A Strategy for Evaluation and Assessment (E&A) for Engineering

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Stakeholders

- Congress
- White House/OMB
- States/Regions
- Scientific and Educational Communities
- Industry/Investment Community
- Students (K-12)/Educational Systems
- General Public
Position Statement

• OMB request: Evaluation & Assessment Plan for Priority Goals
  – Education
  – Innovation

• 2012 NSF Response:
  • Priority Goals
    1.
    2.
    3. I-CORPS
  • Performance Goals
    -
    - Partnerships
GAO’s Guidelines

Planning: What do we want to accomplish with each program? (define outcome objectives)

Performance Evaluation: How well are we accomplishing what we said we wanted to accomplish?

Demonstrating Stewardship: What are the results obtained with the investments we have made?
A Primer on Evaluation & Assessment

Conceptual logic models that link:
- resources
- Activities
- outputs and outcomes

A state-of-the-art information system to collect and report indicators

Program Evaluation
Portfolio Analysis
Analytics for Decision Support
WHERE DO WE WANT ENGINEERING TO BE?

Conceptual logic models

- linking fundamental research to innovation
- life-cycle of ideas --from basic research to innovation
- space to record unexpected outcomes and identify outliers.

A set of few essential metrics

- frontier-engineering research
- an ecosystem capable of producing innovation
- engineering education research that assists the development of the next generation of engineers

A state-of-the-art information system

- data collection, data visualization and data analysis
- business intelligence to aid decision-making

Adaptable system: will evolve as technology, disciplinary fields and evaluation practices evolve.
How do we move forward?
Step One - Developing Logic Models
Resources Invested

Discovery Development Commercialization

University Small Business

Valley of Death

“Ditch of Death”

Foundations Industry Investors

I-Corps NSF overall STC GOALI ERC AIR/PFI I/UCRC STTR SBIR

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Demonstrating NSF ENG’s Impact on Society

**TIME AXIS**

1. **Investment in Basic Research**
   - Short Term Outcomes (papers)
   - Medium-term Outcomes (patents, curricular changes)

2. **ERC Investments**
   - Short-term Outcomes (e.g. partnerships with industry, training of eng workforce)
   - Medium-term outcomes: patents/spin-offs

3. **I/UCRC Investments**
   - Short-term outcomes: interdisciplinary partnerships, interdisciplinary training
   - Medium-term outcomes: multiple partners/new ideas

4. **EFRI or Other Additional Investments**
   - Short-term Outcomes (Interdisciplinary partnerships, interdisciplinary training)
   - Medium-term Outcome: new processes/new devices

5. **SBIR/STTR Investments**
   - Short-term outcomes: innovation in new technologies/devices
   - Medium-Term Outcomes: Commercialization/Implementation Occurs

**IMPACT: society realizes benefits from new products/systems**
What are some of the major hurdles?

Definition of Outcomes and their Indicators

Data Collection Systems

Visualization Tools/Dashboards

Monitoring

Data Collection Systems

Statistical Analysis

Evaluation
Different visions for data collection/visualization

Federal Level

Star-Metrics

NSF Level

Research.Gov

Data Warehouse

ENG Level

IIP DIMS

ERC Web-Based

CMMI/CBET COV
Data collection systems

- Fastlane
  - Unstructured elements

- Research.Gov
  - Incomplete data
  - Static taxonomy
  - Under on-going development

- DIMs
  - Contractor’s server

- ERC/ NSEC Web-based system
  - DIS server compatibility
Data retrieval / visualization systems

- Robustness of topic assignment
- Patents/name disambiguation

DIMS’ Dashboards
- Under development

Data Warehouse: Business Intelligence Capabilities

- ERC/ NSEC
- IUCRC
- Many others

Requires PD involvement

Starmetrics’ Portfolio Explorer/COV

Award Manager

Contractor/ NSF staff produces reports
At the end of the day, I am an IE...

Proposals

Final reports

Highlights

Relational database (Research.gov?)

TOPIC MODELING (e.g. Star metrics)

DIMS (or DIMS-like system) or Research. Gov

Conceptual Model – Desired & unexpected long-term outcomes

PI/institution characteristics, AWARD #, topic, PEC, any other codes, division, expenditures,

Business Intelligence/Data Warehouse Environment

Report (dashboards) at different levels of aggregation

Data for ad-hoc decision analysis

Taxonomy of technologies
Variations in Logic Model Development

- Programs focused on preparing the engineer of the future
- Programs focused on fostering an innovation ecosystem
- Programs focused on interdisciplinary frontiers
- Programs focused on basic research that may or may not be interdisciplinary
Potential Variations

• When the intentions of the program make the outcomes to be measured evident:
  – Engineering education, broadening participation, I-corps

• When the intentions of the program have a clear broader objective besides the basic research:
  – Programs fostering interdisciplinary efforts

• When the objective is to support basic research in a field or fields and societal outcomes might not be as clear
What have we done so far....?

Defining outcome indicators and linking them to data collection systems
EFRI’s Logic Model

INPUT

Funding
Knowledge of potentially, transformative or emerging topics or research
Logistics

Project Activities

OUTPUTS AND IMMEDIATE OUTCOME

INNOVATION OF IDEAS IN AREAS OF GREATER OPPORTUNITY

INTERMEDIATE OUTCOME

POTENTIAL COMMERCIALIZATION OR IMPLEMENTATION

LONG TERM OUTCOME

RESULTS ADVANCE THE FRONTIER / CREATION OF NEW FIELD OF STUDY

LONG TERM OUTCOME

INNOVATIVE RESEARCH OR DISCOVERIES ARE INTRODUCED TO THE CLASSROOM

Life of the award

Year 4-6 after the award

Year 5-10

Year 6-10 after the award
**PROJECT OUTPUTS/KNOWLEDGE TRANSFER ACROSS DISCIPLINES**

- Number of grants co-funded (or supported) by other agencies (or percentage of grants with this characteristic)
- Number of researchers exchanged across laboratories (inter-disciplinary, inter-institutional)
- Number of grants with international collaborations (or percentage of grants with this characteristic)

**INNOVATION OF IDEAS IN AREAS OF GREATER OPPORTUNITY**

- Number of grants with additional continuation of funding at a larger scale (or percentage of grants with this characteristic)
- Number of patents

**POTENTIAL COMMERCIALIZATION OR IMPLEMENTATION**

- Number of grants that have developed out-of-the-box approaches or what disciplinary experts would consider new methods or methodologies (or percentage of grants with this characteristic)
- Number of grants that have induced or are partially responsible for paradigm shifts
- Percentage growth in number of publications in the area (calculated from the first year of funding as a baseline)
- Number of graduate students that pursue research in areas related to EFRI projects

**PROJECT RESULTS ADVANCE THE FRONTIER / CREATION OF NEW FIELDS OF STUDY**

- Number of grants that have generated curriculum changes or inclusions of modules to teach methods, discoveries or innovations funded by EFRI

**INNOVATIVE RESEARCH METHODS OR DISCOVERIES ARE INTRODUCED TO THE CLASSROOM**

- Number of Interdisciplinary collaborations (or percentage of grants with this characteristic)
- Number of students involved in projects (undergraduate, graduate)
- Number of exchange students across labs (inter-disciplinary, inter-institutional)
<table>
<thead>
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<th>INDICATOR</th>
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| • Number of Interdisciplinary collaborations (or percentage of grants with this characteristic)  
• Number of students involved in projects (undergraduate, graduate)  
• Number of exchange students across labs (inter-disciplinary, inter-institutional) | RESEARCH.GOV AND PROJECT REPORT OR ADDITIONAL DATA COLLECTION INSTRUMENT SELF-REPORTED BY PI |
| • Number of grants co-funded (or supported) by other agencies (or percentage of grants with this characteristic)  
• Number of researchers exchanged across laboratories (inter-disciplinary, inter-institutional)  
• Number of grants with international collaborations (or percentage of grants with this characteristic) | E-JACKET/ REPORT SERVER PATENTS MODULE OF STARMETRICS PORTFOLIO EXPLORER |
| • Number of grants with additional continuation of funding at a larger scale (or percentage of grants with this characteristic)  
• Number of patents | EXTERNAL EVALUATION EXPERTS (surveys, interviews, summative evaluation) |
| • Number of grants that have developed out-of-the-box approaches or what disciplinary experts would consider new methods or methodologies (or percentage of grants with this characteristic).  
• Number of grants that have induced or are partially responsible for paradigm shifts | |
| • Percentage of growth in number of publications in the area (calculated from the first year of funding as a baseline)  
• Number of graduate students that pursue research in areas related to EFRI projects | Web of Science/ Google Scholar/ Potentially Star Metrics/ External evaluators |
Dealing with Outcome Development for Basic Research:
Reverse Outcome-Development Process

(1) What are the **major needs in society** at large which could be alleviated by advances (discoveries) in this discipline?

(2) What **innovations** do we need to alleviate those needs?

(3) What specific **gaps in knowledge** exist --within the scope of this program description-- that prevent us to develop those innovations?
When can we have answers to our programmatic questions

Data Analysis

- Statistical Analysis: main predictors of certain outcomes
- Analytics/business intelligence/ pattern recognition/ data mining: likelihood of proposals to obtain certain outcomes
- Economic analysis: Benefit-Cost, Return on ENG Investment
- OR/ Data Envelopment Analysis: Benchmarking proposals/ PIs, programs based on their efficiency/ effectiveness
- Descriptive statistics: e.g. percentage of awards with certain characteristics

Information Systems

Conceptual Logic Models
What is the road ahead?

**E&A Tasks**

- **Conceptual Model(s)**: Understanding existing evaluation efforts and developing Logic Models for each program will allow us to know the kind of data we really need.

- **Data Collection System(s)**: Integrating data sources, and data reporting tools and negotiating modifications to Research.gov and other post-award tools will allow us to get the data we need based on our logic models.

- **E&A Reporting Culture**: Developing canned evaluation reports making use of data warehouse and business intelligence capabilities (a view of the program, division, directorate almost in “real time”)

- **Permanent Function**: Using data from the project life-cycle (Oracle DW), to answer questions on an ad-hoc permanent basis: what are the predictors (PI, project characteristics) of patents, partnerships, innovation
We want your feedback regarding the vision, the plan and the strategies to achieve our vision
How do E&A functions come together?

**Program Evaluation**

- Data by PEC, award #, PI, institution: investments made (US$), topics funded, etc.
- Outputs, immediate, medium-term and long-term outcomes in research and education: e.g. papers, patents, students, additional grants, innovations that are based on basic research funded by NSF; etc.

**Portfolio Analysis**

- Data by proposal number and PI: Characteristics of institutions, PIs, work proposed

**Decision Support Analytics**

- Data by proposal number and PI: Characteristics of institutions, PIs, work proposed
## BRIGE LOGIC MODEL

### INPUTS
- Funding
- Logistics/ Broadening Participation Plans
- Research Plan
- Inputs from other coordinating agencies and Institutions (equipment, facilities, etc.)

### Project Activities
- **Research Activities and Training**
  - Undergraduate, graduate and post-doc students* participate in research, some through supplement mechanisms (REUs, RETs, GRDs).
  - Minority serving institutions, and community colleges are engaged with the project.
  - Training of high school students and K_12 teachers in research activities.
  - Tutoring and mentoring occurs
  - Collaborating activities with institutional

### Outputs and Immediate Outcome
- **Research & Outreach Outputs**
  - Students* trained in labs
  - K-12 teachers trained in engineering research concepts
  - Workshops and meetings
  - Community outreach events
  - Training materials produced
  - Curricula developed
  - Faculty and students publish the results of research
  - BRIGE Faculty perceived as role models
  - Awareness of students’ challenges* increases

### Intermediate Outcome
- **Academic career of BRIGE awardees thrives.**
  - Increased excitement about STEM among students.*
  - K-12 teachers trained introduce engineering research topics in their classes
  - Participating students start considering research or engineering careers
  - BRIGE faculty experience recognition
  - Increased communication among PI, students and other faculty

### Long Term Outcome/ Impact
- **Broadening Participation**
  - Increase of successful women, underrepresented groups and veterans in STEM fields
  - Increased engagement of BRIGE faculty** in STEM research
  - Increased diversity in faculty composition in departments touched by a BRIGE award
  - Increased diversity in students from underrepresented groups touched by activities related to a BRIGE award graduating with STEM degrees (undergraduate and

### Life of the award
- Year 1-4 after the award
- Year 5-10 after the award
- Year 6-10 after the award

*focused on underrepresented groups, including minority ethnicities, persons with disabilities, women and veterans
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<td>• Number of conference presentations</td>
<td></td>
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<tr>
<td>• Number of underrepresented students trained in labs</td>
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<tr>
<td>• Number of K-12 teachers trained</td>
<td></td>
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<tr>
<td>• Number of workshops held with minority participation</td>
<td></td>
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<td>• Number of community outreach events</td>
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<td>• Number of training materials produced</td>
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<tr>
<td>• Number of awardees who report that they introduced innovations in the curricula of classes they teach after the award</td>
<td></td>
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<tr>
<td>• Number of BRIGE awardees who are promoted to Associate in the usual P&amp;T time at their institutions or less</td>
<td>DW/Proposal Search/ E-Jacket/ STAR METRICS</td>
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<td>• Number of BRIGE awardees who apply for additional funding from NSF and other federal agencies</td>
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<td>• Number of BRIGE awardees who get an award from NSF as PI or CO-PI after getting the BRIGE</td>
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<td>• Number of BRIGE awardees who get a CAREER award or other major award that shows recognition</td>
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<td>• Number of BRIGE awardees who increase collaborations national and international after the award</td>
<td>EXTERNAL EVALUATION EXPERTS (surveys or summative evaluation) or external sources (e.g. ASEE)</td>
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<td>• Percentage of students who perceived their BRIGE faculty member as a mentor</td>
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<td>• Number of participating students who state that they started considering research or engineering careers after their involvement with the BRIGE award activities</td>
<td></td>
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<td>• Number of teachers who introduce changes in the classroom after participating in BRIGE activities</td>
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<td>• Percentage of faculty from underrepresented groups actively engaged in STEM research</td>
<td></td>
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<td>• Percentage of students from underrepresented groups graduating with STEM degrees in departments touched by a BRIGE award</td>
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<td>• Percentage of new hires who are considered a minority (women, underrepresented groups or veterans)</td>
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<td>• Percentage of BRIGE-touched students who stated that they perceive an increase in</td>
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