of the COV.

A review of the available data seems to provide sufficient evidence that DMI funded research contributes significantly to both NSF and GPRA goals. The research is found to be of high quality and the program productive, based on review of the interim deliveries. Several representative examples are noted below.

The results associated with DMI investments must be evaluated in light of the driving goals and objectives, reproduced below:

The NSF Strategic Plan states that its mission is:

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

In response, the Engineering Directorate Strategic Plan identifies four strategic goals for the Directorate. Within each of these goals below, implementation strategies and performance measures are specified.

- *Overarching Frontier Research Goal:* Effectively invest in frontier engineering research that has potential for high impact in meeting national and societal needs.
- *Overarching Engineering Innovation Goal:* Effectively invest in fundamental engineering innovation

that has potential for high impact in meeting national and societal needs.

- *Overarching Engineering Education and Workforce Goal:* Effectively invest in frontier engineering education and workforce advancement that has potential for high impact.
- *Public Understanding of Engineering Goal:* Effectively invest in and seek partnerships to educate the public about the value of engineering research and education.
- *Organizational Excellence Goal*: *Effectively organize the Directorate to provide agile, multidisciplinary leadership in engineering research, innovation, and education.*

In DMI's Plan for the Future, the corresponding goals and priorities are shown below:

- Goals - DMI will:
  1. Lead the exploration of new frontiers in design, manufacture, and service that engages the best minds to address issues of national need.
  2. Be recognized as the division that enhances the productivity of wealth-generating enterprise through the use of discovery and innovation and the application of the fundamentals of systems thinking.
  3. Develop people, both in the community and in the Division, who have the knowledge, skills and ability to be leaders in the profession and in the NSF organization.
  4. Be agile, responsive, and fiscally robust to achieve our other goals.

- Priorities for DMI to achieve its goals and support NSF and ENG goals:
  1. Focus resources in core programs to achieve a 25% success rate for competitive research proposals, with program officers managing $10M core programs.
  2. Manufacturing Frontiers is an opportunity to lead a critical national priority, and build on the Division's investments in environmentally benign design and manufacture, nanomanufacturing and supply chain, to enable creation of new enterprises.
  3. Complexity in Engineered and Natural Systems have an intellectual richness that DMI's exploration of engineered service systems for health care delivery, micro/nano scale machines and processes for engineered systems, and multi-scale modeling can contribute to and will provide the knowledge needs for enterprise of the future.

It is noted that there is some ambiguity associated with the objectives at each level and the consistent decomposition from Foundation to Division-level goals. Although providing a considerable amount of flexibility to the Division and its individual Programs, the assessment of outputs and outcomes is confounded by this ambiguity. In light of this, the DMI should be commended for constructing a largely cohesive and quality portfolio.

The following GPRA Outcome Goals were explicitly considered by the Committee. Although laudable, the COV observes that these goals were neither stated nor referenced in the Directorate or Division plans. The general nature of the goals ensures considerable overlap, but a more explicit recognition of the objectives and their common genesis would allow for both a more consistent and focused program complement and a more cogent COV review.

Recommendation:

- Both the Directorate and the DMI Division should examine their strategic plans for consistency with the GPRA goals and make changes to align these strategic plans with the desired outcomes.

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

Efforts to improve the diversity of both the awarded PIs and reviewers is to be commended, in direct response to the Engineering Directorate Strategic Plan. DMI has consistently awarded 30% of awards to new PIs over the last three years. In addition, reviewers from underrepresented groups grew steadily during the same period (21%-28%). Funding rates have also been consistently higher for female PIs (5% differential) over that period, although the total number of female PI awards was flat due to a decrease in overall submissions.

No data was provided that would allow an assessment of impact on competitiveness, although this was a DMI stated goal and appeared to be considered during the proposal review.

There was little data available to the COV to assess the engagement of the global workforce. Collaborations, including international interactions, are clearly valued during proposal review but not tracked after award to assess quality, durability, or outcome.

Overall, interim reports indicate that the outcome in this area appears to be good. The COV feels that these reports also suggest that the ultimate outcome, measured after projects have been completed, could be exceptional.

For example:

- John Dupont from Lehigh University (DMI-9983968) received an NSF Presidential Award (PECASE) for his Multidisciplinary research being conducted on various aspects of Laser Engineered Net Shaping (LENS), to relate processing parameters to product characteristics. The LENS process is an innovative Solid Freeform Fabrication process, which enables the manufacture of complex metallic parts directly from a Computer-Aided Design drawing. The research includes process modeling for composition control in material deposition, direct deposition of copper onto tool steel for the tool and die industry, fabrication of functionally gradient materials and composites, and measurement of process efficiency factors needed for accurate heat flow modeling. This research is leading to processing and microstructure models and fabrication techniques needed by industry for the implementation of the LENS process. The research also involves the education of students in a new and emerging field.

- DMI renewed its support of the Society of Hispanic Professional Engineers' student design contest DMI-0206800) which was held in conjunction with the Society's National Conference. Students work in teams of two to six to provide a design and prototype of a commercially marketable product that could improve the quality of life. Ten finalists present their products in a national competition. This contest instills enthusiasm for engineering design in Hispanic students, and gives them an opportunity to participate in a nation-wide event that gives them good exposure to the professional engineering community, helps them in job placement and gives them a better perspective on the selection of their post graduate education.
- DMI has awarded several Research Experience for Teachers supplements. The following details a few experiences:

  Mr. Matthew Gristina, a high school physics teacher from the New Brunswick School district (NJ, near Rutgers), worked with a graduate student on a research project during the summer of 2001 (DMI-9978720). His research involved determining the solubility of silicon nitride in glass, which led to further measurements of the surface tension of glasses in silicon nitride. These measurements can then be related to sintering stresses. Mr. Gristina also submitted a lesson plan for a high school class on x-ray powder diffraction.

  Mitchell Johnson, a high school physics teacher at Union-Endicott High School, conducted research in the summer of 2002 on the deposition of metals on substrates, and on the preparation of thin-film, multilayered composites. Substrates with different metallizations provide flow surfaces with wetting characteristics that more closely mimic those of the solder obstructions found in real DCA obstruction fields. This work resulted in his co-authorship of a publication, "Calorimetric investigation of the formation of metastable silicides in Au/Si multilayers," R. R. Chromik, L. Zavalij, M. D. Johnson, and E. J. Cotts, J. Appl. Phys. 91, 8992(2002).

  Thomas Mellin performed research on the reflow of solder alloys in an annealing chamber (DMI-9908332) and continued those efforts on a volunteer basis during weekends of the summer of 2003. Thomas also helped to promote long-term interactions between his Binghamton High School and the SUNY Binghamton laboratory. Because of Mr. Mellin's RET connects with SUNY Binghamton, he was able to arrange for Sara Lee, Binghamton High School's Bausch and Lomb award winner for highest grade point average in science, to participate in these reflow experiments.

- Proper management of end-of-life electronics has become a tremendous concern world wide, and implementation of an effective system for the collection of e-scrap could be highly beneficial. The objective of a project headed by Professor Ammons at Georgia Institute of Technology (DMI-0200162) has been to design an infrastructure that effectively plans collection of products such as televisions, monitors, central processing units (CPUs), printers, and peripherals at the end of their life. The research considered which groups to target based upon the recycling behaviors of various age groups, genders, and income level households. From this targeted group, a determination was made on what location would maximize the amount of e-scrap collected. The model incorporates the strategically selected locations throughout the state of Georgia and determines which sites should be opened as a one-day collection site. The resulting solution proves that an e-scrap reverse production system can be a beneficial investment. Through this project, students became involved in activities to promote activities to benefit the environment.

- The National Academy of Engineering was commissioned by DMI (DMI-0222041) to conduct a study to identify engineering applications with potential for significantly improving healthcare delivery in the short, medium and long terms; to identify factors that affect the deployment of these applications; and to identify engineering research areas capable of improving healthcare delivery. A committee of 14 experts was convened and reviewed the literature, conducted site visits and took testimony. Two fact-finding workshops involved 68 researchers and practitioners from engineering, healthcare and management fields, and a consensus report was prepared. The study made the case for investment in a new partnership between engineering and healthcare to enlist systems engineering tools and information technologies, especially to address the current quality/cost/access crisis. Important opportunities and challenges for research in engineering and related fields were identified.

- DMI conducted a study (DMI-0228112) to assess African nations for their potential for export-based manufacturing and their potential for U.S.-African collaboration in manufacturing research. A team of Princeton University researchers traveled to South Africa, Tanzania, Nigeria and Senegal to assess and document these nations' abilities to develop new manufacturing industries. The team looked at the quality of the nations' universities, economic policies and political frameworks, and from these data assessed the ability of each nation to support small, medium and large-scale manufacturing enterprises, and determined areas for potential collaborations. This project will set the stage for future interaction between U.S. academic researchers and their counterparts in Africa.

- Professors Antoinette Maniatty of Rensselaer Polytechnic (DMI-0115330) and Wojciech Misiolek of Lehigh University (DMI-0115146) have developed a predictive model of microstructure evolution, particularly texture, grain structure and precipitate evolution, during hot forming of Aluminum-Magnesium-Silicon alloys based on underlying microstructural mechanisms. Their formulation, involving grain-scale modeling, provides a new formulation for generating, meshing and modeling large deformations of polycrystals, and enables investigators to observe three-dimensional grain structures. Based on these results, a web site for middle and high school teachers with experiments and lesson plans was produced. This work will provide a guide for process designers and expose middle and high school students to engineering and materials science.

- Under a CAREER grant (DMI-9984051) in collaboration with General Motors and Adept Technologies. Professor Constantinos Mavroidis of Rutgers University has developed a procedure for the application of rapid prototyping in the fabrication of non-assembly robotic systems and mechanisms with inserts. This procedure uses stereolithography and selective laser sintering to fabricate prototypes of complex, multi-articulated, multi-link, multi-loop systems in one step and without requiring assembly. The research also explores methods of insertion of component parts during the rapid prototyping process. A rapidly prototyped mobile vehicle was fabricated to demonstrate the process. This effort has resulted in the development of an upgraded and renovated graduate course on design of mechanisms, and it has provided an opportunity for undergraduate students to participate in the research.

- Under joint support from the National Science Foundation (DMI-0207533)and the National Institutes of Health, Mitzi Diley and James Deye conducted a workshop focusing on rigorous optimization methods applied to radiology for the treatment of cancer in order to more effectively kill tumors while minimizing exposure to surrounding tissue. Treatment would be administered by an external beam accelerator

that can be rotated all the way around the patient's body. The workshop was a collaborative effort between NSF and the Radiation Research Program of the National Cancer Institute. It brought together about 30 experts in radiation physics, biology and radiation oncology, and operations research to discuss significant problems of treatment plan optimization in radiation biology and how they could more effectively collaborate.

- Professor Ravindra Ahuja at the University of Florida (DMI-0217359), Professor James Orlin of MIT (DMI-0217123) and Dr. Amit Mukerjee of the Information Services Division of United Airlines are collaborating on research into optimization search techniques that involve very large neighborhoods. A neighborhood search involves a discrete optimization in which objects are selected to be included in the optimal set. The very large neighborhood search technique extends the concept of swapping to the replacement of several objects simultaneously, thereby reducing the probability of hanging up on a poor solution. The reduced order problem created by the very large search is solved using a rigorous technique, thus enabling consideration of very large neighborhoods. An application of this search technique is the airline scheduling problem in which an airline wishes to add or change its flight legs to maximize profitability.

Recommendations:

- Additional information should be provided to future COVs that will enable them to make a more informed judgment on the effect these projects have on creating a competitive, globally engaged workforce. Data such as patents developed, companies started, extension of the research into industry, eventual placement of graduate students, etc. is needed to fully evaluate this metric.

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

The COV found a commendable breadth of investigations and a noteworthy and explicit dedication to educational and service interactions. The DMI performance for this goal is very successful. The Division has demonstrated that it is a clear leader in the initiation and conduct of leading-edge research across a broad frontier including manufacturing, medicine, design, nanotechnology, and environmental science.

- Professor Edward DeMeter of the Pennsylvania State University (DMI-0125515) has performed research leading to the development of a light-activated, adhesive-based workholding technology capable of ultra-short load-unload cycle times. When a part under production must undergo a cutting procedure, such as milling, the part must be held rigidly to a mount and positioned for the cutting operation. Fixtures can be complex, and mounting parts in fixtures can be time consuming. With the technology developed by Professor DeMeter, the part is glued to a mount with light-activated adhesive. This adhesive holds the part firmly in place during the cutting operation, and then releases it quickly upon command. This technology has several advantages over conventional fixturing, including its flexibility to handle a variety of parts, ease of use, high rigidity, and it does not distort the work piece with the usual clamping forces. Rapid load-unload times enable reduced cycle times for parts manufacture. Technical feasibility of the process has been established through the research conducted to date. As a result of this work and its value to industry, Professor DeMeter was presented the Association of Manufacturing Technology's (AMT) Charles Carter Advancing Manufacturing Technology Award.

- Professor Rajiv Mishra and his doctoral student Ms. Lucie Johannes at the University of Missouri-Rolla have researched the use of friction stir processing to refine grains of metal alloys (DMI-0323725). Friction stir processing uses mechanical mixing of metals to alter the grain structure. Extra fine grains can result in a super-plasticity phenomenon. The team used multiple passes of friction stir processing to treat the as-received aluminum alloy 7075, achieving an elongation greater than 200 percent at a strain rate of 0.1/second and a temperature of 400 deg. centigrade, compared to less than 20 percent elongation obtained from the as-received aluminum alloy. Potential applications of this research can be in automotive and aviation sectors. This work on the fundamental understanding of the role of alloy chemistry and process parameters on friction stir processed microstructure and superplasticity can further enrich this solid-state processing technology.

- Under a GOALI project (DMI-030084), Professor Gevelber at Boston University has applied a new sensor scheme to better resolve process variations in plasma spray processing to produce surface coatings for applications such as fuel cells and thermal barriers. Based on the sensor scheme employed, Professor Gevelber has demonstrated a closed-loop controller to compensate for variations in plasma spray applications, and he has used this controller to explore process-structure relationships that enable improved engineering of coating structures. He has also been able to model factors that are related to crack formation in plasma spray coated products. This work has been conducted together with an industry partner to aid in rapid technology transfer and application.

- Professor Dornfeld at the University of California at Berkeley (DMI-0300549) is studying the fundamentals of burr formation in hole drilling. Many precision products demand expensive deburring of holes after drilling. One such product is a modern jet airliner, which can require the drilling and deburring of over 3 million holes per aircraft. The approach includes the development of a finite element model of single and multi-layer drilling operations and, in the case of multi-layer drilling, an investigation of inter-layer gap formation, which arises as the drill bit exits one layer and begins to penetrate the next layer. The study has provided valuable insights into drill shape optimization. Among the results obtained to date, the fundamental mechanism of burr formation at interfaces between materials has been identified, and an analysis has been developed to determine the drill exit conditions and geometry to minimize burring. Of particular interest is the drilling of materials such as graphite composites and titanium. This research is being conducted in collaboration with Boeing. In addition, software companies Third Wave Systems, ABAQUS and DEFORM are collaborating with Professor Dornfeld on drill modeling development.

- Professor Wei Sun, A. Shokoufandeh and William Regli at Drexel University (DMI-0219176) are studying novel approaches to the representation of heterogeneous objects, namely objects that are comprised of spatially varying materials, and to the design of such objects. Typical examples of heterogeneous objects are bone, tissues, tissue engineered structures, scaffolds, and tissue replacements. The investigators are using constructive heterogeneous solid geometry algebra and feature-primitive-based design methods in which the object is decomposed into cellular units in terms of mechanical properties. Discrete optimization techniques are used for optimal design, with examples in bone scaffold that include biophysical and biological constraints. This research is delivering new techniques and tools to represent, design and develop heterogeneous tissue scaffolds, and it will lead to fundamental computer science and engineering advances in solid modeling, computer-aided design and tissue engineering.

- Professor Jennifer Lewis, at the University of Illinois, has developed a fundamental understanding of the flow behavior of concentrated colloidal inks (DMI-009360). This has application in materials processing and in the design of new coatings and inks. The resulting development of concentrated colloidal inks for robotic deposition of three-dimensional periodic structures has resulted in structures that include spanning elements. This capability has been applied to the fabrication of three-dimensional structures with features sizes down to 100 microns, and that have a piezoelectric figure of merit that is up to 70 times better than that of conventional monolithic structures. A significant application could be in the fabrication of scaffold structures for tissue engineering.

- Jack Zhou from Drexel (DMI-0300405) is developing a new manufacturing process and a machine for three-dimensional bone scaffold using biomaterials, solid freeform fabrication techniques and biomimetic bone structure modeling. The resulting scaffold is required to have a shape and internal structure similar to that of bone tissue, and sufficient mechanical strength to support loads normally imposed by the body. The approach is integrating knowledge from biomaterials research, biomimetic modeling, solid freeform fabrication, systems and control, and tissue engineering. Modeled sucrose serves as a negative skeleton material (named porogen). A bone tissue solid freeform fabrication machine first makes the sucrose porogen and then casts the bio-composite into the porogen to form scaffolds. To date a prototype fabrication system has been constructed, and it has formed modified sucrose material into reverse engineering-generated self-supporting structures. This research will lead to new treatments for bone repair and reconstructive surgery.

- Stephen Creager of Clemson University project (DMI-0303645) is to synthesize carbon aerogels with

grafted fluoropolymer electrolytes and dispersed nanoparticulate catalysts in the pores, and to characterize the resulting materials to demonstrate their utility in Polymer Electrolyte Membrane fuel cell technology. This is achieved by modifying carbon aerogels using sulfonyl imide fluoroionomer electrolytes. Following modification with nanoparticulate platinum catalysts, characterization with respect to structure and electrochemical properties will reveal whether these new electrode materials have the expected high activity of fuel cell reactions. PEM fuel cells use a simple chemical process to combine hydrogen and oxygen into water, producing electric current in the process. To date, the carbon aerogel synthesis has been accomplished, and synthesis of fluoroionomers suitable for grafting inside aerogel pores and characterization of modified aerogels are in progress. The materials under development are targeted for use in hydrogen-powered fuel cells and support current administration goals with respect to the hydrogen economy.

- Wei Lu, under a CAREER award to the University of Michigan (DMI-0348375), is using material strain to guide nanoscale self-assembly on solid surfaces. Through an investigation of surface elastic and electric interactions, Professor Lu has found that various self-assembly patterns can be obtained, which can lead to engineered self-assembly as a low-cost, high-throughput nanofabrication method to produce a variety of nanostructures in diverse material systems. The research has included the development and validation of dynamic models for self-assembly that includes manipulation fields to guide the self-assembly process.

- Professors David Wu, Morris Cohen and Patrick Harker at Lehigh University have conducted research to examine electronic market mechanisms as a means of coordination and communication in industrial supply chains (DMI-0121395). The research focuses on two main components: (1) innovative market mechanisms exploring the theoretical and computational foundations of electronic market intermediaries in the supply chain, thereby deriving market mechanisms beyond price determination to include activity, resource, and structural coordination), and (2) a focused industry survey to gain understanding of the economic realities and key development trends in the industry. Insights developed from the research will lead to the development of efficient market mechanisms for supply chain coordination, and versatile market analysis tools.

- David Morton at the University of Texas at Austin is working to develop a methodology for selecting sites at which to install detectors sensitive to nuclear and radiological material in order to prevent smuggling of such materials (DMI-0228419). The approach has been to develop a stochastic network interdiction model in which a smuggler seeks to select a path in a transportation network to maximize his probability of avoiding detection. The interdictor's goal is to install detectors, subject to a budget constraint, to minimize the smuggler's probability of success. This problem is formulated as a bi-level two-stage stochastic mixed-integer program. Solution of this mathematical model provides guidance for sensor location. The importance of this problem derives from the efforts of terrorist organizations, such as al Qaeda, and rogue nations, such as North Korea and Iraq, to obtain nuclear material and technology to produce a nuclear weapon. Securing U.S. borders from the possible smuggling of nuclear/radiological weapons or precursor materials is an important step in minimizing the associated threat. Other U.S. organizations are focusing on issues needed to secure the border. For example, scientists at Los Alamos National Laboratory are developing radiation sensor equipment to detect minute quantities of nuclear material and data on terrorist groups. The Immigration and Naturalization Services, the Federal Bureau of Investigation, and the Customs Department are collecting data on potential smuggling routes. Significantly less effort has been devoted to developing a methodology to use these data to determine where detectors should be located.

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."

The COV found the Division's performance in this area to be successful. The DMI has supported a wide variety of quality research topics in tool and infrastructure development. Several examples follow:

- Robert Hocken at the University of North Carolina at Charlotte (DMI-9821003) is conducting research in motion control by magnetically suspending and driving a stage with sub-atomic positioning capability over macroscopic ranges. Extreme measures were taken in the design of the stage, including ultra-precise temperature control, heterodyne laser interferometer systems, linear motors with Halbeck

magnet arrays and the use of high stability, low expansion materials. *The measuring machine has obtained the highest resolution motion over a large distance of any such machine to date.* The machine will be used for initial tests of plasmonic lithography, which offers a possibility of revolutionizing the manufacture of integrated circuits.

- DMI is sponsoring research (DKI-0002934) with Alex Slocum at MIT to create a nanosystem with molecular-scale control over the separation of two large, flat surfaces. To do this, the PI used a MEMS-based fabrication process that allowed the creation of inexpensive high-precision parts. The MEMS components are combined with high-precision external actuation and metrology. The resulting valve can be actuated with Angstrom precision and can control extremely small flowrates. *To date, the nanogate has demonstrated the finest control of helium flowrates of any MEMS-based valve.* The on-off flow rate control ratio is approximately 100,000, and Angstrom-level control of the surface separation has been demonstrated. This device provides a tool for the study of the physics of fluid flows at extremely short length scales and offers a possible extension to small-gap chromotography or separations in a nanometer-scale channel.
- Professor Crawford at the University of Texas at Austin has developed a technique to enable engineers to analyze, identify and visualize relationships and tradeoffs between multiple product designs, leading to better product design through a better understanding of the design space (DMI-0323838). The method draws upon techniques developed for computer graphics and has resulted in a new class of sequential sampling criteria to enable the creation of metamodels using far less data than currently needed.
- Timothy Fisher at Purdue University has been developing a teaching laboratory and the provision of educational materials for the manufacture of devices with small-scale features, and the dissemination of the knowledge gained for adoption at other institutions. Soft lithography manufacturing systems enable the replacement of expensive and complex sub-micron lithography and etching processes with vastly simplified and time-saving processes that avoid the use of highly toxic chemical etchants and are therefore substantially safer for students than many microelectronics fabrication lab processes. These processes have been used as models for small-scale manufacturing and complement the traditional teaching of larger-scale manufacturing. The laboratory is fully functional, and courses will begin in the spring semester of 2004. This laboratory could serve as a model for the establishment of multi-scale manufacturing educational laboratories in other institutions.
- The problem of optimal manufacturing facility layout is very difficult. Despite this difficulty, even small variations in layout can make large differences in production efficiency, time and cost. And, since there is so much to be gained through facility layout optimization, global competition demands near optimal facility layout. Professor Meller at Virginia Tech (DMI-0355178) developed a heuristic that combines the sequence-pair representation from integrated circuit design and the mixed-integer programming approach from optimization theory and tested the resulting heuristic against optimal results for small problems and against heuristic results for large problems. The initial results have shown improvements over the best-known results for each large problem tested to date. This GOALI project has included an industrial partner, which is interested in immediate application of the approach.
- Professor Alok Chaturvedi of Purdue University (DMI-0122214) has developed a synthetic environment for analysis and simulation to support the study of organizational, social and economic issues. The simulation environment includes interactions among human and artificial agents, and provides elements for building a wide variety of synthetic environments. The approach has been to develop behaviorally accurate artificial agents that enable realistic simulations of economies, nations, markets and organizations while demanding only a few active people in the process. It is implemented on a distributed tera-grid of over 900 processors, and provides a highly scalable system that can be applied to a wide range of issues, such as response to bio-terror attack, response to other forms of terrorism, product planning and supply chain evaluation, and other business and political decision making situations.
- The goal of the research of Heiko Jacobs at the University of Minnesota-Twin Cities (DMI-0217538) has been to develop a parallel tool to position nanoparticle building blocks on surfaces. The tool is

based on directed self-assembly. It uses patterned surface areas (receptors) that interact with nanoparticle-based device components. Electrostatic forces are used to direct the assembly of nanoparticles from the gas or liquid phase. To date, the PI has developed a parallel technique using a thin silicon electrode to pattern charge with 100 nm resolution, and has demonstrated the assembly of 10 nm sized nanoparticles from a powder, gas phase (aerosol), and liquid phase (suspension). He further developed a nanoxerographic printer to print nanoparticles from the gas phase with 100 nm resolution. This is 1000 times finer than current xerographic machines. This process could enable the parallel fabrication of computer chips and circuits that use nanoparticles as building blocks, and it could demonstrate the ability to assemble nanoparticles of arbitrary materials onto arbitrary substrates in support of the manufacture of a wide variety of nanotechnological devices such as single-electron transistors, quantum-effect-based lasers, photonic bandgap materials and high-density data storage devices.

- Professor Julie Ann Stuart, a Career Award recipient at Purdue University (DMI9734310), is investigating methods that will aid engineers design products, businesses plan strategies, and government develop legislation for take back and reuse of products at the end of their life cycle. Her research defined metrics and evaluation models to help improve reverse production planning decisions. She developed new algorithms for product return disposition that consider forward distribution parameters and, for returns from end-of-life, a mixed integer program to determine which products to accept, process and store. From this research have come new scheduling rules that offer to reduce backorders significantly. For older product returns, her rules improve product turnover and recycling economics. This research has led to new algorithms that improve customer service, increase product reuse, and reduce materials use. The results may also assist policy makers in evaluating proposed legislation for product take-back. Her education plan focuses on the challenges and approaches for materials reuse, product design for demanufacturing, demanufacturing planning, and sustainability will be communicated to undergraduate and graduate students, researchers, and practicing engineers through innovative learning modules, presentations, papers, and workshops.

- Professors Hearn and Lowphongpanich at the University of Florida have used concepts of value pricing to address highway congestion (DMI-0300316). Specifically, the objective of their research is to study the problem of determining tolls for the purpose of reducing congestion in large metropolitan areas. This research involves the development of functions for measuring the efficiency of use of a transportation system, determination of toll structures to maximize efficiency, and evaluation of the proposed techniques using data from major metropolitan areas. To date, models have been developed to predict the shift from private vehicle use of highways to public transportation as a function of tolls, and the fundamental properties of toll pricing problems have been examined along with their solution techniques. This research will lead to the development of software useful for reduction of traffic in a manner that is fair and equitable to both private vehicles and users of public transportation.

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]

The COV found the Division's performance in this area to be successful. The DMI has committed to, and demonstrated, a credible, fair, and efficient merit review system as noted in detail in Section A of this report. In addition, the Division has made an aggressive move toward the implementation of electronic proposal processing and completing this effort is highly recommended. In the future the Division might consider the exploitation of virtual meeting capabilities to reduce travel time and cost.

The DMI staff was found to be highly competent, dedicated, and motivated, and has consistently demonstrated a committment to excellence and high integrity. Additional and consistent details regarding staff are noted in Section A of this report.

The use of peer review for assessing both the quality of the portfolio and the quality of the management and

[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>.

operation of the Division (e.g. the use of COVs) is both a well-established and highly effective means of ensuring high quality and performance of the Division and its Programs. NSF and the DMI Division have exceptional records in this regard and the COV recommends that these practices be continued to ensure continuous improvement in their intellectual and management assets.

PART C. OTHER TOPICS

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

The COV discussed the impact of the reorganization on the efficiency, financial management, and the intellectual value for DMI. The conclusions follow:

- DMI should articulate more clearly the positive impact of this reorganization on DMI's ability to address problems of national significance.
- During the transition when DMI and CMS merge, care should be taken to ensure that the historical differences in financial fund management between CMS and DMI not adversely impact on DMI's ability to fund projects. Specifically, the percentage of standard grants in DMI is higher than in CMS and the programs historically under CMS should have to meet those obligations.
- To maintain the relatively high efficiency of DMI, the reorganization should be used as an opportunity to maintain and even increase support staff.

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.

The COV feels that DMI in general meets and exemplifies their major goals.

Budget constraints are creating a situation that constrains the reach of the Division. It has created a situation where strong proposals are left unfunded and the top proposals are funded at lower levels. Renegotiating the budget (to levels as much as 50% of the request) leaves the PIs in a position of promising more than can realistically be accomplished within the awarded budget.

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

The COV strongly suggests that the reorganization be used as an opportunity to align the Eng Directorate with the critical and important issues facing the nation today. Issues such as alternate energy sources, the decline in the number of engineering graduates, sustainability, security, health care, and competitive manufacturing, which require significant advances in engineering and are urgent and essential to the stability of the nation, need to be supported in the reorganization structure and reflected in the mission and programs of the new division.

The COV found that NSF databases are incomplete and incompatible with one another. Throughout the COV meeting, there were questions about the demographics, gender and race distributions of the PIs, reviewers, and awardees which could not be answered easily. In particular, the dearth of data on awards to under represented groups should be rectified immediately. Data on nationality, race, and gender of PIs with respect to submissions and awards and the same data on reviewers should be collected and reported regularly.

There were discussions about the length and funding level of CAREER awards. There were mixed views. All felt very strongly that junior faculty should be supported. Some felt that the funding level should be reduced and the duration of the awards changed to 3 years which would free up funds for other awards and reduce the amount of funding provided to non-experienced awardees. Others were strong proponents of the current system in that the 5 year period was needed to support PhD students to completion and the prestige and impact of the award would be reduced if the period was changed to the standard 3 years.

The COV discussed the web site and it was agreed that while the web site is very useful, there are many out of date documents on the NSF web site that are found during a search which should be archived.

The move to electronic jackets is encouraging and promises to reduce paperwork and hopefully, dwell time. The COV found that it is important to review the panel matrix when reviewing proposal jackets. The matrix is not currently a standard part of each e-jacket and we strongly recommend that this procedure becomes standard.

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

Questions about measuring the impact of the research could not be answered sufficiently given the data that was provided to the COV. Data on the number of students supported and the type of employment they found after graduation, the number of publications in top ranked journals, the number of patents generated, the number and survival rate of start-up companies resulting from NSF supported research, the number of jobs created and the impact of the research results on the tax base would have helped the COV members evaluate the impact of the research on the nation.

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

While the overall process was informative and well constructed, the COV does have some suggestions.

- The data made available to the COV should be consistent and clearly identified. For example, the information in Tab 7 is labeled Proposals Submitted and Reviewed by DMI Programs; however, this data is for core DMI programs only and did not include agency-wide programs which had DMI participation.

- It is important that the COV be given data not only on proposal submission from under represented groups, but also on awards to under represented groups. In addition, the percentage of faculty from underrepresented groups would be valuable.

- During the presentations by DMI staff, a complete description of the process flow for a proposal from receipt to final disposition would be helpful, particularly in terms of time at each step and any rate limiting steps.

- Assembling the COV report could be more efficient if every member of the COV had access to his/her own sections of the report on the NSF website. This could be handled similar to the electronic panel summary where everyone has an opportunity to send in comments and/or edits.

- The COV should be provided with a list of staff and support staff changes over time.

- A higher sample rate for award jackets and SGERs would be helpful. While we rectified this by asking for additional jackets during the COV meeting, future COVs should consider pulling more of these jackets at the outset.

- More of the data relevant to the outcome questions should be made available in a statistically analyzed format. If the data was organized under the topics that the COV had to answer, this would improve the efficiency of the COV.

- Provide the COV with the GPRA Outcome Goals.

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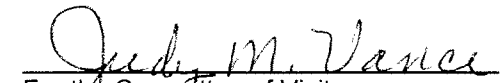
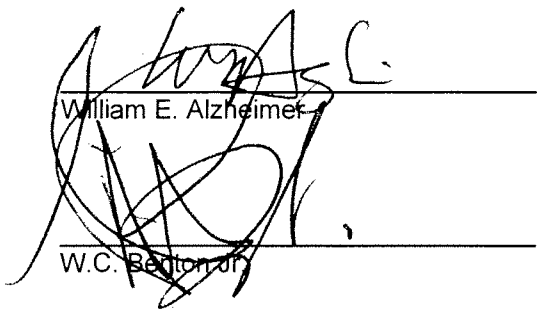


For the Committee of Visitors
for the Division of Design and Manufacturing Innovation
Judy M. Vance
Chair



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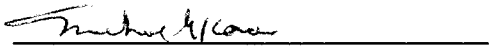
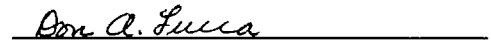
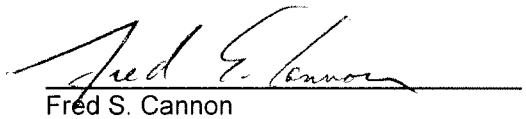


Michael Kovac

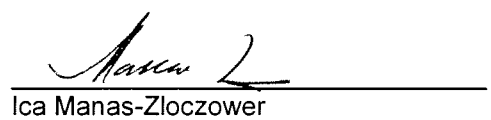
W.C. Benton, Jr.



Don A. Lucca



Fred S. Cannon



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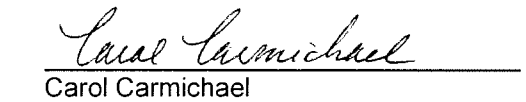
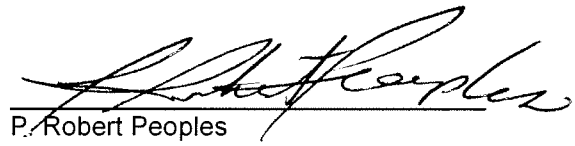
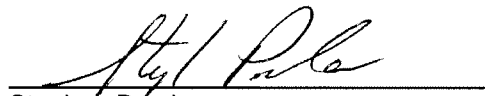


Carol Carmichael

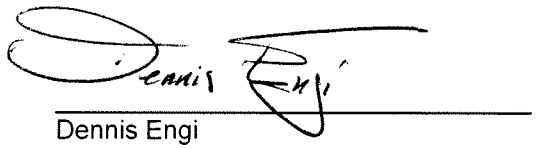


P. Robert Peoples

Brenda L. Dietrich



Stephen Prusha



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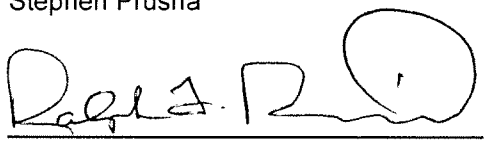
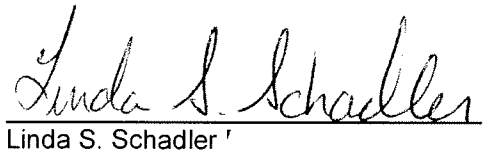
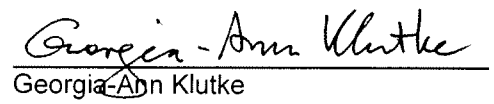


Ralph L. Resnick

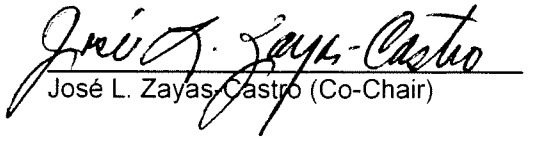
Richard V. Gregory



Linda S. Schadler



Georgia-Ann Klutke



José L. Zayas-Castro (Co-Chair)