



NSF Proposal Development Workshop

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CIVIL, MECHANICAL AND MANUFACTURING
INNOVATION

NATIONAL SCIENCE FOUNDATION

International Mechanical Engineering Congress & Exposition
Tampa, FL

November 3-9, 2017



Goals of this Presentation

- Motivation through numbers
- Mission and workings of the NSF
- The Merit Review process
- Foundations of an NSF proposal: goal, objective, hypothesis
- Special considerations for the CAREER proposals
- Do's and Don'ts summary (if needed)
- Identify the next steps

Motivation

BEAT THE FUNDING RATE BY IMPROVING!



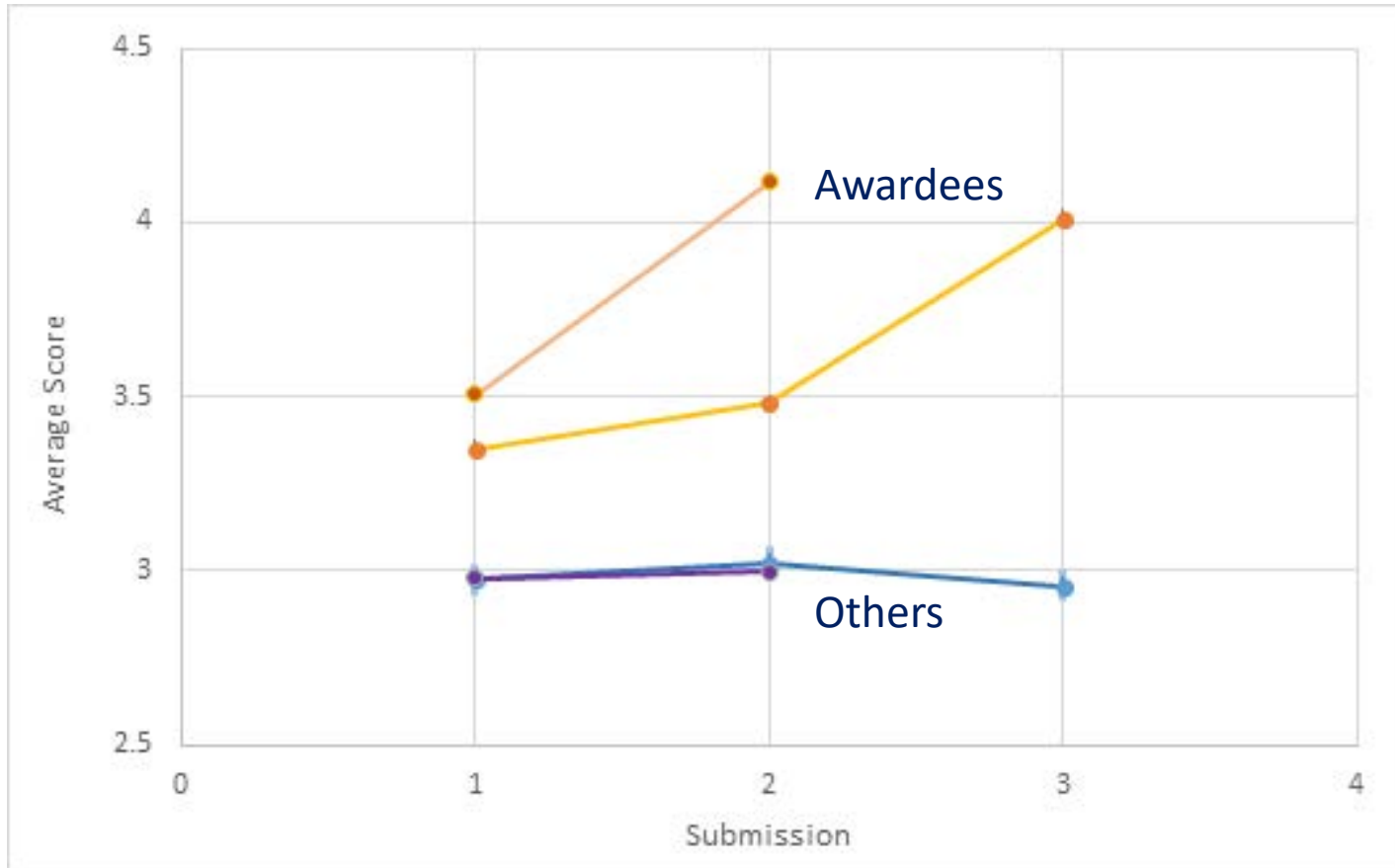
Funding Rate: CAREER

- **Funding rate data are not truly indicative!**
- The annual funding rate for CMMI CAREER proposals is 14.6%
- 32% of the CAREER proposals submitted to CMMI are resubmissions
- 1st try, 13.8% funding rate; 2nd try, 15.9%; 3rd try 17.9%
- The overall funding rate for CMMI PIs is 21.3%

Data from 2010-2016



Ratings of Awardees vs. Others



NSF Introduction

GOALS & MECHANISMS



NSF Strategic Goals

Strategic Goal 1: Transform the Frontiers of Science and Engineering

“to promote the progress of science”

Strategic Goal 2: Stimulate Innovation and Address Societal Needs through Research and Education

“to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes”

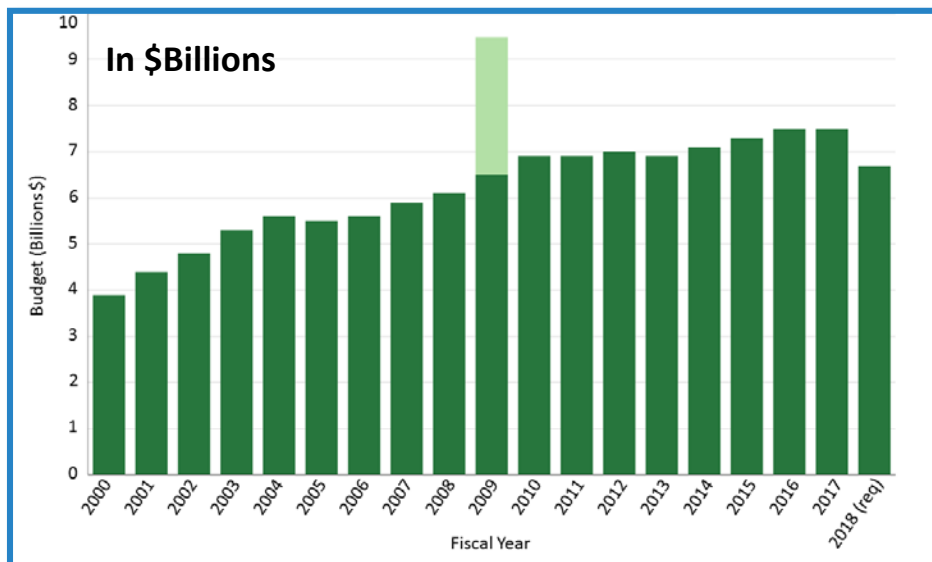
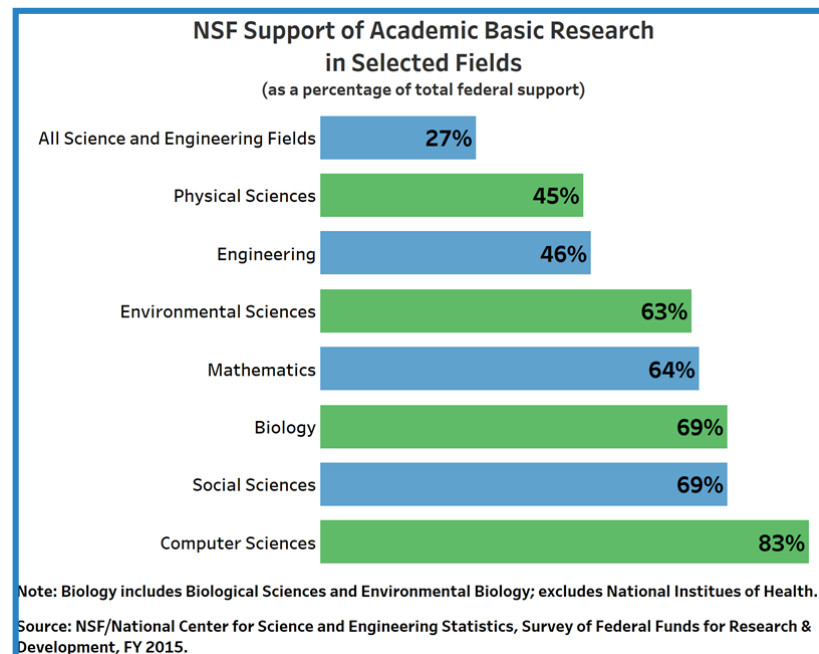


What NSF Does

- Supports all fields of fundamental science and engineering, except for medical sciences.
- Ensures that research is integrated with education so that today's revolutionary work will also be training tomorrow's top scientists and engineers.
- Vehicle of change: research grants



NSF By the Numbers





NSF Supports Basic Research

- **Not specific mission driven** → **not applied research**
- **Winning proposals focus on research, not development**
- **If the focus of the proposal is an artifact (a device, system, product, process,...) → it's probably development**
- **If the focus of the proposal is knowledge (the truth of a hypothesis) → it's probably research**



Funding Mechanisms

- **Core/Unsolicited:** Usually supports one graduate student and one month PI salary—typically \$300-500k; 3-4 years
 - Individual/small collaborative teams: funds increase for collaboration
- **Solicitations:** Small to large funding size; multiple divisions can be involved
 - Special research call – DMREF, NRI, SNM, CRISP, BIGDATA
 - Early Career – CAREER
 - Instrumentation – MRI
 - Centers – ERC, STC, I/UCRC
- **Workshops/Conferences**
- **International Collaborations**

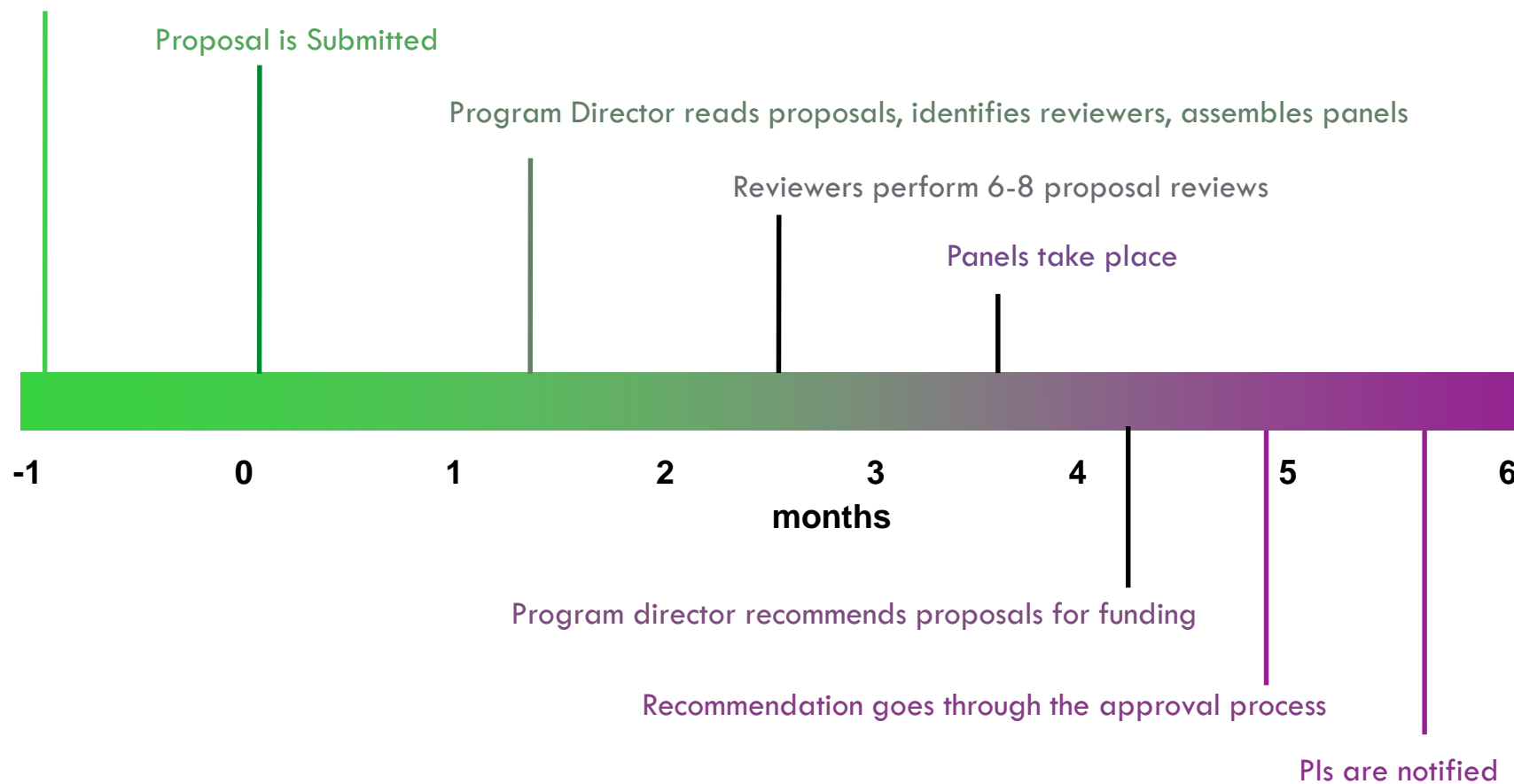
Merit Review Process

TIMELINE & RUBRICS



Merit Review Timeline

PI communicates with Program Director to determine program fit



The Five Elements of Merit Review



1. What is the potential for the proposed activity to:
 - advance knowledge and understanding within its own field or across different fields (**Intellectual Merit**); and
 - benefit society or advance desired societal outcomes (**Broader Impacts**)?
2. To what extent do the proposed activities suggest and explore creative, original, or potentially transformative concepts?

The Five Elements of Merit Review (2)



3. Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?
4. How well qualified is the individual, team, or institution to conduct the proposed activities?
5. Are there adequate resources available to the PI (either internally or through collaborations) to carry out the proposed activities?



Caution

Your goals, objectives and approach should drive the proposal, not the need for Intellectual Merit and Broader Impact statements.

Proposal Foundations

BASICS, GOAL, OBJECTIVE, HYPOTHESIS,
EDUCATIONAL PLAN & ASSESSMENT, PROJECT
SUMMARY



Proposal Basics

- Write to the reviewers (not to the program director and not to yourself)
- Your proposal will be judged by the reviewers
- Reviewers want to know four things:
 - **What is it about (the research objective)?**
 - How will you do it (the technical approach)?
 - Can you do it (you and your facilities)?
 - Is it worth doing (intellectual merit and broader impacts)?
- This is, basically, all the proposal needs to convey – but it needs to convey this



12 Steps to a Better Proposal

1. Know yourself - strengths/weaknesses
2. **Know the program (director) from which (whom) you seek support**
3. Read the program announcement and PAPPG
4. Formulate clear and appropriate research and education objectives
5. Develop a viable plan to accomplish your stated objectives
6. State your objectives up front in your proposal
7. Frame (contextualize) your project around the work of others



12 Steps to a Better Proposal

8. Grammar and spelling
9. Format and brevity are important
10. Know the review process
11. Proof read the proposal before you submit it
12. Submit your proposal early and proofread it after you submit it

Writing a good proposal takes common sense and effort—it's not magic!



What is Research?

Research is the *process* of finding out something that we (everyone) do not already know.

Scientific research builds upon the extant knowledge base and it is methodical, repeatable and verifiable

- Methodical - you can specify in advance of the research a method to accomplish your objective
- Repeatable - not a “strange” (random) event
- Verifiable - tangible evidence

Question: Exactly what will your research contribute to the knowledge base?



Objective versus Goal

The goal is what you want to pursue, the objective is how you intend to achieve it.

We pursue goals, we achieve objectives.

Goals motivate objectives.

There may be many ways to pursue a goal, but few ways to achieve an objective.

- **Goal:** To stay dry
- **Objective:** *Replace the leaky roof over your head*
- **Objective → Challenge → Approach / Tasks**
 - Task 1—remove the present shingles
 - Task 2—install new shingles
 - Task 3—clean up the mess



The Research Objective

- This is probably the hardest part of the proposal!
- **Four constructions (examples) :**
 - The research objective of this proposal is to test the hypothesis H.
 - The research objective of this proposal is to measure parameter P with accuracy A.
 - The research objective of this proposal is to prove conjecture C.
 - The research objective of this proposal is to apply method M from field Q to solve problem X in field R.

Specificity is the key (towards clarity)!

The Research Objective

How to Get it Wrong!



- **Examples of what not to write:**

- The research objective of this project is to create novel new transformational knowledge.
- The objective of my research is to provide a quantum leap in the design of anti-gravity boots.
- The objective of this project is to develop an integrated modeling tool for the hardening process.
- The goal of this project is to develop innovative advances to enhance wire sawing processes.
- Rapid prototyping machines are an important part of the vast array of tools. It is very important that we improve these machines. Rapid prototyping will form the backbone of manufacturing in the future.

The Research Objective

How to Get it Right!



- **Examples of what to write:**

- The research objective of this proposal is to test the hypothesis that physical phenomena x , y , z dominate the chip formation process in the machining of brittle materials.
- The research objective of this project is to account for uncertainty in engineering design decision making through the application of utility theory.
- The research objective of this project is to measure the cross-section of the muon-nutrino interaction at 5 GeV accurate to 5%.

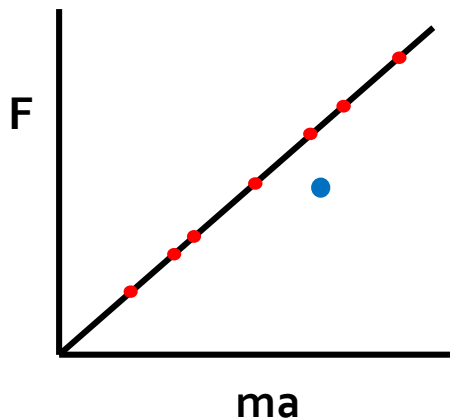
Reminder: A well-stated objective leads one directly to the approach that must be taken to accomplish the objective.



Hypothesis Testing

- If you are going to do an hypothesis test:
 - You must state a **testable hypothesis**—one for which you can write a plan
 - Recognize that you can falsify the hypothesis or fail to prove it—generally a well stated hypothesis cannot be proven true
 - Karl Popper—induction vs. empirical falsification
 - The test of the hypothesis needs to be well planned

Force is proportional to rate of change of momentum ($F=ma$)



- Each data point is a point, n points fill nothing
- The model fills the space
- One valid outlier disproves the hypothesis
- Ergo, we only disprove hypotheses

We accept an hypothesis as true only after repeated attempts to disprove it fail.



Poorly Stated Scientific Hypotheses: Lack of Specificity

- By adding nanoparticles to aluminum, I can make it stronger
 - Not falsifiable
- The addition of additives to steel will make it better
 - Not falsifiable
- Possible reasons/problems:
 - Absence of prior results or data
 - Fishing expedition—do something and let us see!

The Research Objective Summary



Doing it right

- Frame your research: “My research goal is...”
- Then: “As a step toward this goal, the research objective(s) of this proposal is(are)...”
- Limit: 25 words or less (a suggestion)
- Be specific about your research objective
- Note - if you are specific, the research methodology will follow directly
- Be sure your statement is comprehensible
- Put it up front – may be, sentence one, paragraph one, page one
- Do not give a weather report or state-of-the-union address

Exercise

TAKE 5 MINUTES. IDENTIFY THE GOAL AND OBJECTIVE OF ONE OF YOUR STUDENT'S PHD THESIS OR YOUR OWN. WRITE IT OUT. WE SHALL DISCUSS EXAMPLES FROM VOLUNTEERS.

Exercise

CONSIDER THE OBJECTIVE STATEMENTS PROVIDED IN HANDOUT.

GET TOGETHER WITH 4-6 PEOPLE NEAR YOU.

DETERMINE WHAT, IF ANYTHING, IS WRONG WITH THESE OBJECTIVE STATEMENTS.

REFRAME THE PROPOSED RESEARCH.



Writing the Project Summary

- The most important part of the proposal is the statement of your proposed objectives, approach, their merits and impact:
 - It should be at the very beginning of the proposal, potentially based on a meaningful conversation with a program director
 - Do not begin with a weather report: “The sky is falling. Tools are breaking. Designs are failing...”
 - Do not begin with a state-of-the-union address: “The U.S. lags in the development of a strong manufacturing base...”
- Remember, this is not a tech paper nor it is a murder mystery (where we find out what the objective is on page 15)
- Your educational plan, Intellectual Merit and Broader Impact statements are all important part of the summary

How to Achieve Broader Impact?



NSF Mission: To promote the progress of science; advance the national health, prosperity, and welfare; and to secure the national defense

Broader Impact: Advancement of scientific knowledge and activities that contribute to the achievement of societally relevant outcomes

Can be accomplished through:

- the research itself, OR
- the activities that are directly related to specific research projects, OR
- through activities that are supported by, but are complementary to, the project.

Broadening Participation is one Broader Impact goal

CAREER Awards

SPECIAL CONSIDERATIONS



Introduction

- Foundation-wide activity that offers NSF's most prestigious awards for faculty members beginning their careers
- Provides stable support at a sufficient level and duration **to enable awardees to develop careers** as outstanding researchers and educators who effectively **integrate teaching, learning, and discovery**
- *High priority for Engineering!*
- ENG award size is \$500,000, period.



Beware!

The CAREER award is NOT a
research award

The CAREER award is a career
development award

Your proposal must reflect
this focus



You

- **Who are you?**
 - Your expertise/interests
 - Your career/life goals
 - Your position/resources
- **Your proposal should fit into your life plan**

What is your life plan?
Do you need to develop a strategic plan?



Your Strategic Plan

- **A strategic plan has three parts:**
 - Where are you today?
 - Where do you want to be in the future (5, 10, 20 years from now)?
 - How do you get from here to there?
- **Questions: What do you want to leave as your career legacy? Do you need to work on important problems?**

A strategic plan is a roadmap for your life!



Your Proposal

- **Should advance you toward your life goals**
 - Should be a stepping stone to the next thing
- **Should be compatible with your institution's goals**
- **Should represent a contribution to society at large**

Test: If you accomplish your objectives, are you better off for the effort?



Your Field

- **Know your field:**
 - What is the current state-of-the-art?
 - Who are the top ten researchers?
 - What are they doing right now?
 - Where do they get their funding?
 - What do they consider to be the key research issues?
 - Who would likely review your proposal?
 - What are your potential sources of funding?

Reminder: Beyond the Research Objective



Your proposal must address four critical questions that reviewers will face:

- What is the proposal about?
 - Be sure to include clear statements of both research and educational objectives as well as **integration of research with education**
- Will the proposed approach accomplish the stated objectives?
 - Be sure the reviewers are evaluating your approach based on your objectives
- Can the PI carry out the proposed approach?
 - Preliminary results and previous work as well as available resources argue this
- Is it worth doing?
 - Make the argument through the intellectual merit and broader impacts statements



The Summary Page

- First paragraph
 - My long-term research goal is...
 - In pursuit of this goal, the research objective of this (CAREER) proposal is...
 - The research approach is...
- Second paragraph (for CAREER proposals)
 - My long-term educational goal is...
 - In pursuit of this goal, the educational objective of this CAREER proposal is...
 - The educational approach is...
- Third and fourth paragraphs
 - Intellectual Merit
 - Broader Impacts
- Anything else may lower your rating
- Use the template



Educational Plans

- Undergraduate

- Curriculum
- Projects (REUs)

- Graduate

- Curriculum
- Conferences

- Involvement with industry, national labs

- Networks, Partnerships, Faculty in other colleges

- K-12 outreach (RETs)

- Museum projects

- Not for profit organizations (4H clubs, First-robotics,

The education plans with the most potential impact are the ones that are motivated by your own life experiences.



Assessment and Evaluation

- PIs are strongly encouraged to describe how the impact of the educational activities will be assessed or evaluated
 - Helpful document: NSF publication 02-057, The 2002 User Friendly Handbook for Project Evaluation

Do's & Don'ts

PLUS ETHICS AND SUMMARY



DOs

- Have a strategic plan
- Build on your strengths
- Differentiate this proposal from your Ph.D. thesis work and other sponsored work
- Perform a thorough literature search and exploratory research before writing the proposal
 - Journal articles (update with personal contacts)
- Read the NSF PAPPG
- Establish and keep your contacts



DON'Ts

- Rush
- Wait until last minute (1 month) to contact program directors
- Make the proposed work (research and education) too broad
- Make the proposed work too narrow
- Ask for too much (or too little) money
- Ignore rules (PAPPG) and misc. items – violation of the PAPPG requirements will result in return without review
- Try to submit your proposal late



Ethics!!!

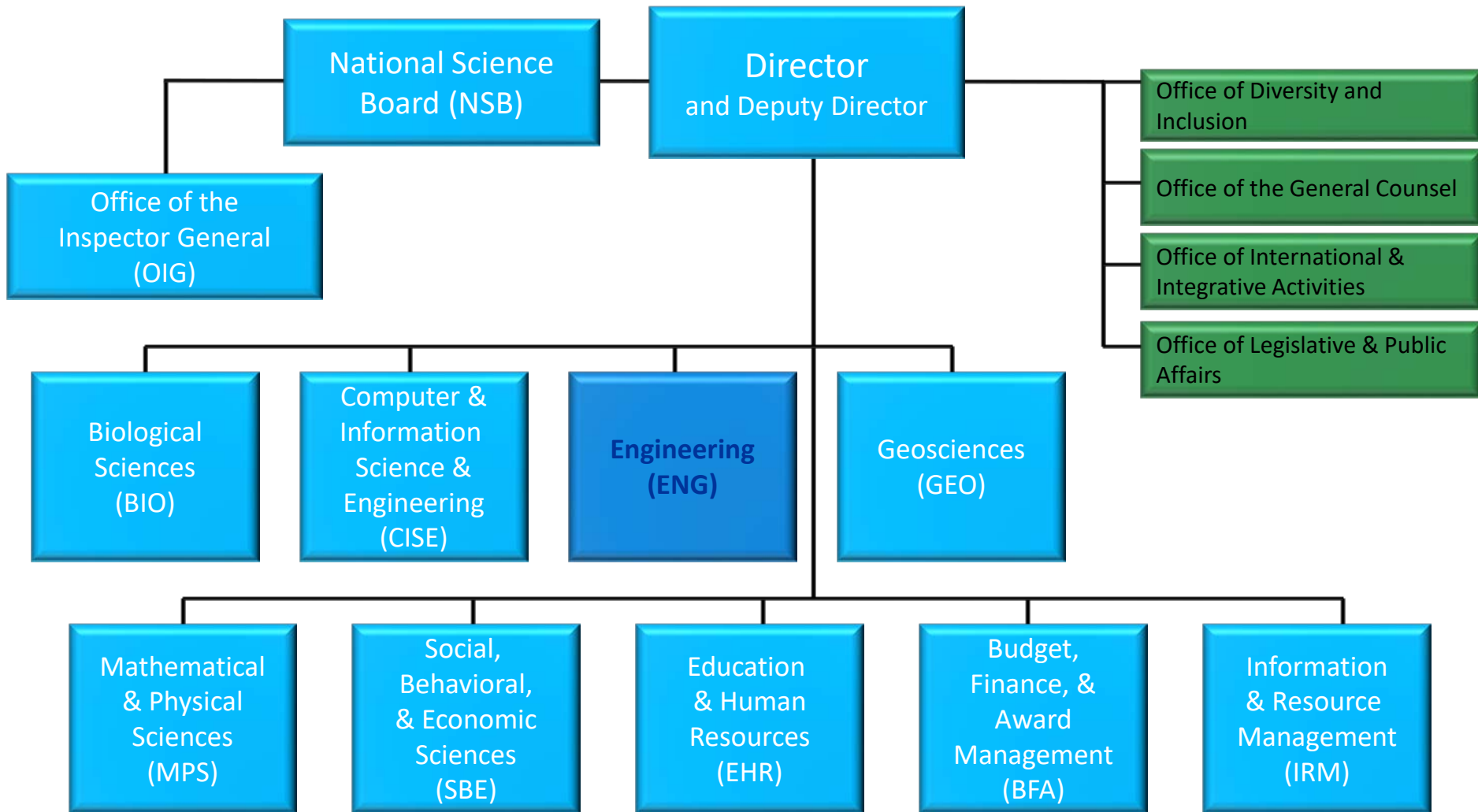
- Persons submitting proposals to the Federal government are held to high standards of conduct
- Misbehavior can be dealt with quite severely
 - PI barred from submission to NSF for up to 2 years
 - Permanently barred from proposal review
 - At least two cases of jail time (Grimes case, 42 months in Federal prison)
 - Maximum \$250,000 fine, 5 years in prison
- Institutions must train and verify

What Next?

IDENTIFY PROGRAM

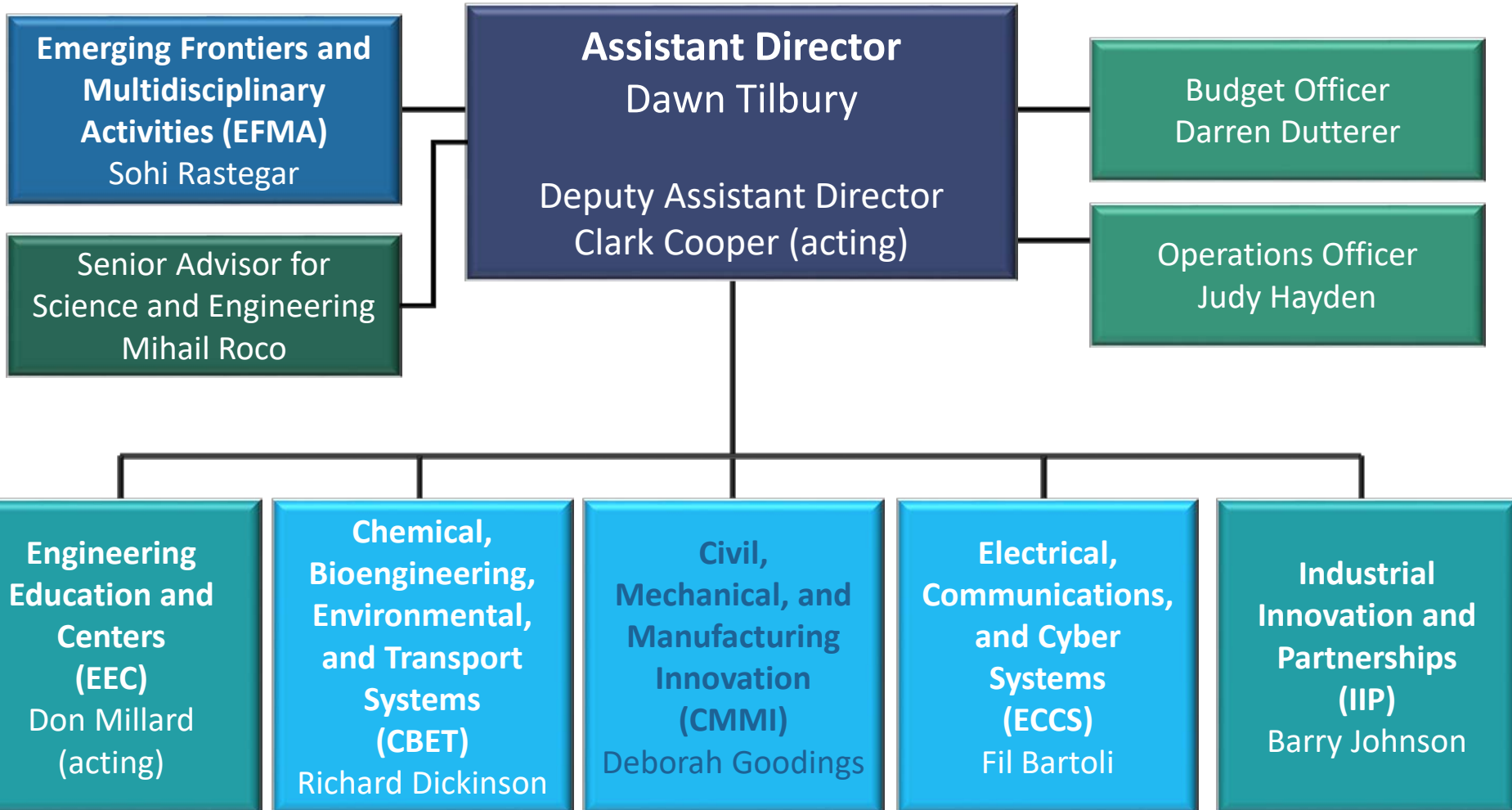


National Science Foundation

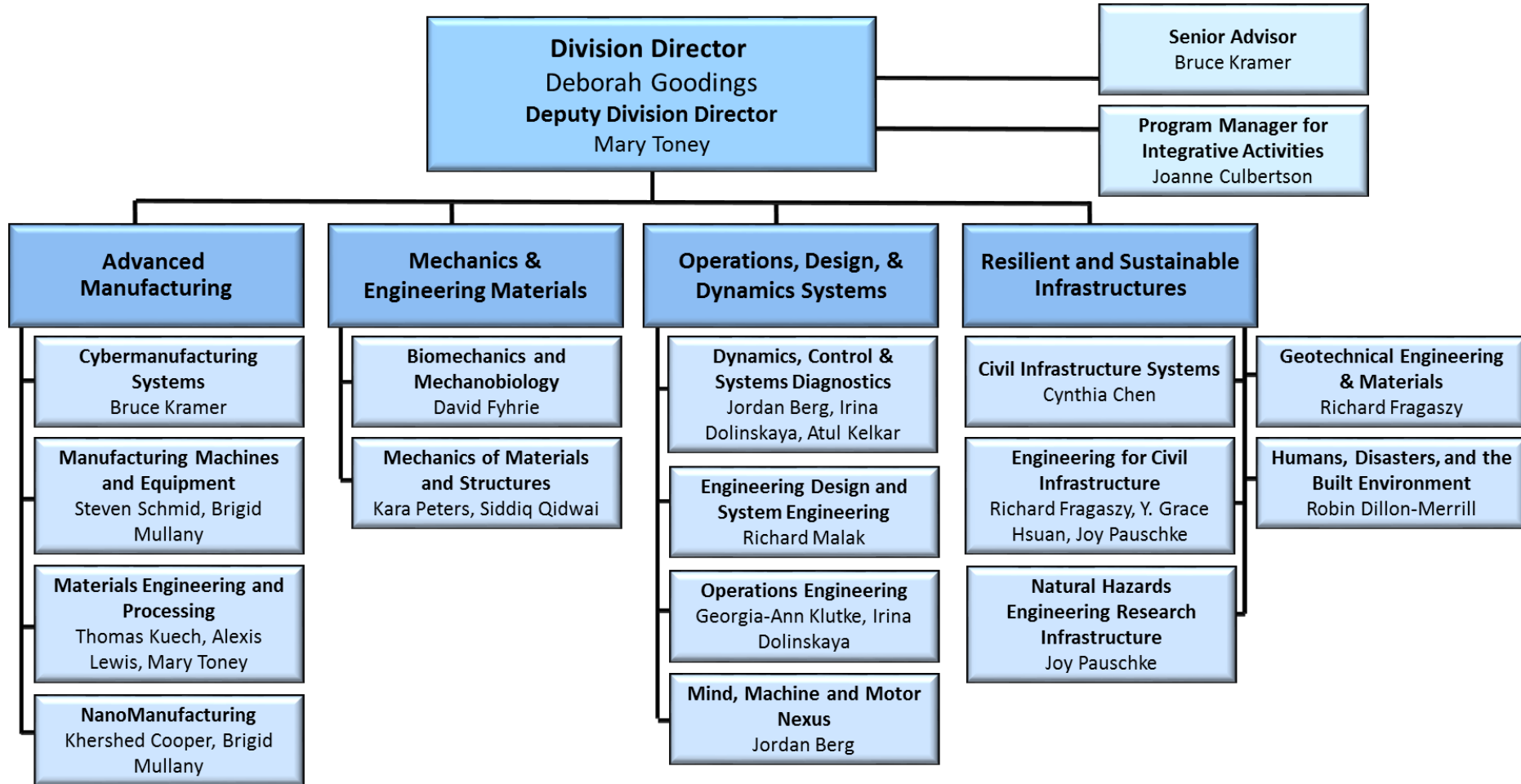




Directorate of Engineering (ENG)



Division of Civil, Mechanical and Manufacturing Innovation





Target Program

- Begin with
 - **White paper**, i.e., one-page summary
 - **Dialog** with program officer
- Be an NSF **proposal reviewer**—best place to learn about what makes a winning proposal!
- **Remember, we're from the government, and we're here to help!**

IMPORTANT NOTICE: Submission Windows



CAREER Proposal:

- **Third Thursday in July**
- **Repeat annually**

Unsolicited Proposal:

- **September 1 - September 15**
- **January 10 - January 24**
- **Repeat annually**

Questions?

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