National Science Foundation

Directorate for Engineering

Awards Impact & Assessment Task Group Report – Part 1

Final

21 June 2005

Table of Contents

Contents Page

EXECUTIVE SUMMARY 4

CONTRIBUTORS to this REPORT 6

INTRODUCTION 7

CHANGING CIRCUMSTANCES 8

CURRENT ASSESSMENT STATUS in NSF ENG Divisions 14

- BES, CMS, CTS, DMI, ECS, EEC, SBIR Approaches 14
- AIA Task Group Methodology 19

RECOMMENDATIONS 20

- Enhanced Nugget System 22
- Modified FastLane Reports 23
- Annual NSF FastLane Reports for Standard Grants 24
- Case Study Assessments 24
- Committee of Visitors 26
- Grantee Conferences 26
- Staff Dedicated for Assessments 27
- Secondary Recommendations 28

IMPLEMENTATION of Primary Recommendations 30

- Enhanced Nugget System 30
- Enhanced FastLane Modified Reports 30
- Case Studies 31
- Committee of Visitors 32

Contents Continued on Next Page

Contents – continued

IMPLEMENTATION of Secondary Recommendations 33

ASSESSMENTS & MEASURES OF PERFORMANCE 34

- Introduction 34
- Metric Recommendations from the Strategic Thinking Group 36
- Assessment Discussion and Alerts 37
- Discussion of Broader Assessment Issues 39

CONCLUDING REMARKS ON ASSESSMENTS 40

APPENDIX (See Separate Document / Part 2)

- Support Documentation 4
  1. Nugget Quad-Chart from George Hazelrigg, DMII 5
  2. ENG Program Evaluations & Studies 1993-2004 6
  3. Engineering Research Centers – Performance Criteria 10
  4. Sample Nuggets – Three Formats 16
     - A. PowerPoint Format 17
     - B. GPRA Format – Scientific Version 19
     - C. GPRA Format – Simplified Version 22
- Comments on Assessments 24
- NSF Committee of Visitors / Assessment Duties 28
- Original Charge to Task Group 29

EXECUTIVE SUMMARY

It is of increasing importance to assure that upper NSF management, the Administration, Congress, and the general public are aware of Engineering NSF projects and programs that are especially noteworthy and that may have significant impact on society.

The Engineering Directorate must be sure that effective assessment techniques are in place to define, measure, and clearly document the impact of its research awards.

The ENG Awards Impact & Assessment (AIA) Task Group was charged with (1) reviewing the current assessment techniques being used in ENG and (2) recommending new or additional approaches that ENG could use to determine or assess the impact of its investments in research, education, and innovation.

In addition to documenting examples of significant impact of research projects, systematic assessments of groups of projects can also serve as an administrative tool to improve effectiveness of program activities. Therefore, the goal of the Task Group is to propose a set of improved assessment methods that are pragmatic, systematic, and timely for use in managing current and future project awards.

Considerable attention is focused in this report on assuring that the impact data that Engineering needs for assessments is systematically collected and available to judge the Directorate's fulfillment of the Engineering strategic objectives. A systems approach to evaluate Directorate performance is proposed.

Recommendations (Overall Summary)

The AIA task group offers the following priority recommendations as to how to gather research impact data on NSF engineering project awards. In general, these are improvements to existing approaches. They generally call for uniform and systematic application to all Engineering NSF projects. They are related to:

- **Enhanced Nugget System** (Highest Priority)
- **FastLane Modified Reports** (Highest Priority)
- **Committee of Visitors** (High Priority; up to date assessment metrics; added focus on specific Directorate and Division strategic goals; possible use of case studies related to these goals, possible use of contracted case studies to assist)
- **Case Studies** (High Priority; commissioned to third parties)
- **Grant Conferences** (comprehensive)
- **Dedication of a Staff Person for Coordination of Division Assessments** —longer term

The AIA task group recommends that the divisional COVs serve as the central coordination point of the assessment process in each division—using the impact data collected via the improved methods recommended in this report. Assessment criteria specific to Engineering should be added to the NSF COV mission. Possible additional ENG metrics are discussed and recommended in this report beyond those currently specified in the NSF COV report template. The set of supplementary assessment metrics may be different for the "regular" ENG research divisions (with their emphasis on academic research and education) in comparison with the efforts in the SBIR activities (with their emphasis on business and market applications). However, the strategic objectives of obtaining results from innovative and cutting edge research—and identification of research results which address significant societal impact—are performance measures important to all elements of the organization.

Integration of COV findings and determinations that strategic Directorate goals are addressed and met must be assured through a special Directorate mechanism. As a part of Directorate implementation, the designation of divisional coordinators is recommended to assure consistent implementation across the Directorate.

The AIA task group recommends a number of enhanced approaches to the types and quality of award nuggets, integration into the NSF Fastlane system, as well as their use, including applications by COVs and their availability to the public and for the NSF proposal review process within Engineering.

This report also recommends additional interesting and useful approaches for collection of supporting information on grants that can be useful in ENG assessments of the impact of the research supported by NSF. These are given in a secondary priority recommendation section of the report.

The assessments and the gathered information outlined in the AIA report should also be useful in making the case for sustained support for NSF engineering activities.

To implement the first two recommendations over the long term, it will be desirable to work collaboratively with representatives from other Directorates—with similar interests—to have NSF Fastlane modifications made part of the —official reporting template.

Finally, measuring the impact over time of an entire NSF research program's added knowledge base on the user community is a very challenging endeavor. Time and the diversity of the user community are complicating factors. In this area, it will be useful to join with the NSF staff in EHR who have much experience in knowledge management and project data monitoring systems, as well as outside experts in the field.

CONTRIBUTORS to this REPORT

ENG Awards Impact & Assessment (AIA) Task Group Members

Wellek, Robert	CTS	Chair
Culbertson, Jo	OAD/ENG	Vice-Chair
Hamilton, Bruce	BES	
Parker, Linda	EEC	
Hazelrigg, George	DMII	
Werbos, Paul	ECS	
Hennessey, Joe	SBIR	
Aung, Win	EEC	

Other NSF Contributors

The AIA task group thanks the following individuals who either gave significant testimony and recommendations to the AIA task group and/or reviewed one or more of the various drafts of the AIA report:

Esterowitz, Leon	BES
Waite, Thomas	BES
Chong, Ken	CMS
Ulsoy, Galip	CMS
Larsen-Basse, Jorn	CMS
Pauschke, Joy	CMS
Blevins, Linda	CTS
Buckius, Richard	CTS
Burka, Maria	CTS
Ortega, Al	CTS
Goldberg, Lawrence	ECS
Rastegar, Sohi	EEC
Lynn Preston	EEC
Kemnitzer, Susan	EEC
Schwarzkopf, Alex	EEC
Narayanan, Kesh	SBIR
Ellis, Art	CHEM
Jim Dietz	EHR
John Brighton	AD/ENG

Academic Contributors

Enrique Iglesia - Professor of Chemical Engineering,
College of Chemistry, University of California at Berkeley
Faculty Scientist, Chemical Sciences Division, Lawrence Berkeley National Lab
Director, Berkeley Catalysis Center & Editor-in-Chief, Journal of Catalysis

Babatunde A. Ogunnaike – Professor, Chemical Engineering Department,
University of Delaware

Irving Wender – Professor, Chemical Engineering Department
University of Pittsburgh, (Former head of the DOE Energy Research Center, Pittsburgh)

INTRODUCTION

In a time of tighter budgets, growing emphasis upon accountability, and increased global competitiveness, it is more important than ever that NSF allocates its resources wisely. Program assessment and evaluation provides a foundation for sound portfolio management. It is also of increasing importance to assure that upper NSF management, the Administration, Congress, and the general public are aware of NSF Engineering projects that are especially noteworthy and that may have significant impact on society. By identifying the ENG-supported projects with the greatest impact and innovation, these assessments should help to more effectively promote and "make the case" for both the engineering profession and the contributions of the ENG / NSF research and education activities. Systematic assessments of groups of projects can also serve as an administrative tool to improve effectiveness of program activities. In short, the Directorate for Engineering needs to be sure that effective assessment techniques are in place to define, measure, and clearly document the impact of our research awards and projects.

The ENG Awards Impact & Assessment (AIA) Task Group is charged with (1) reviewing the current assessment techniques being used and (2) recommending new or additional approaches that ENG could use to determine or assess the impact of its investments in research, education, and innovation.

The goal of the Task Group is to propose a set of improved assessment methods that are pragmatic, systematic, and timely for use in managing current and future awards. The approaches should not place an undue workload impact on either NSF staff or the research communities of NSF grantees. In these times of tight budgets, the financial resources required to implement such improved assessment techniques are also a consideration. Whenever possible, the use of existing information management systems like FastLane will be a part of the solution—if they can be tailored to assist us.

The results of the future impact assessments—using the data accumulated by the proposed system approaches—should be important elements in determining the significance of the research Engineering is supporting, in our making the case for engineering and NSF in a variety of settings, and in assuring that we are moving in strategic directions.

It is recognized that not all organizations in ENG may need the same approaches, but some minimum standard information and assessments will be required from all units. For example, assessment methods for a program with many small academic projects will be significantly different from an activity with a relatively small number of large projects, or for projects with significant industrial collaboration (e.g., Engineering Research Centers, Industry/University Cooperative Research Centers, Small Business Innovation Research) and Special Education Coalitions.

With an adequate data base of each project's impact statements or reports, subsequent overall assessments may be used to achieve different or multiple NSF management goals–depending upon the desired "objective." For example, are we interested in highlighting significant and novel contributions to the fundamental engineering knowledge base, or the potential impact of the research results on industry manufacturing processes or competitiveness, or the impact on the human resource infrastructure? The assessment measurement objective may emphasize any number of different goals desired by NSF management. The ENG/OAD may stress one set of objectives, divisions and programs another set, and outside organizations even other sets. Therefore, the choice(s) of the objective function is currently considered outside the current scope of the AIA Task Group, since it depends on the specific goal.

The AIA Task Group cautions that assessing the significance of a project's results is a somewhat subjective process—dependent on who is doing the determination of the significance. Also, it may take the support of a number of projects over considerable time—with seemingly incremental progress with possibly insignificant impact—to finally build to a recognizable major breakthrough or innovation.

With very tight program budgets, all program directors and reviewers will want to look back at the track record of a specific principal investigator or program—as well as weighing and evaluating the promise of moving on to newer topics or programs. The question most often asked is: What has been the impact of the results from previous NSF support? It is especially important in situations where program officers and administrators change or rotate that a readily available database of accomplishments and impacts be available. These data are needed at the program or cluster level, as well as at the principal research investigator level. The performance of individual programs may need to be considered in the context of the overall division/directorate portfolio, and the metrics for assessment generally need to be based on the specific decisions to be made.

The assessment issues raised and addressed in this report should be similar to those encountered in other parts of NSF—as well as other organizations. Thus, there may be lessons learned from other organizations that can be applicable to Engineering.

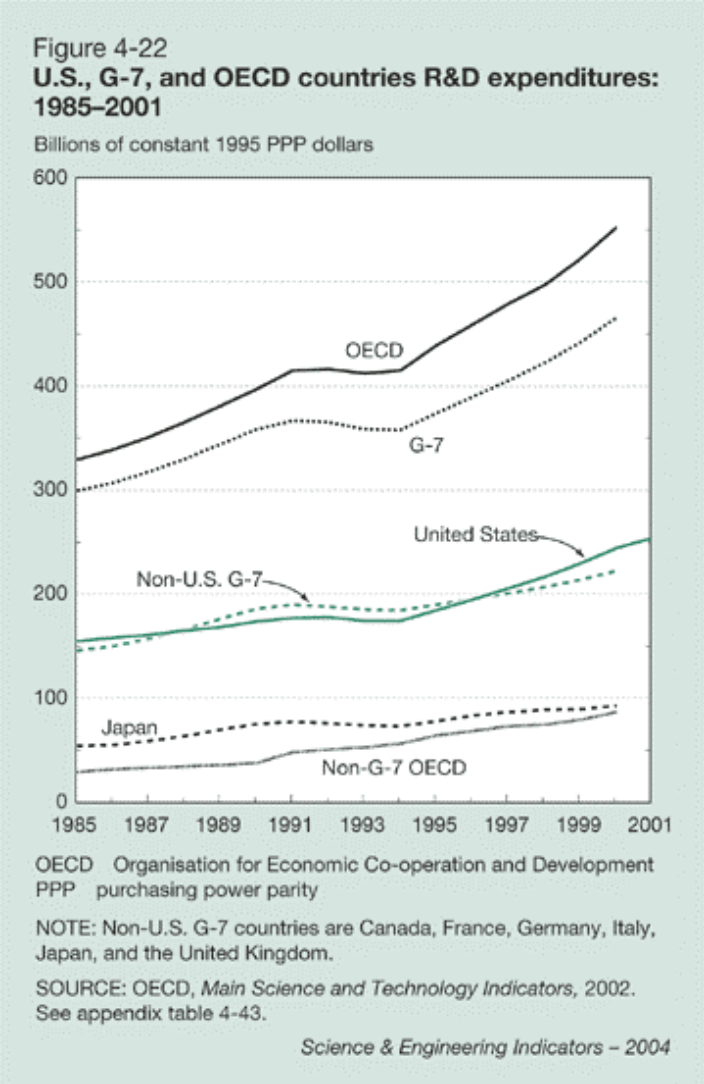
CHANGING CIRCUMSTANCES

The fiscal support available and method of operation in a research-funding agency must reflect to a significant extent the external fiscal and economic changes in the country and the world. This changing environment is reviewed in this section.

Increasingly, the international competitiveness of a modern economy is defined by its ability to generate, absorb, and commercialize knowledge. Most nations have accepted that economic policy should focus not only on improving quality and efficiency but also on promoting innovation (SRS 2004 indicators, Chapter 4). Korea and China, in particular, have significantly expanded their support for R&D.

There is concern that U.S. technological leadership may be facing a challenge due to greater global competition and greater emphasis by other countries on investing in R&D and development of a technical workforce. The U.S. still is the world leader in total R&D expenditures. U.S. R&D expenditures are almost half that of all the Organization for Economic Cooperation and Development (OECD) countries combined and are 2.7 times greater than those of Japan, which ranks second [see Figure 1 (4-22) on next page.

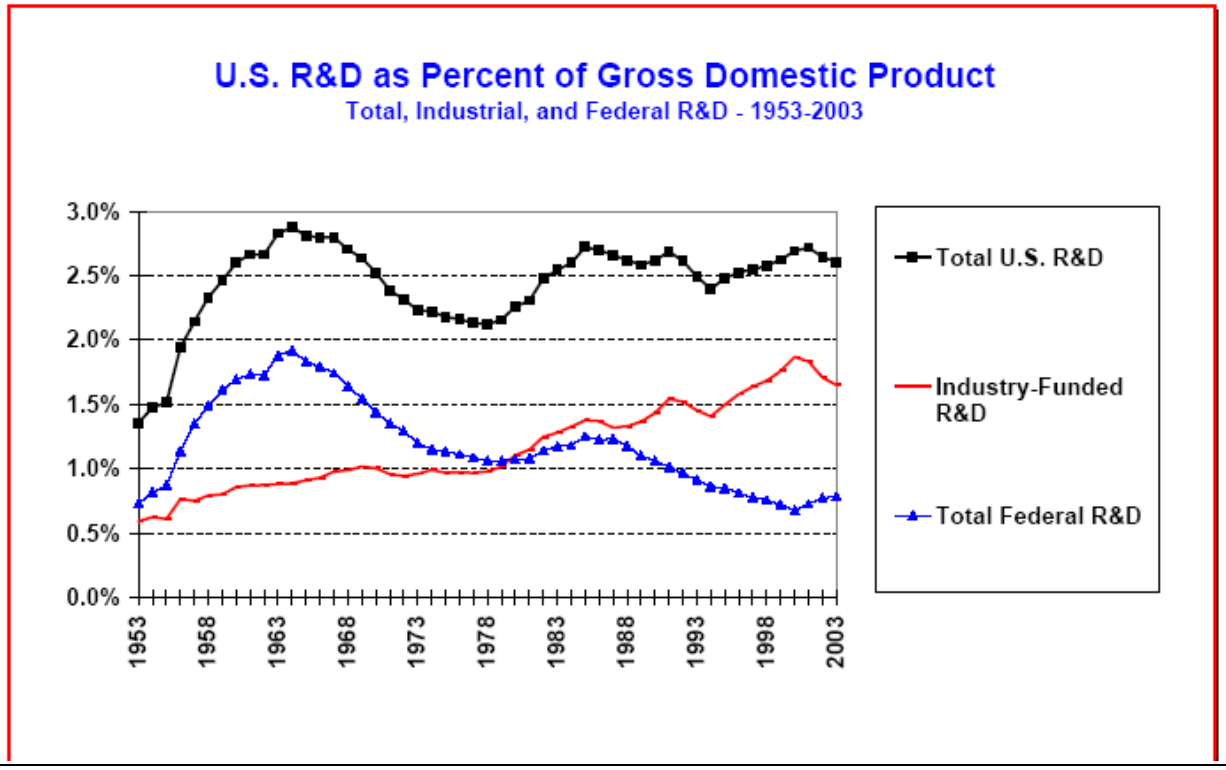
Figure 1



However, the U.S. ranks sixth in the world on a relative basis (R&D expenditures as a percentage of GDP) behind Israel, Sweden, Finland, Japan, and Iceland (Figure 4-17).

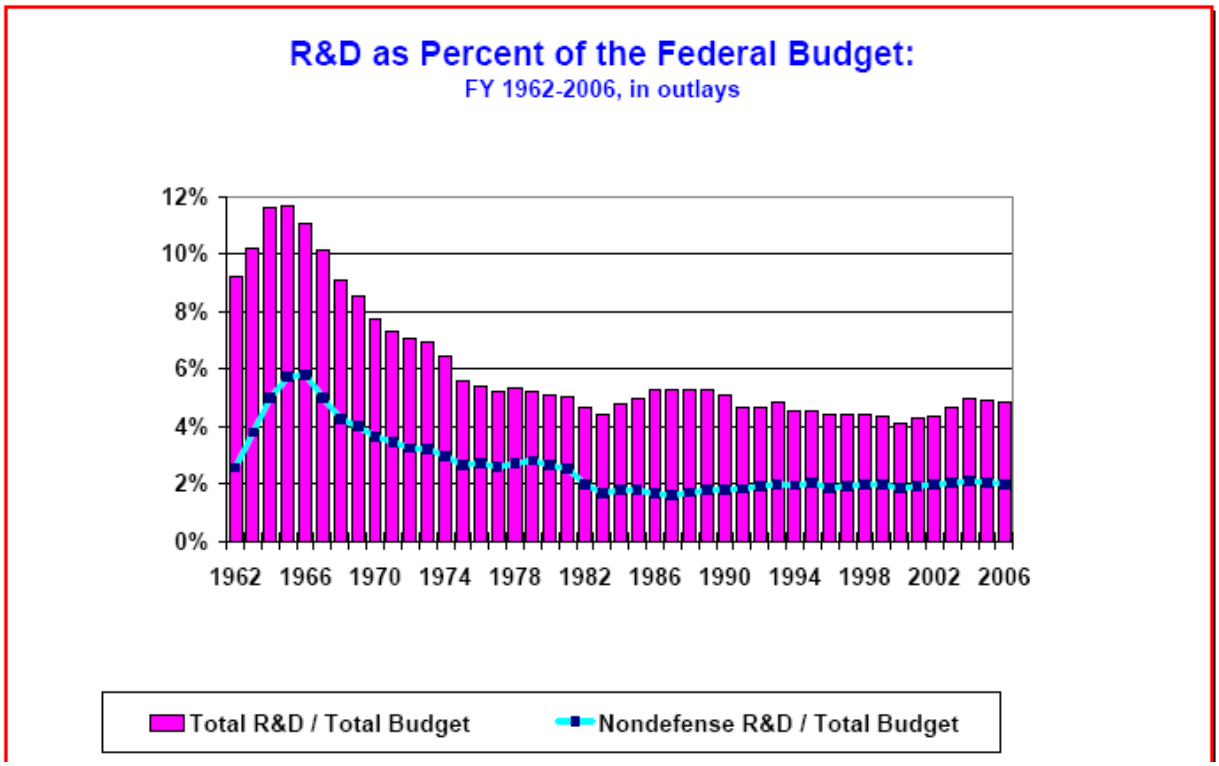
U.S. Federal R&D as a share of total R&D has been falling since the 1970s as shown in Figure 1 below. R&D as a percentage of the federal budget peaked in the 1960s at about six percent and has been fairly constant at about two percent since the 1980s (see Figure 2). With the exception of the doubling for the NIH, most Federal R&D agencies have experienced modest growth since the mid 1990s (Figure 3). With the President's FY 2006 budget, discretionary spending is projected to rise by 2.1 percent, lower than the rate of expected inflation. In an effort to reduce the deficit by 50 percent, the FY 2006 budget projects that, aside from homeland security, overall domestic spending will be frozen at the FY 2004 level through FY 2010 (Figure 4).

Figure 2



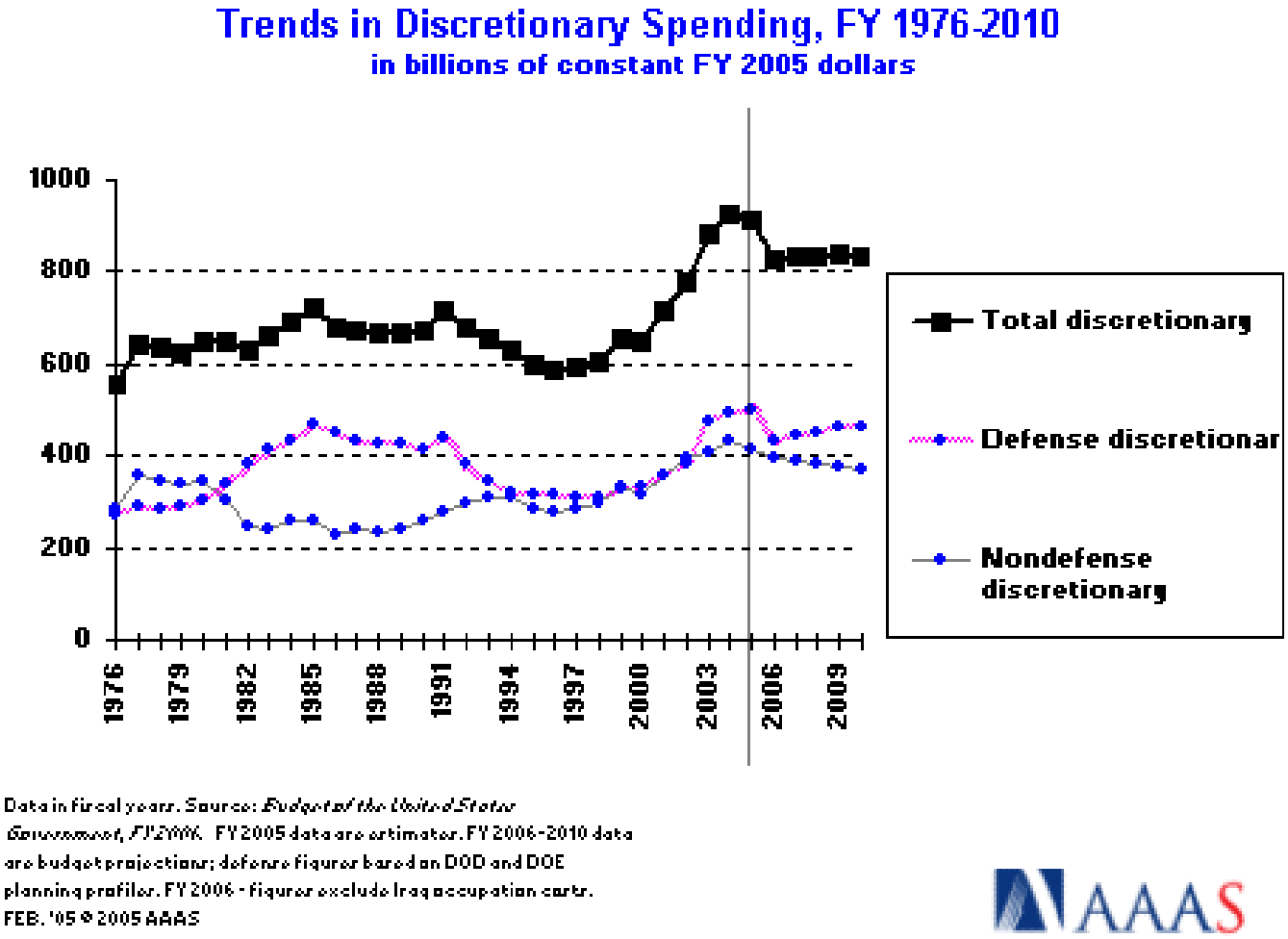
Source: NSF, Division of Science Resources Statistics.
2002 and 2003 data are preliminary. R&D funded by other sources (universities, nonprofits, etc.) included in Total U.S. R&D. Includes defense and nondefense R&D.
FEB. '04 © 2004 AAAS

Figure 3



Source: AAAS, based on Budget of the U.S. Government FY 2006 Historical Tables. FY 06 data are budget proposals.
FEB. '05 © 2005 AAAS

Figure 4



Similar patterns are evident for the Directorate for Engineering. In FY 2006, the Engineering Directorate received a 3.5 percent increase over the FY 2005 budget, or about a 2.7 percent over the FY 2004 actual values. This is modest growth that may not even keep pace with the rate of inflation.

Because of the above Federal fiscal situation, this is a time when it is critical to allocate resources to the highest priority uses and to monitor and evaluate the investment portfolio on an ongoing basis. The need to carefully assess ENG investments is reinforced by requirements under the Government Performance and Results Act (GPRA) and the Office of Management and Budget's Performance Assessment and Rating Tool (PART). Furthermore, to effectively make the case for engineering, the Directorate must be able to clearly communicate the nature of its investments and how they address societal needs and concerns.

GPRA is the primary legislative framework under which agencies are required to set strategic goals that form the basis for measuring and reporting on their performance. Each agency is required to develop a strategic plan that covers a period of at least five years and to define strategies for achieving the plan's

goals. Each agency submits an annual performance plan to OMB. OMB reviews these plans and develops an overall performance plan that is submitted annual to the Congress.

With GPRA, the intent is to shift the focus of government decision making from an emphasis on activities that are undertaken to the results that have been achieved. GPRA also asks agencies to assess the value of individual programs, but this has not been a major emphasis for most agencies.

OMB's PART analysis seeks to fulfill this function. Each year, OMB selects a sample of federal programs for assessment. The PART reviews focus on program purpose, planning, strategy, management and results, using common criteria for all federal agencies. At NSF, the COV process, independent evaluations, and reporting on quantitative goals all play an important role in monitoring progress under PART.

In view of the growing interest of OMB and others on program and Agency performance analysis, it behooves NSF and Engineering to focus more intensely on performance documentation and evaluation for a variety of reasons.

References:

Assessing the Capacity of the US Engineering Research Enterprise, preliminary report NAE, Washington DC, February 2005

Science and Engineering Indicators 2004, National Science Foundation, Washington D.C., 2004

One important strategic consideration in a changing global information and economic society is the extent to which the United States of America (USA) is a rapid and effective user of the fundamental research results generated by NSF grants. These concerns clearly go beyond issues of the quality and impact of ENG NSF grants on the advancement of the USA engineering research and education communities. To what extent, can Engineering research grants lead to a net increase in quality jobs in the USA? There is some concern in the engineering community that other nations may be more effectively be utilizing research results in moving to the development and application stages—leading to more effective and economic manufacturing and processing industries. This is most likely due to factors other than generation of research results, for example, related to factors such as adherence to intellectual property right, patents, labor and health costs, safety and environmental concerns. To what extent should the investment in research emphasize topics and fields more likely to benefit and impact USA industry, as opposed to international industries? Another important factor is the USA's ability to train a much better science and engineering workforce than our international competitors. Thus, the overall assessment of the impact of NSF Engineering research grants on USA industry and society may be very complex because of the international dimension, global economics, USA government policies, and education and workforce factors—to name just a few points. The procedures followed by the ERC, I/UCRC, and SBIR activities may come close to understanding some of these grant impact issues.

CURRENT ASSESSMENT STATUS in NSF Engineering Divisions

BES, CMS, CTS, DMI, ECS, EEC, & SBIR Approaches

These ENG Divisions primarily use the following approaches to collect assessment data:

- **FastLane** annual (continuing grants) and final reports –these reports are passable on reporting research findings, but usually very weak on reporting the potential impact of the research on society and industry. All projects report on publications, numbers of researchers and students, and provide a synopsis of the engineering science results. Each report is generally given a "pass" or "fail" grade by PDs. Most PDs do not assess the impact of each report through iterative inquires with the PI. Nor do the PIs generally provide an assessment of the overall impact of the results from their portfolios of various past NSF awards.

- Collection of **research nuggets** from selected projects. Usually, the most interesting projects are canvassed for research nuggets. Nuggets are prepared to showcase NSF's most significant achievements; they do not capture the outcomes for the overall portfolio. Nuggets highlight research and education achievements, but they don't always do a good job of describing societal implications. These selected nuggets are often used for input to the GPRA review—after being reduced to the very simplified language required by GPRA. Often, the selected nuggets address general issues of potential impact in very simplified terms. Typically, in an average program with 50 awards only about five nuggets are submitted for Directorate GPRA review. Currently, the primary emphasis is on preparing nuggets for review by the Advisory Committee for Government Performance and Results Act compliance. The nuggets developed for this purpose are often highly simplified since individuals from diverse backgrounds must read hundreds of summaries in a short time. [AIA believes that there may need for a NSF data base of more technically and in depth nuggets. These more technically advanced nuggets including references to the technical and societal impact should be available for the more technically literate—in a more open venue to the research community. These would serve both as a transparent reporting mechanism, as well as a model to the grantee community as to NSF reporting desires related to broader impacts.]

- Some divisions periodically use **grantee conferences**, where the impact of awards is reported on posters and short presentations—and also with the use of informal questioning. Assessments of the impact of the individual awards are generally not made—certainly, not in a readily accessible database. However, these conferences can be an effective way to gauge progress and some impact. Also, grantee conferences have the advantage of rapidly disseminating information and allowing peer review, although in a limited and informal manner. Because of time constraints, the coverage of award portfolios may not be 100%. ENG has been holding grantee workshops for the NSF priority areas (e.g. an annual grantees workshop for NS&E as well as many topical workshops) and for many of the project awards that have been made under solicitations. These workshops provide input on the Directorate's multidisciplinary and cross cutting activities.

Site visits: All of the above divisions use random annual site visits for their small projects, but they cover only a very small fraction of the active grants—perhaps around 3% of the projects. However, for the large centers dealing with national nanotechnology (NNIN) and the national earthquake (NEES), these projects have annual site visits from ECS and CMS staff, respectively.

Case Studies: The BES, CMS, CTS, DMI and ECS divisions have employed a few case studies, for example the BES tissue engineering study, the WTEC benign manufacturing study, etc

♦ EEC Division

The EEC division has the strongest and longest history and experience in documenting and assessing the impact of it research activities—whether it is for research in the ERCs, I/UCRC's, or large educational projects. Annual site visits are used in the assessment process, in part because of the larger and more complex scope of the projects and the large investment in centers. The ERC program carries out somewhat uniform formal evaluation procedures for the nearly 22 on-going centers. In the case of ERCs, there is a very vigorous third year study to determine if the project should be terminated after five years.

♦ ERCs

ERC research and education activities are assessed through annual reports and site visits. These follow guidelines set by NSF. The reports are comprehensive documents that must conform to special guidelines set by NSF. Beyond these, Linda Parker also works with the ERCs to assess their progress, sometimes with outside contractors. These assessment studies have been focused mainly on the research side. Starting last year, ERC program has also directed its attention to "assessment of education innovations" of the ERCs.

The Engineering Research Centers Program began in 1985 and set up a system for post-award assessment and evaluation at that time. Each center provides an annual report on progress and plans, which are assessed by an outside team of experts through the site visit format. These reviews are guided by a uniform set of review criteria that sets a standard for excellent and poor performance for differing stages of development of an ERC. Each center develops a database of indicators to report on progress, impact, and financial management. These data are included in the annual reports and are submitted to an electronic database, where they are available to NSF and the ERCs. Linda Parker, an evaluation specialist assigned to EEC, periodically carries out program-wide evaluations to determine whether the ERC Program as a whole is effective in achieving its goals. These have included studies of the impact of the ERCs on their member firms, the effectiveness of ERC graduates in industry, the impact of ERCs on their home universities, the variation in industrial involvement in revolutionary and next-generation ERCs. The program uses the outcome of these studies to improve program and center-level execution. For example, one study found that many ERC students did not get enough exposure to working on systems, a key feature of an ERC. That indicator plus concerns at the program level about how effectively ERCs focused on systems led to a change in the strategic planning constructs for ERCs. Studies of student involvement in ERCs led to the requirement that all ERCs form Student Leadership Councils (SLC). The SLCs are responsible for organizing an ERC's students to be sure that the ERC provides the research and educational experience envisioned by the program goals. The students carry out a

Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis that feeds into the deliberations of the annual review site visit teams and the ERC's management team. The ERC Program's evaluation studies have served as models for other center programs as well. The ERC database has also served as a model for other NSF center programs. Linda Parker manages data base efforts for the Nanoscale Science and Engineering Centers, the Partnership for Innovation Program, among others.

♦ Education Activities in ERCs

The emphasis on education assessment in ERCs is a relatively new requirement by NSF. Until a few years ago, there was no requirement for any education grantee to incorporate an assessment component in an education grant, like it is today.

Modern assessment of education innovations usually involves feedback from faculty and students while the innovation (a new course, for example) is being designed, tested and implemented (such as when the course designed and offered). If the developers (faculty and consultants) do not capture the feedback data in a formative and summative self-calibration/assessment process, then it becomes very hard for NSF to do any meaningful assessment after the fact.

So far, EEC has focused on determining how much information is created in the ERCs that NSF can use to do an Engineering assessment. Since many ERCs, like all older NSF education grants, have not focused on assessment of education innovations, there is very little information in their annual reports on education assessment. EEC is just starting to work with the ERCs to do an inventory of the ERC undergraduate and graduate assessment efforts.

EEC is planning on cataloguing the curriculum innovations that have been made and determining which ones might be more broadly shared through the ERC Program's web site as opposed to through individual ERCs' websites. To do that, EEC staff is focusing on methods for determining quality. Over the last several months, EEC has been attempting to catalogue their education innovations, in bioengineering to start, and determine overall what current assessment methods are used by ERCs and their associated faculty/departments and how to improve them.

♦ I/UCRC, Engineering Education and Centers Division

The Industry/University Cooperative Research Centers (I/UCRC) Program was initiated in the 1970s. Each I/UCRC has an in-house evaluator charged with providing input to the Director and the industrial partners on how to strengthen performance. There is a database, of indicators of outcome and impact, available on-line for program-level reporting and assessments. The I/UCRC Program has carried out numerous evaluations of program effectiveness through an evaluation specialist at North Carolina State University.

Local, on-site evaluators collect an assessment questionnaire process/outcome data from faculty and industry from each I/UCRC in order to provide feedback to NSF center management. National analyses are performed for benchmarking and program-level analyses. The impact data are reported by local evaluators to center directors on an annual basis to

highlight strengths and weaknesses of center operations. National results are reported to NSF to provide a program overview. Qualitative impact data are reported to identify factors that might affect the success of centers, and these data have been published in various journal articles.

♦ EEC Education Projects

The EEC Coalitions were started in 1990. EEC employed an on-site peer assessment process for each of the Engineering Education Coalitions in the early phase of their existence. The chief purpose was as much to determine the progress achieved by the coalition and to assess how the coalition was functioning as a team, both being critical criteria.

Except for the fifth year renewal evaluation, the initial evaluation had no impact on funding decisions, since the cooperative agreement was designed to give each coalition time to concentrate on doing the work and learning to function as a team. These initial evaluation processes, however, were necessary in order to smooth the process for the evaluation for the fifth year evaluation, the outcome of which was decisive towards funding for five more years. Over the life of the Coalitions Program, six coalitions were supported. Out of the six, five received recommendations from the NSF/EEC program officers for continued funding for five more years, and one failed to receive a recommendation for continued funding.

EEC contracted with SRI International for an evaluation study of the Coalitions Program. The assessment was completed in 2000. The focus of the evaluation was on the results within participating institutions after the first five years of operation, and this helped identify areas for improvement. This assessment study was used to focus the final years of the participating institutions in identifying the best curricular products, evaluating them, and implementing and disseminating them beyond the coalitions.

Another EEC education program, the Combined Research and Curriculum Development (CRCD) Program, was also evaluated in 2000. The focus was on awards in the first three years of the program (1992-1994). ABT Associates conducted the study. An expert panel using curricular materials provided by awardees performed the assessment. This represented the effort to assess EEC-funded curricular materials. Since not all awardees had materials to provide, the study was altered to focus on a pilot test of the methodology.

Lessons learned: The Coalitions and CRCD education evaluation studies underscored what ENG needs to focus on more in the future, i.e., ensuring that awardees receiving EEC funding for education projects have deliverables. The deliverable products are such items as new courses and course modules. Also, awardees were found to need to pay attention to implementation and outcomes assessments. These are required tasks in EEC funded education projects, and the assessment suggested that EEC must find and use additional methods to ensure that awardees follow through in this regard. Without the deliverables, which must be preceded by outcomes assessment, there can be no outside assessment, as was the case in the CRCD study. In other words, an important lesson learned in their assessment approach is the need to adjust the timing for the evaluation of program impact such that the program is well enough along in its history of operation. In this manner, the program can have sufficient output products to evaluate.

♦ SBIR - - Evaluation of SBIR Awards

Phase I Awards: NSF staff meet with each Phase I awardee at the three month interval of their six month award to access their award progress as part of the Phase I Grantees Workshop NSF formally assesses the award results in the Phase I Final Report. The last $33,000 of the $100,000 award is withheld, until SBIR is satisfied with the Final Report.

The Phase I Final report is also part of the Phase II proposal, and the Phase II outside reviewers evaluate it again. It can make or break the Phase II award recommendation.

Phase II Awards: The Phase II research plan has milestones and a Gant chart for the 24-month duration. The grant awardee receives about 20% of the $500,000 award up front. The additional payments are tied to interim award assessments every six months. Payments are released only when satisfactory research progress in being made. In about 33% of situations, payments are delayed because adequate progress is not being made.

SBIR also requires attendance at two Phase II Grantees conferences during the 24 months of the award. The grantee is required to provide an update of his/her progress at those events.

For Phase II awardees that receive a Phase IIB supplement (up to an additional $500,000). SBIR requires the same research assessment during the grant, plus reports on the schedule of third party investment payments that the supplement is predicated on.

After the Phase II award is complete, the SBIR company is required for five years to provide an annual assessment of the commercial consequences of the award. (SBIR has not been diligent with follow up with these assessments, but this is about to change.)

Outcome Assessment on Completed SBIR Awards: Ritchie Coryell has been assessing the commercial consequences of selected individual awards, as well as assessing the impact of multiple Phase II investments in individual companies.

The National Research Council (NRC) Assessment of The SBIR /STTR Program: The NRC is conducting a Congressionally mandated study of the overall federal SBIR/STTR program as well as agency specific programs. NSF is helping to fund this study and is a prime participant. The SBIR Division can provide more details.

♦ Case Studies

In addition to the case studies of special activities described above in the operation of the EEC division, entire division portfolios or more focused studies have been occasionally commissioned for other ENG divisions with the assistance of Linda Parker in EEC. A summary of these studies is presented in the Appendix. Generally, an experienced outside contractor like Abt has been utilized. Contractors have been used to evaluate individual programs, the impact

of ERCs and I/UCRCs on Industry to identify success stories, and to assess NSF's role in comparison to that of other agencies and the private sector in areas of long-term investment (e.g. tissue engineering). Because of the cost of such studies and the time required, case studies are used in only selected situations and only in a few ENG divisions. On an ongoing basis, ENG commissions benchmarking studies of international comparisons of entire fields of R&D in the United States with major Global economic blocs through WTEC. A list of some of these studies is given in Appendix 1.

Committee of Visitors

NSF Committee of Visitors (COVs) have served traditionally as a mechanism for NSF to obtain an independent analysis and review, every three years, of each NSF Division's adherence to NSF policies and operating norms Prior to the use of COVs, NSF Divisions had dedicated Advisory Committees made up of external professionals whose mandate included what is now the purview of COVs—along with the possibility of a broader role of assessing the overall performance of a Division's activity. This broader role could have included assessing the impact of a Division's programs and projects, if so desired. However, until recently, the COV role of review of NSF divisional performance was largely focused on reviewing whether the NSF division staff had followed appropriate NSF policies in managing and administering the processing of proposals and dispensing NSF funds. In other words, the divisional COVs primarily focused on "process issues."

The current NSF COV requirements mandate a significant formal broadening of the COV role to include a very useful form of assessment of Divisional activities—including project and program impact issues. These are given in Appendix 2. The use of the COV to address AIA issues will be discussed in the recommendation and implementation sections that follow. An example of its use by the BES division is given in Appendix 2. (The COV will form the heart of the recommended assessment approach for Engineering.)

AIA Task Group Methodology

The original AIA task force was expanded by three members (Jo Culbertson, Linda Parker, and George Hazelrigg) in order to include a greater range of Engineering expertise. The task group made extensive use of interviews with many NSF staff as its approach to analyzing what data impact results were available, should be available, and possible approaches both to assembling data and assessing them. Each AIA task group member provided information on award impact assessment techniques that had been used in their various organizational units. Other members of their divisions also provided information where necessary. In addition, several members of the task group volunteered to provide information on crosscutting topics such as changing circumstances, case studies, committee of visitor experiences, division grantee conferences, mathematical assessment techniques and difficulties, etc. The task group either interviewed or solicited comments on various drafts of the AIA report from program officers and division directors from nearly every Engineering division. The task group also contacted NSF staff from outside Engineering, for example, Chemistry and DMR. Discussions have been held with the EHR Directorate (Jim Dietz) , and they are to be expanded to include Bill Neufeld who is their knowledge management expert and oversees our project data monitoring systems. Because the results of this

task group are important to several other ENG task groups, more inter-task force exchanges are anticipated. Connections between the strategic planning group and the making the case task group are especially important. Comments from the OAD/ENG have also been useful to the final recommendations regarding increasing the quality of research nuggets.

A listing of the current and participating contacts and providers of ideas and experience to the AIA report is provided in the beginning of this report. We gratefully acknowledge and thank these many individuals for their valuable assistance.

RECOMMENDATIONS

The AIA task group offers the following highest priority recommendations as to how to gather research impact data on NSF engineering project awards. In general, these are improvements to existing approaches. They generally call for uniform and systematic application to all Engineering NSF projects. They are related to:

- **Enhanced Nugget System** (Highest Priority)
- **FastLane Modified Reports** (Highest Priority)
- **Case Studies** (commissioned / contracted to third parties; added use by COVs)
- **Committee of Visitors** (up to date assessment metrics; added focus on specific Directorate and Division strategic goals; possible use of case studies related to these goals to assist)
- **Grant/Contractor Conferences** (every 1 ½ years)
- **Dedication of a Staff Person for Coordination of Division Assessments - -** longest term
- **Secondary Recommendations**

Overall Concept: The first three recommendations will lead to greater knowledge of various metrics characterizing the research results. The fourth recommendation--use of the COV—is critical to providing the overall qualitative assessment.

The most important approaches for gathering performance data are improved research nuggets and final /annual reports. The improvements are primarily including a required reporting of: (1) the societal impact; (2) and the degree of novelty; (3) and reporting of project research on cutting edge and risky new concepts.

With the capturing of these additional performance indicators, one will be much better able to judge of the impact of ENG awards, including many other performance metrics, for the next step:

As recommended in this report, the role of the Committee of Visitors assumes a greater role in impact assessments in view of its current broadened mandate. This may require additional third party contracting assistance (case studies), in order to assist Division staff in the overall assessment process. This is discussed later.

Greater involvement of the OAD/ENG in the common tasking and analysis of the COV reports will be required for maximum benefits. The AIA task force recommends qualitative assessment of performance impact by objective third parties. This is accomplished primarily by the COV, but also should include special “case studies” by third parties that are made available to the COV.

Identification of excellent examples of interesting and important research findings by program directors and the COV members is helpful to promoting the value of the Engineering programs to society.

Details of the recommendations are provided in the following sections. The recommendations are practical and in some cases already in limited use. If accepted, the recommendations will not place an undue workload impact on either NSF staff or the research communities of NSF grantees. The use of the existing NSF information management system, Fastlane, is a part of the award impact assessment recommendations and, therefore, this should provide an archivable system for use by the COV.

The above recommendations—involving improved and/or more widely and systematically used data capture and impact assessment mechanisms will allow and help promote long-term improvements in program administration in Engineering. They will also improve the outcomes of research programs in terms of identifying result impacts. The recommendations should also help NSF Engineering management better account for its activities to upper NSF management, Congress, OMB, and the public, as well as help better justify continued and growing fiscal support for its program activities.

However, it can be very difficult to apply mathematical decision theory to evaluations related to such concepts of quality discrimination, degree of novelty, classification of frontier or cutting edge, and importance of impact. The task group and a number of other individuals giving testimony caution that overall quantitative impact assessments for fundamental research and education projects must be done very carefully and by knowledgeable and objective individuals. Erroneous conclusions may result if assessment results are used in any context other than that for which the assessment was specifically designed. Thus, extreme care should be taken if assessment results are used as administrative management tools. These concerns are addressed in the **Appendix** and in the final section on caveats and metrics for assessments.

Discussion of Recommendations

The goal of the following recommendations is to introduce improved methods of efficiently acquiring outputs, results, and potential impacts of a research award (or a set of awards) from which an assessment of the quality of the research may be inferred at a given time. As will be pointed out later, an assessment of quality depends on the data collected and the selectively chosen objective of the assessment. In other words, is the object of the impact assessment the enhancement of engineering science literature, or the novelty and significance of the findings, patents, ability to impact industrial practices, to start a company product line, or the development of an educated class of engineers—just to name some obvious possible performance objectives.

Discussion of the high priority recommendations to gather this information is given as follows:

◆ Enhanced "Nugget" System

Brief illustrations of significant project accomplishments ("nuggets") from every award are essential annual products to program, Division, and Directorate administration. The very brief nugget reports must address key aspects of the program, Division, and Directorate assessment metrics. They also form the basis for responding to NSF GPRA requirements.

It is recommended that the Directorate introduce an Enhanced ENG Research Nugget System, until the changes to NSF Fastlane (described in the following sections) are officially accepted.

- Require that all ENG Principal Investigators address two items (**Uniqueness / Innovation and Societal Impact**) be included to the brief enhanced nugget report on NSF FastLane, in addition to addressing the substance of the engineering results. These enhancements stress the impact of the award results.

- Require that **all** ENG Principal Investigators submit a "Nugget" (in Word) of major anticipated and actual accomplishments of the NSF project to their PDs—as an attachment to the Fastlane report. (This is in addition to special calls from PDs for nuggets for GPRA or other NSF needs.)

- **A nugget should be required** with each submission: Standard Nuggets with clear Engineering and Scientific details; Later the Program Directors may prepare shorter GPRA nuggets with simple, layperson type language. (Examples are given in the Appendix, starting on page 16.)

- It should be noted that until NSF policy approval is obtained that allows NSF to require all grantees submit an annual nugget, submission of nuggets must be on an optional or ad hoc basis.

- Review panelists will have access to the annual and final award nuggets submitted as part of their review of proposals that are renewal requests of previous awards. This procedure supplements the section of proposals that includes a summary of previous NSF sponsored award results. The introduction of this procedure should increase the attention placed on the preparation of useful nugget-type statements of previous accomplishments, as well as the effort to describe the impact of award results. It is expected that this procedure will enhance the quality of the nuggets.

- "Final report" nuggets should/could be selectively posted on public ENG Divisional web sites in a format similar to the GPRA Nugget database. These final report nuggets would provide immediate visibility for Engineering Directorate activities and accomplishments to the public—assessing the impact. These nuggets would be somewhat more in depth and technically oriented than the GPRA nuggets. This public availability of report nuggets also provides a synergy that will play a key role in selling the "Scientific and Engineering" message to a larger audience—with potential increased support from NSF decision makers, the public, Congress, etc. (This Enhanced Nugget reporting activity is relatively easy to implement.) However, it should be noted that until NSF policy approval is obtained that allows NSFENG divisions to disseminate this information, this recommendation can not be implemented. A policy ruling regarding how to satisfy OMB and NSF guidelines for ensuring and maximizing the quality, objectivity, utility, and integrity of the final report nuggets has to be obtained. One approach might be to submit the final nuggets to internal and external review. NSF might also have to obtain a PI release to post the nuggets on a Division Web site.

- All award principle investigators will be informed that selected PIs, with the most interesting nuggets, will be invited to present their project accomplishments at NSF in a special meetings hosted by each Division. If scheduling issues can be resolved, the presentations may also occur at the Divisional Grantee Conferences, but with special honorific recognition. It is expected that this honor will enhance the quality of the nuggets.

- All PIs should be reminded 1-2 times a year that Engineering encourages the submission at any time of "Flash nuggets" that alert Eng program officers and management of: special accomplishments with major impact, or "to be published" findings in very prestigious journals, or special honors. These high impact "happenings" can then be shared with Engineering and NSF-wide media/publicity staff responsible for developing broader dissemination of the information and credit to Engineering and NSF to/with the more general public.

It is important to stress that in order to maintain the quality of research accomplishment nuggets all program officers must carefully review the submitted nuggets and offer comments to the PIs as to how to improve the clarity and usefulness of the content. It is expected that the average nugget may require up to two recycles until all PIs understand what content is desired by Engineering. The placement of the outstanding nuggets on a public web site is also expected to aid in raising the quality of the accomplishment descriptions.

Examples of some styles of nuggets are given in the Appendix. Although the content of nuggets we recommend must be standard, AIA recommends that the style of nuggets be allowed to vary based on the creativity of the PI and program officer, as well as the purpose for which the nugget is used. For example, we have recognized that GPRA exercises require very "simple " styles understandable to the layperson, whereas the Standard nuggets will be more technical/scientific in language content. For many applications, the program officer will also be advised to request a one page backup narrative that explains in more detail the meaning of the nuggets or special focus relevance.

NUGGETS for EDUCATION: AIA TG recommends that the same techniques discussed above be applied to building a database, within FASTLANE or otherwise, on all education projects emanating from NSF funding within EEC, as well as in the five "disciplinary" research divisions.

◆ Modified NSF FastLane Reports

The current NSF template for award reports submitted through Fastlane is structured to provide information that is useful for determining and assessing the award accomplishments. But the template leaves it up to the awardee to volunteer information on the degree of innovation (whether in a cutting-edge or frontier area) and on the broader impact of the results, aside from adding to the general body of engineering and /or scientific knowledge or education practice.

The requirements and format of NSF Fastlane Project Grant Final Reports should be modified to call for the addition of simple, concise statements of the following two items that would be useful in assessing impact:

- What is **unique** or **innovative** about this project in terms of engineering science research or education? What distinguishes the results from other current research and knowledge on the topic? Is the research in a "frontier" area? Why are the engineering science aspects of the results important? How will the results advance the field or define new areas of inquiry? To what extent was this research considered risky or groundbreaking?

- What are the current and anticipated **future impacts** of this project on industry, society, and academia?

Fastlane should provide a **specific template** location for the above points, so that researchers are prompted to provide information. The above points address the potential usefulness of the NSF research and education development to the public and the government—as opposed to the typical research paper published in the literature. These reports will have to be carefully reviewed and improved before approval by NSF program officers —if the results impact statements are unclear.

It should be noted that until NSF policy approval is obtained that allows NSF/ENG to require that all FastLane reports use a template that calls specifically for Impact and novelty statements--requirements for this information must be on an optional and *ad hoc* basis.

The AIA task group recommends that final, approved reports be **public information** on a NSF FastLane Web site and /or on Divisional Project Report Sites—perhaps referenced in concise nugget format. These data form an important database for future assessments of the impact of the research.

◆ Annual NSF FastLane Reports for Standard Grants

For continuing grants, annual reports are required. They may be used for assessment purposes through the life of the Grant. However, standard grants do not require an annual report through FastLane--and, as a result, voluntary annual or interim reports are usually never entered in FastLane.

The AIA Task Group recommends that all ENG standard grants require interim annual reports be submitted to NSF through Fastlane. As many ENG divisions move toward increasing the use of standard grants, this recommendation becomes doubly important. Implementation of this recommendation would require NSF policy approval.

AIA recommends that all ENG Program Directors be required to review progress annually for all current standard grants and strongly recommend to Engineering that annual or interim reports be automatically requested and submitted through Fastlane. (The AIA TG does not believe that any changes to FastLane would necessarily be required, because this would be an ENG recommendation to all ENG Principal Investigators. After an initial test of this procedure, perhaps it could be implemented NSF-wide in Fastlane.) (Note: It was just learned in a meeting with DGA staff that PIs with standard grants may be asked—and reminded—that such interim reports would be called for at the NSF-wide level. This is not yet approved.)

Program officer must review the reports to assure that information related to key assessment metrics are included before approving the reports. This especially includes issues related to Uniqueness / Innovation and Societal Impact.

Case Study Assessments

The AIA Task Group recommends the use of relatively large retrospective Case Studies of NSF/ENG Divisions, Programs and activities. This recommendation should include division-by-division, randomly selected, award-level case evaluations done by a contractor, as well as a program and integrated Division analysis in support of COVs (discussed below) and other assessment needs. These are fairly in depth studies and will require a significant set-aside of resources for the use of a third party contractor. Because of the heavy workload currently on NSF staff, the contractors can greatly increase the depth of the case studies.

While case studies may be used for a number of reasons, case studies of Divisional award portfolio impact are best if done well in advance of a division COV. This is discussed in the next section on COVs. If desired, the case study may also include a completed award portfolio assessment, but certainly a reasonably complete, but at random partial, examination of the program portfolio. ENG management may also require special additional case studies for activities related to important ENG strategic goals, and/or for high-visibility ENG activities. Examples are micro and nano-materials technology, earthquake research, manufacturing, CAREER, exploratory/innovative research, education, engineering human resource issues, etc

As in the case of the NSF nuggets and reports recommendations discussed in the previous sections, the case studies must address the performance metrics or the programs, divisions, Engineering Directorate, as well as at the NSF level for the required COV reports discuss below.
While a fairly complete NSF COV template exists, case studies will be an excellent opportunity for Divisions and programs to address their specific performance measures in both quantitative and qualitative senses. For example, what are the true success rates for unfenced funding activities as compare to fenced or solicited activities, and what is the difference in quality and innovativeness from awards in the two funding categories. The divisions might also make comparisons from other countries in terms of productivity, quality, and with impact of results. Other examples of interesting approaches are given as follows:

Case Study Tracking Investigators: Another type of case study is related to tracking a random sample of ENG individual awardees (PIs) over their careers. The AIA Task Group recommends that this approach focus primarily on investigators with sustained NSF support to assess their long-term accomplishments. (Another recommendation is to focus on PIs five years after completion of major, sustained support ends.) Use of a third party to assess the impact is strongly recommended. These studies should be performed at the program level.

Longitudinal studies**:** These studies can help to determine:

- Role of NSF support and of different modes of support (e.g., Regular grants vs. SGERs; Individual vs. Multi-disciplinary Groups and Centers)
- Role of other Federal agencies (and areas of potential interagency cooperation/collaboration)

- How curriculum/areas of specialization/ educational experiences shaped the individuals' careers
- Process of lifelong learning and adaptation. (ENG could hire a contractor to conduct surveys, including interviews, of this small sample on a periodic basis (say every 5 to 7 years).

Long-Term Impact on Society of NSF Projects**.** "Society and Industrial impact tracking" case studies can follow the handoff of major ENG discoveries to industry and society by hiring a contractor to:

- Collect data on new start up companies resulting from NSF-funded awards (Done now by ERC program)
- Document NSF's role in transferring technology to other agencies through interagency collaborations
- Patent activity (ERC data are available)
- And the role of NSF-funded investigators in helping to spawn new fields

Summary: The case studies will help NSF assess and improve the overall program effectiveness. They also will assemble important data on new accomplishments with significant impact to the public body of knowledge. The results of the case study assessments will be used in conjunction with planning and "making the case activities" conducted at the Directorate level.

◆ Committee of Visitors

The AIA recommends that the every three-year mandatory NSF review by the Divisional COVs serve a key element or platform for assessing the impact of the Engineering divisional and program research and education portfolios. The issues addressed in the NSF template are given in **Appendix 2**. The NSF COV template for reporting includes in Section 4 of the NSF requirements a very complete set of AIA-type questions, and they are time consuming to complete fully. The template questions require answers from the COV that address many of the key assessment issues related to quality, impact, and innovativeness of the award results. The selection of members of the COV is primarily made by the DD of the particular division. Membership also includes a representative of the Engineering Advisory committee.

The NSF COV review now extends well beyond its traditional emphasis on program "process" administration.

The task of the COV and the supporting divisional professional staff can be made immeasurably easier and complete with the acceptance of the other recommendations of the Engineering AIA task group, especially those related to enhanced nuggets, enhanced Fastlane reports, and Case studies discussed in the previous section. Case studies made in support of the COVs should begin about 1½ years prior to the COV.

The ENG management should very carefully frame any additional issues that we ask the COVs to address. In other words, while ENG may find it useful to include a statement that in order to take full advantage of the opportunities that we have under the current COV guidelines, that the Divisions may wish to formulate some strategically and very targeted chosen issues/ topics on which they would like input from the COVs. AIA does not recommend additional analyses that could overburden the COVs or

NSF staff—unless NSF is able and willing to give the COV extra outside help through a Case study performed by outside contractors and/or independent third parties in advance of the COV.

The head of the previous divisional COV, the future COV, Divisional, and Directorate representatives should meet about 1 ½ years ahead of the next planned COV discuss what performance indicators can be studied in detail in any Case study meant to assist the next COV in preparing its report. The initial plan for potential case studies should be proposed by the Division Director and Division coordinator in consultation with the AD COV coordinator.

◆ Grantee Conferences

Grantee conferences are commonly used in Federal and non-Federal mission-oriented research organizations, and some ENG divisions also successfully use them.

For example, the DMI model for a grantees conference works particularly well. This conference has been held annually, although DMI is moving it to an 18-month cycle. DMI grantees submit proposals to host the conference, and a host is selected from among these proposals. A goal is to have the conference in a different location each time, spanning the nation, however it is important to take into account considerations of weather, particularly for winter conferences. The conference spans three days, with pre-conference activities including a proposal writing or research development workshop, and other workshops for graduate students and CAREER awardees. The core of the conference includes plenary speakers on topics of importance to DMI grantees and a banquet with an inspirational talk. But the main feature of the conference is a series of poster sessions at which every DMI grantee is requested to present their research. Progress papers and research nuggets are published on CD, and comprise a major input to the Division for meeting its GPRA reporting requirements. The conference offers a very cost-effective approach to enable DMI program directors to meet all their grantees and talk to them on a periodic basis.

Recommendation: Award Principal Investigator Conferences should be made mandatory for all ENG Divisions, perhaps on a 1½ or two-year cycle. Annual or Bi-annual Grantee Conferences give a convenient opportunity for Management and Program Directors to assess and compare the impact of all the individual active NSF supported Research projects over a period of time. Third parties can be invited to help prepare an independent Impact Assessment. When convenient, members of Division COVs and special evaluators/observers could be invited. *(If the conferences are held in Washington, the NSF PDs may also be assured of conserving their travel funds and NSF management has a better opportunity to attend. Cohesiveness of the grantee cohort is also achieved as well as the opportunity to effectively communicate and interact on late breaking NSF issues. These meetings should be especially useful in assessing progress and impact of CAREER grantees.)*

◆ Dedication of a STAFF PERSON for COORDINATION OF DIVISION ASSESSMENTS - - longest term

The implementation of all of the above five recommendations on a continuing basis will initially require the dedication of a portion of an Engineering division staff person's and contractor's time to coordinate

the divisional assessment activities. Some of the staff requirement will be for setting up a web site that explains the new comprehensive division (and/or Directorate-wide) assessment information requirements as they are accepted for implementation. Those data that are not currently collected through Fastlane may have to be collected on some dedicate shared drive location—and archived. This would include assisting the division director with COV preparations and collecting findings from a division focused case study, from Grantee Conference, and other special sources—including the secondary recommendations described later in this report. For example, the collection and proper aggregation of the desired data into various useable formats is very time consuming and exacting, as any division director preparing for a COV can attest. It is recommended that a single contractor – with experience and assistance — may be able to serve several divisions in setting up a unified format for assembling and pre=analyzing the information. Even with this assistance, program officers have the key role of assuring that principal investigators (PIs) provide useable results through critical review of the assessment data (from Fastlane reports and nuggets).

◆ Secondary Priority Recommendations for Impact Assessment

The following additional AIA recommendations are proposed for consideration and potential use, but they are of a secondary nature compared to those in the previous section. They should not be required across all divisions.

Database / Text Mining (selected priority areas): Periodic database assessments of ENG investments that may have led to new paradigms / paradigm shifts are of potential usefulness in broad impact assessments. One proposed technique for database assessments is the use of database "mining" which is described below.

Advanced data mining and information visualization techniques can be applied to support science, engineering, and technology management. Large amounts of, e.g., publication, patent, and grant data are analyzed, correlated, and visualized to map the semantic space of researchers, publications, funding, etc. The resulting visualizations can be utilized to objectively identify major research areas, experts, institutions, grants, publications, journals, etc. in a research area of interest. In addition, they can assist identify interconnections, the import and export of research between fields, the dynamics (speed of growth, diversification) of scientific fields, scientific and social networks, and the impact of strategic and applied research funding programs among others.

Recommendation**:** AIA recommends that each division consider conducing an assessment of its programs on a 5-10 year cycle. This could include "text mining," such as a citation analysis, patent analysis and interviews by key experts to determine whether they believe that patents / highly cited research articles did, in fact, lead to a scientific paradigm shift in a engineering sub-field. For example, a point to be considered is—have new interdisciplinary engineering fields emerged, or have new industrial processes or products emerged, as a result of the sustained NSF support? Many other approaches might be envisaged. A supporting approach recommended is use of "knowledge mapping and visualization" techniques. This would employ content analysis and situation analysis of patents, scientific literature, proposals, and grants to determine growth patterns in various technologies and relation to NSF

supported studies. A few pilot approaches for selected division or other organized ENG activities are recommended, similar to the recent joint effort by the NSF SBE program and the Nanotechnology coordinator—supported at the AD/ENG level.
ENG could commission a consultant, such as Dr. Hsinchun Chen, at the University of Arizona Artificial Intelligence Lab, to perform a "Study on NSF Engineering Support and Research Development Based Upon Patent Analysis". ENG and /or Division management could pick priority or strategic areas and activities in ENG to evaluate. Such a study could apply "knowledge mapping and visualization" techniques [mostly via content analysis and citation analysis of patents, scientific literature, and proposals) to assess the research output and impact of NSF-funded Engineering research.] This recently has been done very successfully by the SBE and NS& E coordinator for NSF's nano S&E award investments.

Program Review Articles (selected priority areas): AIA recommends the periodic use of openly "published" review articles of NSF projects, because AIA believes that they may help raise the quality of research results and of the reporting to NSF by PIs. The impact of the NSF projects would be made more widely available in a comprehensive manner.

Each division would commission review articles covering each program in a Division on a three-year cycle, and the review placed on a public ENG web site. The articles would be prepared by a "third party" academic in conjunction with OLPA and ENG communications directors to give an overview of key program projects. The articles would summarize the major accomplishments. Communication specialists would help assure that the feature articles are on the complexity level of the Scientific American journal. While the articles would help promote the relevance and vitality of the engineering programs, they would also help assess the potential impact of the ENG programs. The outside engineering community would have the opportunity to help assess the impact of the ENG programs through voluntary and informal contacts with PDs and ENG management in reaction to the review articles.

Random Sampling Assessments of Individual Grants: A part of any assessment of award results and potential impacts should include some on-site visits to PDs to talk to them and their students to verify their actual accomplishments. PDs have constrained travel budgets and time, and so the Task /group recommends occasionally commissioning third party visits to Grantees.
Customer Surveys: Periodic and objective "customer survey" type assessments, similar to student course evaluations at universities, can be a useful and powerful mechanism for continuous improvement at NSF. These surveys may be used to focus on the NSF process or even on the impact of the NSF projects supported. (However, we use this type of assessment, we must be mindful that disgruntled university customers can negatively sway results from customer survey assessments, especially at a time of low success rates. Industrial observers may be valuable customers regarding long-term use and impact of NSF project findings; however, those using NSF project results may be difficult to locate on an objective basis.)

Individual Grantee / PD interaction: Regularly schedule –once a year—telephone conversations with each NSF PI to assess their progress and impact. The conversation would be preceded by completion of an up-dated progress report and/or discussion guide in order to aid in the telephone discussion. This special report can be inserted into Fastlane as a special report.

International Assessment of Engineering Fields: Each Division or Engineering management may wish to commission a comparative case study of specific fields of Engineering research that are highly recommended in the latest ENG Strategic plan. The comparison assessment would focus on countries with major science / engineering activities and with strong industrial track records in pioneering and emerging fields. These could follow the pattern of the WTEC studies. (An impact assessment of the past studies is recommended, because of the significant cost of WTEC studies.) ENG front office support is recommended only for those areas that represent NSF and Directorate priorities.

Common Data Elements related to All Impact Assessments: The AIA Task Force should develop and recommend to ENG management the data elements that should be collected for subsequent impact analyses—common to all ENG programs. Many of these elements may already be required through Fastlane or are discussed in other sections of this report—but further consideration of these common data is warranted. (Should be expanded. Would like input from M. Reischman's task group.)

IMPLEMENTATION
of Primary Recommendations

The Engineering Directorate needs to consider the ease or difficulty to the NSF staff and the external grantees in the introduction and implementation of the proposed recommendations.

◆ Enhanced Nugget System (Highest Priority)

Discussion: The AD/ENG office and Division DDs will play the major role in notifying all active PIs of the ENG program need to receive enhanced nuggets (with inclusion of scientific and societal impact statements) on a regular basis on December 1st of each year. PDs will assist in dissemination of the new policy regarding inclusion of statements of potential impact and significantly novel scientific findings in research nuggets. This recommendation would replace the somewhat ad hoc, non-uniform, and selective approach currently use by PDs for obtaining nuggets. This recommendation will require NSF policy approval.

Timing of Implementation: This "Data and Nugget" collection activity could be implemented simultaneously Engineering-wide as soon as possible--so that the timing contributes to the gathering of Nuggets for the annual GPRA assessment or other requirements. With such timing, all current Principal Investigators are simultaneously introduced to the "Data and Nugget" requirement. Once the initial Nugget submissions have been modified appropriately (usually a simplification), the PIs would then be required to also include the same general nugget information (updated, of course) as part of their Annual and Final Reports. Widening the scope of the nugget collection and their capture in Fastlane increases the scale above what is current practice and assures an archive system for many users.

Nuggets /Information on new, breaking Findings: The AIA task group suggests that ENG DDs should send e-mail reminders to PIs twice a year on the importance of informing NSF of major discoveries, well in advance of their announcement in research publications. This will aid in OLPA developing timely media announcements. The NSF Chemistry Division currently uses this approach.

◆ Enhanced FastLane Modified Reports (Highest Priority #1)

The NSF awardees should have little difficulty including a paragraph regarding the novelty and impact of their work in the Fastlane system. However, discipline is necessary on the part of NSF program officers to review the PI input and maintain quality of the responses. The major difficulty in introducing and implementing this recommendation is the effort to make any modification to NSF's Fastlane procedures and format. In this case, the change amounts to making two simple additions in the template for the award reports. Conceptually this is easy, but NSF-wide policy approval is required.

In the interim, it would be relatively simple to request most ENG grantees to insert these additions into the existing Report format on an ad hoc basis. Upon acceptance by the ELT and the ENG/AD, each division would have to encourage its PIs to submit this required addition to Fastlane reports. One possibility would be to ask DGA to include this requirement in the award letter. But, NSF-wide policy approval is required.

◆ Case Studies

Each Division should conduct a "case study" of the impact of its awards once every three years in order to assist the COV review. It could also include targeted issues of interest to the division and the Directorate. These studies should be developed with the assistance of an Engineering Evaluation Officer to assure that common approaches are used. The OAD/ENG should participate in the development of uniform ENG data requirements and objectives.

Implementation Details: Each division would set aside an allocation of about $250K for a case study. The case studies could be modeled on the *Abt* DMII academic award study (covering the period 1986-96) administered by Linda Parker. The studies may take 1-2 years to complete. The studies should direct its primary goal to identify good nuggets of accomplishments and impacts over an extended time period.

Background Details: Linda Parker has assembled a summary of the results of a number of past NSF case studies employed by ENG and other elements of NSF. This is Appendix item 1. For each past ENG evaluation (case study), various actions were taken in follow-up to the Case Studies evaluations by the contractor. This compilation answers: what were the outcomes of the case study, and what was learned from the experience? On the compilation summary, AIA provides an indication of: what management actions were taken in follow-up to the evaluations, what were the outcomes of the actions, and what there is to learn from the past experience to help the potential user make recommendations to management as to whether and when to implement a case study. This is useful because of the time and significant resources required for its completion of such comprehensive studies.

Discussion of Past Case Studies Relevant to Implementation:

Past BES and DMII studies: Our perception from limited conversations is that the DMII and BES studies were not used very much as management tools to set strategic or tactical directions. However, the studies were made available to the COVs. We believe one can learn much from these studies, e.g., about study design versus the purpose for which one want to use the potential case study output for; the role of NSF research vs. other support I developing a field.

The SBIR Commercialization Study: Ritchie Coryell in SBIR led this. This study has been under way for two years and is being actively used by the SBIR COV, the Advisory Committee, as well as the NRC. It is believed the study is having a significant impact on the tactical and strategic direction of the SBIR program.

◆ Committee of Visitors

The recent BES COV experience is relevant to the recommended implementation approach using the current comprehensive COV requirements. BES's implementation procedures are described as follows and can be used as an initial model for other ENG divisions: The BES COV addressed all the "key" impact assessments issues by responding to all the NSF template questions. (**See Appendix 2 regarding COV impact issues**.) However, given the brief duration of the COV, the COV's answers were far from comprehensive. The responses were more of an anecdotal (nugget-like) character.

The BES procedure for assembling the COV information: The BES division staff provided the COV with both printed and electronic copies of the BES Nugget packages for each of the 3 COV years. BES provided the COV in advance with the most recent version of the BES draft Strategic Plan, which summarizes BES accomplishments and provides, highlights of examples.

At the COV meeting, the BES DD provided an overview presentation and BES's program officers made short presentations, which provided some highlights on program accomplishments. BES provided the COV with pre-prepared resource material for answering each and every COV template question (see more below on this). The various COV members inspected a total of 92 jackets, including 47 awards, from which they obtained some information. This represented approximately 20% of the grants active in BES in the past three years. Some of the COV members had prior experience with BES, from panels, ENG Advisory Committee participation, their participation on WTEC studies led by BES (e.g., the WTEC studies on tissue engineering), their own grants and declinations from BES, and with grants of colleagues from BES.

Amassing most of the necessary information took considerable time of the COV and significant staff time to summarize it. This process was managed as follows: In advance of the COV, each BES program officer was assigned to be a "buddy," i.e., a specific COV member to interact with during the process. Each COV member was assigned specific template questions for which to be lead discussant at the COV. In each case, the BES program officer buddy had pre-prepared resource material relevant to answering the template questions assigned to their COV-member buddy. BES program officers took significant time to prepare these resource materials in advance. Two weeks before the actual COV, BES

had a "mock COV," where each BES program officer played the role of his COV buddy. Based on the pre-prepared resource material that they had prepared for the COV, the BES PD presented an answer for each of the template questions assigned to their COV buddy (as lead discussant).
As a result of this experience, the BES DD recommends the following key changes from what they recently used: "… I am an advocate of one of the strategies that we came up with in AIA task group, namely, a year in advance of the COV, having a divisional assessment done (some years ago) by an outside contractor, such as was performed by the Abt assessment of DMII."

Future COV Implementation: The AIA task group strongly supports the recommendation of using the COV process as part of the assessment process in Engineering. AIA also recommends use of an outside contractor in order to obtain a more comprehensive analysis of the award impacts and in order to reduce (somewhat) the tremendous burden on the Division staff in providing the necessary information. The additional recommendations as to enhanced nuggets and enhanced Fastlane reports are also necessary to make the task of the preparer of the Case study more complete and effective. As each subsequent ENG Division completes a COV review, the procedures will be refined.

The head of the previous divisional COV, the future COV, Divisional, and Directorate representatives should meet about 1½ years ahead of the next planned COV to discuss what performance indicators should be studied in detail in any case study meant to assist the next COV in preparing its report. Traditionally, one member of the Engineering Advisory Committee has served on the Division COV. The AD/Engineering may wish to nominate other members to the COVs with broad experience in the sub-disciplines of the particular Division to insure independent oversight of Directorate representation and interests with regard to strategic Directorate goals. A member of the ENF Advisory Committee may also be invited to the planning session or allowed to comment on the case studies plans. AIA recommends that the initial plan for potential COV-related case studies should be proposed by the Division Director and Division coordinator, in consultation with the AD COV coordinator. AIA does not recommend additional analyses that could overburden the COVs or NSF staff—unless NSF is able and willing to give the COV extra outside help through a Case study performed by outside contractors and/or independent third parties in advance of the COV.

Summary: The AIA task group believes that Directorate's use of the COV reports for assessments serves as an integrated and systematic way to obtain a qualitative assessment of the impact of the Division's programs and grants.

- **Grantee Conferences.** The experience and procedures used by the DMII division and other ENG divisions such as EEC can serve as a model for other ENG divisions.

Implementation
of Secondary Recommendations

Discussion of the implementation of the secondary recommendations is integrated into the previous sections on their recommendation.

ASSESSMENTS & MEASURES OF PERFORMANCE

◆ INTRODUCTION:

The goal of the AIA task force report is to ultimately answer and deal with the following aspects of any assessment:

- How do we more effectively collect results from engineering research awards? (In earlier sections of this report, we have reviewed, recommended (and prioritized) specific approaches for Engineering for capturing these results.)
- What kind of assessment objectives or measures are we primarily interested in-- from the standpoint of Engineering? (What are the performance metrics or indicators?)
- What class of results are we interested in for generally small individual and group grants? Are there additional or different results we are looking for in the case of Engineering Centers and SBIR awards?
- What is the role of time in capturing the measure of performance for fundamental research and education projects whose impact is generally slow to recognize?

Also up to this point, we have not specifically addressed in detail the issues of:

- **Quality**: How we tell if the results are good—and to what degree. How do we carry out the assessment in terms of deciding what is the quality performance?

- How do we determine if the results have a **significant impact**? And impact on what?
- How do we determine the **extent of innovation** in pioneering areas, or in general?
- An important point is whether one uses **qualitative** (perhaps subjective) **assessment approaches**, or whether we use quantitative assessments. Or, do we use a mixture of these approaches.

It has been previously recommended in this report that the cornerstone of the Engineering Directorate's assessment approach and metrics should be based on using NSF Divisional COVs and, therefore, using the current required NSF COV template metrics. (These are outlined in the Appendix.)

The **current NSF COV assessment metrics for program or division portfolios** include key questions regarding impact, and they are given as follows (rearranged):

- Overall quality of the research and/or education projects supported
- Appropriate balance of high risk
- Appropriate balance of innovative *(frontier*) projects
- Appropriate balance of multidisciplinary projects
- Appropriate balance across disciplines and sub disciplines of the activity
- Appropriate balance of projects that integrate research and education
- Appropriate balance of emerging *(frontier*) opportunities
- Noteworthy achievements of the year based on NSF awards
- Examples of outcomes (nuggets)
- Expectations for future performance based on the current set of awards
- Program relevant to national priorities, agency mission, relevant fields and other customer needs
- Ways in which funded projects have collectively affected progress toward NSF's mission and strategic outcomes
- 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

The above NSF assessment metrics are generally qualitative in nature, but are linked to a sample of specific project awards. Generally the sample size is about 15% of the division actions. Each Division Administrative Officer can provide fiscal investments for specific fiscal metrics for whatever award set is examined.

(The NSF COV template also has the traditional process-oriented assessment issues to review, such as the award and proposal review process, including proposal dwell time, reviews used, etc)

The AIA task group recommends the following additional indices based on information received in Fastlane:

- Record of journal, book publication, presentations from awards. Including:
  - Reference Citations
  - Citations analysis
  - Publication in very prestigious journals (e.g., Science, Nature,..)
  - Invitations to publish review articles in field
- Honorific Awards for Past NSF supported work
- Impact in other disciplines / research used by other researchers
- Human resources (Grad Students with degrees; Undergrads,)
- Educational Impact (adoption of new approaches)
- Integration into bigger Groups/ Centers (the Multiplier effect)
- Industrial Partnerships (GOALI; I/UCRC; SBIR..)
- International Collaboration

The AIA task group also explicitly recommends that **award and overall program quality issues be assessed using the collective qualitative judgment of the COV committee members** to answer the key qualitative measures are given above. The COVs will have these metric data assembled by the Division and the Division Assessment coordinator--using the methods recommended earlier in this report for arrive at their judgments.

It is very useful to have contractors (through the use of case studies) help in the assembly of the assessment metrics received in Fastlane and/or identified by program officers.

The current metrics (above) used in the COV template and the added metrics are necessary and useful, but not sufficient in the Engineering Directorate—and in some of the divisions.

AIA recommends using added metrics specific to the needs of the Engineering Directorate and the particular Division or activity. The Directorate assessment indicator needs are emerging from the Strategic Thinking Group (STG) task force deliberations and are outlined in the next section.

Those metrics necessary for a specific division are left to future decisions by the divisions.

◆ METRIC RECOMMENDATIONS
FROM THE STRATEGIC THINKING GROUP:

The Strategic Thinking Group (STG) has developed (additional) specific metrics and number/investment goals that focus on the following Engineering **STRATEGIC GOALS OF identifying and nurturing** the following:

- Frontier research areas
- High risk research (SGER awards; non-SGER high-risk/high-payoff research)
- Partnerships between industry and academe, including workshops that focus on identifying research topics of mutual interest to industry and academe
    - Industry/University Cooperative Research Centers (I/UCRC)
    - Opportunity for Liaison with Industry (GOALI
    - "Innovation acceleration supplements"
    - Patents, spin-offs, innovations.
- New generation of intellectual property (IP) policies
- Innovation in engineering education

The existing COV template and the Final report and nugget mechanisms discussed earlier will capture the first three and the fifth strategic goals metrics. The other goal of intellectual property (IP) policies and some elements of the third point will need to be the added metrics assign to the COV, nugget, and report approaches—coupled with grant numbers and financial data supplied by Division Administrative Officers.

These metrics will have to be tracked each year and reported in some uniform fashion to the AD/ Engineering for all Divisions. However, comprehensive reports to the AD/ENG will occur at the time of the division COVs.

◆ ASSESSMENT DISCUSSION AND ALERTS:

With regard to the issue of--how does one tell if the grant results are good and has (or will have), for example, a significant impact-- we believe it is important first to address the issue of qualitative vs. quantitative assessments. Being mostly engineers and scientists, we might be tempted to suggest that we try to reduce results to quantitative or numerical metrics, and then judge success that way, by looking for a numerical maximum, minimum, or comparison to a specific numerical goal. For example, one could use the number of pioneering and /or research projects, papers, patents, students graduated, successful outreach mentoring contacts, new courses, etc. as an objective measure. We caution against that approach as an exclusive measure to gauge division or program performance—across the board. Qualitative assessments should be made of quantitative performance indices—as a companion to any quantitative analyses. The qualitative analysis would address the quality and significance of the reported achievements. For example, how "pioneering/innovative " is a project result? How significant is a claimed impact on society or industry? The assessment data acquisition approaches recommend here will report on the number of SBIR or exploratory grants, number of patents, etc—but these data are probably only a rough indicator of measuring the quality of performance. They may be necessary and sufficient for some types of assessments, especially yearly metrics. But the value behind some of these data are slow to emerge over time, and they are recognizable generally by a consensus of experts in the field—in some cases through honorific recognition awards well after the research is reported or the new educational approach is introduced. The COV approach moves in this direction, but the expertise on some panels and the time devoted may not be fully sufficient. However, if for example, management

wishes to increase the fiscal resources and number of high-risk studies or increase funding in pioneering areas, there have to be in place metrics for accountability. The approaches recommended in this report will capture those data along with clear and brief examples of the representative awards and their exceptional characteristics.

NSF has given considerable thought regarding the above issues in developing its approach in compliance with GPRA. The agency decided that quantitative indicators were not the best way to evaluate the effectiveness of NSF's research and education activities, or the results. This was particularly true for the unsolicited and single investigator awards. Instead, NSF chose to use qualitative metrics to assess the quality of the proposal review and award processes. NSF primarily relies upon these qualitative assessments of results and impact of awards (e.g., through the use of COVs, external evaluations using experts, Grantee Conferences, as well as internal qualitative review of nuggets and final reports) to evaluate the effectiveness and impact of our awards and by extension our programs.

Summary: As discussed earlier, the current qualitative scope of review by the COVs is quite comprehensive. (See Appendix 2.) It involves the collective sense of a group of supposed knowledgeable individuals. The AIA task group believes that it is appropriate to rely significantly upon this mechanism to review and assess the impact and effectiveness of programs and divisions, and, perhaps, to supplement the current COV review with a few questions to elicit greater strategic input. The improved and comprehensive approaches recommended earlier in this report will make the qualitative assessments more meaningful to ENG because more useful information on innovation and impact will be uniformly requested by the previous recommendations. In addition, ENG can conduct more targeted evaluations, what we call case studies, where the metrics, if any, would be carefully defined by the characteristics of the individual program and the specific decision (or objective) is being considered. Thus, this places greater stress on all managers, administrators, outside consultants and advisers, to study the results statements from the grants and deliver objective and qualitative judgments and opinions as to the novelty, contribution to society, or meeting strategic program objectives. However, these qualitative assessment studies can be used effectively to make the case for either more funding or for less funding.

As shown in an appendix, one member of the AIA task force believes that some quantitative approaches (using mathematical decision theory) to assessments might lead to wrong conclusions in too many cases. Quantitative assessments may cause the grantees to “play to the test” without significant movements toward real creativity and real societal impact.

In mission agencies where achievement of a specific technical goal is desired (e.g., a live human on the moon, or development of a vaccine for a targeted disease), one must rely heavily on quantitative based assessments. In the case of NSF’s SBIR and to some extent the ERC centers awards-- where connecting with industry is important--quantitative assessment measures become appropriate. Therefore, for the industry-oriented projects some metrics such as the number of patents and spin-off companies and partnerships with different kinds of institutions (K-12, community colleges etc) make sense—in addition to qualitative measures such as the generation of new knowledge. We refer the reader to the extensive list of measures for the performance of the ERCs as shown in Appendix Z. The ERC program has already collects most of this information and it is available—and these data are used in a largely qualitative sense for decisions related to funding levels and continuations.

SBIR/STTR is a completely different type of activity, and AIA believes that it makes sense to collect metrics very specific to this program. We do not think that AIA should propose specific measures in this report, as this warrants more extended and careful consideration than was available at this time. We do, however, recommend that with regard to the SBIR activities that the reader refer to a few of the measures in the ERC process that relate to industry. Also, the recent SBIR COV proposed changes in

the review process (separating the technical and commercial reviews), and they noted the need for adequate feedback both to the PIs and to the companies (this feedback process is quite different from that for normal NSF awards). They recommended that SBIR strive for greater uniformity in the quality of proposals that are funded under the different topics. Finally, the SBIR COV noted that future success of the SBIR program depends on providing greater mentoring support to small businesses. The observations of this report could be used as an example of why SBIR/STTR is different and warrants a workshop or other focused effort to define specific performance metrics). We concur in this recommendation.

◆ Discussion of Broader Assessment Issues, beyond Results of current awards:

The AIA task group recommends that assessment of **potential or future options** for management actions involving changes in financial resources in more focused strategic and frontier research directions should involve external discussions with the research and education communities from the various divisions as a procedure prior to significant financial commitments. This includes the introduction of strategic areas with significant out year commitments or future mortgages. In other words, it makes considerable sense to get greater input from the COVs/external evaluations / workshops on qualitative topics like the following: What are the future frontier areas of emerging opportunity/grand challenges? What are mature areas in which NSF should place less emphasis? How has a community within a given research area developed and what has been NSF's role in promoting the development of this community? (This is also where we see the "knowledge networks" –one of the secondary recommendations--making a useful contribution). Because AIA recommends and supports a set of performance metrics to assess investments in innovative and high/risk areas, the definitions used to decide the extent of innovativeness and high risk deserves considerable thought.

Also, it is important to engage the external communities in suggesting how NSF/Engineering might more effectively promote the development and/or transformation of a research and education community in promising new frontier areas from involvement in more traditional research communities. Sometimes, "workshops" accomplish this goal, but their effectiveness often depends on the futuristic and unbiased character of the participants.

To the maximum extent possible, assessments should be used to determine the extent to which Engineering encourages the marshaling of the existing talents of each engineering community in new future focused areas. And assessments should address issues of enhanced collaboration across discipline boundaries, as well as division boundaries.

CONCLUDING REMARKS ON ASSESSMENTS

The AIA task group firmly supports the need for assessments and justifications of the Engineering Directorate's use of taxpayer's funds—especially for significant changes future investments.

The AIA task group recommends the following high priority approaches as to how to gather research impact data on NSF engineering project awards. In general, these are improvements to existing approaches. They generally call for uniform and systematic application to all Engineering NSF projects. They are related to:

- **Enhanced Nugget System** (Highest Priority)
- **FastLane Modified Reports** (Highest Priority)
- **Case Studies** (commissioned to third parties)
- **Committee of Visitors** (up to date assessment metrics; added focus on specific Directorate and Division strategic goals; possible use of case studies related to these goals, possible use of contracted case studies to assist)
- **Grant Conferences** (comprehensive)
- **Dedication of a Staff Person for Coordination of Division Assessments** - - longest term

The AIA task group recommends that the divisional COVs serve as the central coordination point of the assessment process in each division--using the impact data collected via the improved methods recommended in this report. Assessment criteria specific to Engineering should be added to the NSF COV template informally and used by all Engineering COVs.

APPENDICES

(Follow in Separate Document)