

**Writing Successful Technical Proposals**



**Tips from the Trenches,  
or *Things I learned the hard way***

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With thanks to Brian DeMarco, who introduced me to George Heilmeier  
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**Caveat lector!**

1. I am not a scientist; I'm a science writer and technical editor.
2. All of my experience in proposal writing has been in nuclear engineering and physics (broadly defined), but I think the advice I offer transcends disciplinary boundaries. Your mileage may differ.
3. All of my experience has been at the University of Illinois. I know the rules for FFRDCs are different, and I may make stupid statements that have no relevance to your practices and constraints.
4. Anything I say today is trumped by an agency's general rules, specifics of an individual program announcement, and directions from the cognizant program officer.
5. The opinions expressed are solely my own and are not necessarily shared by Sandia National Laboratories, the US Department of Energy, the University of Illinois, or federal funding agencies. But they should be.

## **Most proposals include standard parts**

**A “cover page”**

**Project summary**

**Project description**

**References cited in the technical narrative**

**Biographies of key personnel**

**Itemized budgets and a budget narrative**

**Other support of the project personnel**

**Facilities, equipment, other resources**

 **Every section is important; the ones you don't care about are often the tie-breakers**

A proposal is more than just the technical description, and *every element* is important.

The tie-breakers are often the sections that scientists ignore—the title, the project summary, the bios, the facilities and equipment descriptions, and the budget justification.

Agencies receive far more proposals than they can possibly fund. If a panel has to decide which 3 proposals it's going to rank as “must fund” out of 25, it usually takes the most meritorious from a scientific standpoint and then ranks them based on the other components of the proposal.

**Decisions are made on the margins.**

**First step, read the FOA with your  
highlighter in your hand**



**Submission details & deadlines**

**Deviations from standard procedures**

**Formatting requirements**

**Special requirements**

**Program objectives**

**Key words in the synopsis**



**Make a checklist with these items to  
review before you submit**

The FOA is your bible; your careful reading and understanding of it, including all the fine print, often determines the difference between “funded” and “declined.”

## **Meet George Heilmeier: scientist, inventor, industry leader, government official**

**PhD in solid-state materials**

**Inventor of the LCD**

**Member of the National  
Academy of Engineering**

**National Medal of Science, IEEE Medal of  
Honor, Kyoto Prize**

**White House Fellow, assistant to Secretary of  
Defense, director of DARPA**

**VP & CTO, Texas Instruments; Pres & CEO,  
Bellcore; Chairman & CEO, SAIC**



Credit: IEEE

# 1. What are you trying to do?

State the goal of your project  
using absolutely no jargon.



Federal funding agencies want to support hypothesis-driven research. Instead of saying “we will study this process” or “we will measure  $x$ ,” state the overall goal of your project in terms of a question to be answered or an hypothesis to be tested.

Make a distinction between “goals” (hypothesis to be tested) and “objectives” (intermediate steps along the path to answering the overarching question) and state them both.

NIH requires a “specific aims” section for every proposal submitted to it. I think adopting a “specific aims” section is a useful exercise for a proposer and reassures reviewers and program officers that you’ve thought carefully not only about what you want to do (goal), but specifically **how** you’re going to go about accomplishing it (objectives).

The “no jargon” rule is a good one. Not everybody who reads your proposal (and decides its fate) may be an expert in your narrow field.

If you have to use jargon, explain your terms. And never, **ever** use undefined acronyms. Ever.

## 2. How is it done today, and what are the limits of current practice?



Explicitly address this question in your “background and introduction” section. Cite freely.

### **3. What's new in your approach, and why do you think it will be successful?**



Explicitly state why your approach is faster, better, cheaper—don't rely on the reviewers to intuit it.

Show how you've tested your approach and its promise; provide preliminary data.

Discuss your "Plan B." If your approach doesn't work, what is your alternative plan to save the project (and the funding agency's investment)?

## 4. Who cares?



Is the problem important to anybody besides your research group? Tell the program officer and reviewers who benefits.



## 5. If you're successful, what difference will it make?



What will your successful project mean for your research? For the infrastructure of your institution and future capabilities? For your discipline? For related disciplines? For society? For the ***funding agency***??

Will it create new knowledge?

Train the next generation of scientists and engineers?

Contribute to the nation's research infrastructure and technical capabilities?

Solve an important scientific, technological, or societal problem?

Contribute to economic development?

Why should a Congressman care?

## 6. What are the risks and the payoffs?



Candidly discuss risks, but use positive language. Don't ever **say** a proposal is "risky." (Funding agency employees tend to be risk averse.) "Promising" or "potential high-payoff" is okay—"risky" is the kiss of death.

## 7. How much will it cost?



Think not only of dollars, but of time and resources (personnel and infrastructure). The program announcement will often specify the maximum funds that can be requested. Typically, if you exceed that limit, your proposal will be deemed “non-responsive” and will be returned without review.

If the program announcement does not specify a budget limit, it will often indicate how much money has been allocated for the program and how many awards the agency expects to make. Use that information to set boundary conditions for your budget.

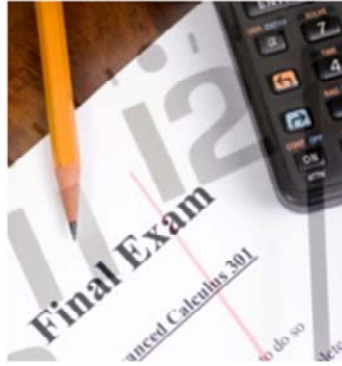
## 8. How long will it take?



Read the program announcement carefully and be sure your proposal fits the prescribed duration.

A great addition to any proposal is a narrative or figural timeline for the project.

## 9. What are the midterm and final “exams” to check for success?



How are you going to evaluate the project as it proceeds, so that you know when to make mid-course corrections?

What metrics will you use to evaluate progress?

How will you analyze and evaluate your data? How will you know when you're "done"?



Put a section in the project description titled “Qualifications of Key Personnel” and tell the reviewers why you and your team are uniquely positioned to succeed. Describe your expertise and success in related work. Mention the facilities you have at your disposal and your organization’s institutional strengths, including the availability of other experts to assist you.

Not every reviewer will look at the biosketches or the facilities description, but they will read the project description.

## C2. Why now?



Talk about “opportunity costs.” “Opportunity cost” means what is the cost of not doing the project NOW? What will be lost if the agency decides “Not this year. Maybe next year.”?

**Here's how to use the questions to get started on a compelling proposal**

**Think about how each question relates to the project you have in mind**

**Write down answers to the questions in full sentences—*be explicit and specific***

**Use the answers to #7 and #8 to put boundary conditions on your proposed project**

**Read the FOA again and map your answers to mandatory sections of the proposal**

**Put the mandatory sections first—in the order they're presented in the FOA**

**Put the rest of your answers to the Heilmeier questions in their own separate sections**

Thinking about the questions is a great way to get started in writing your proposal.

The answers to the questions (particularly 7 & 8—how much will it cost and how long will it take) will help you put necessary boundary conditions on your project before you get too far into the process.

Incorporating the answers in your project narrative will help the reviewers positively assess your proposal.



**Now you've got an outline and are ready to start writing...**



**“If you don't know where you are going, you might wind up someplace else.”**

**—Yogi Berra**

**Now for some more tips...**

**Ask for assistance from people who can help you—be polite but persistent!**

**Pay attention to what we tell you—we're trying to ensure your success, not create obstacles**



**Ask early—ask often!  
Communication is key**

**Don't *assume* anything...**

**Give us time to help you\***

***\*nothing is more frustrating for us than to have to do less than our best work because we got your proposal at the last possible minute***

From the program officer:

- Ask what kind of projects have been supported.
- Describe your project and ask for suggestions.
- Ask if the program officer will look at a brief white paper.
- Request referrals to other investigators or prospective collaborators.

From your colleagues

- Ask them to read a first draft of the proposal and give you constructive criticism.
- Ask them to share copies of their successful proposals.

**Tip:** Have someone not particularly familiar with your field read the project description without taking notes. Then ask him or her to tell you—from memory—what you are planning to do, how you will do it, and why it is significant. If the answers are not clear and immediate, start rewriting. Pay attention to the questions the person asks.

From your business office

- Ask them for boilerplate and templates.
- Ask them to prepare the budget—or at least double-check your numbers.
- Ask them what the procedures are for submitting a proposal.
- Find out what ***the business-office*** deadlines are; frequently, a proposal must be submitted to the business office well in advance (days) of the agency's deadline.



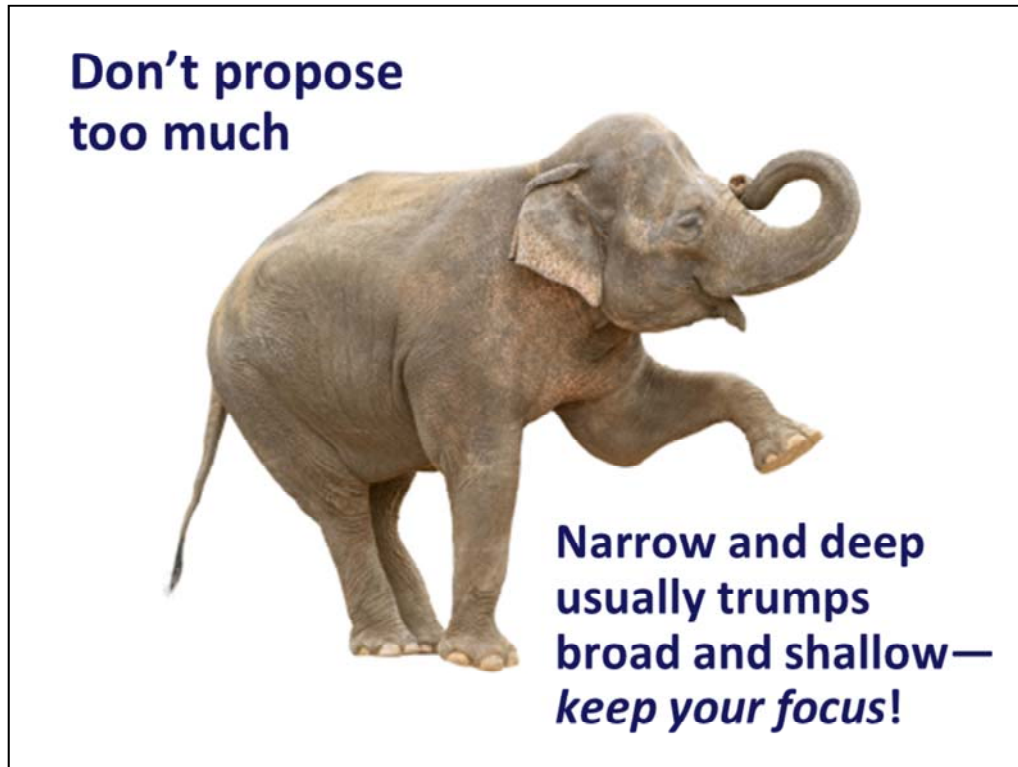
Go through the solicitation with a highlighter and make note of all required information and any deviations from standard requirements for that agency.

Everything you've highlighted, put on your checklist.

Many agencies provide a standard checklist for proposals—use it!

Pay particular attention to:

- Fonts, margins, page limits.
- All points specified in the project description.
- All required sections.
- All required budgetary information.
- IRB, drug-free workplace, lobbying, and other certifications.
- Postdoctoral mentoring plan. (NSF)
- Data management plan (NSF, DOE)
- Resource sharing plan. (National Institutes of Health)
- Ethics training. (NIH)



Don't bite off more than you can chew. Be realistic in what you say you can accomplish, given the time and \$\$ constraints of your proposal.

Reviewers are skeptical people, and they know what things cost, what one person or a small team can reasonably be expected to do, and how long it will take.

If you overpromise, you risk underdelivering and putting your *next* proposal in serious jeopardy. Nearly every funding agency asks, as part of its proposal review process, "What did you accomplish with the money we gave you last time?"

**According to Dr. Sally Rockey,  
Deputy for Extramural Research, NIH:**

**“So, often times, new investigators have so many great ideas that they come in with ten or twelve objectives and that really would not be accomplishable in a three- to four-year time frame. And reviewers pick up on that. So, first and foremost, you want to try to put some boundaries around your objectives...Usually we say no more than four objectives or specific aims in an application for a new investigator.”**

NIH, “Grant Writing for New Investigators,” interview with Dr. Sally Rockey, April 30, 2010,  
[http://grants.nih.gov/podcasts/All\\_About\\_Grants/episodes/Grant\\_Writing\\_April\\_2010.htm](http://grants.nih.gov/podcasts/All_About_Grants/episodes/Grant_Writing_April_2010.htm)

While this statement is specific to new investigators applying to the National Institutes of Health, I think the advice is applicable to all federal funding agencies.

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**Emphasize metrics and deliverables**

**Explicitly state how you will analyze and  
validate your results**

**Articulate metrics—how will you  
determine success and know when  
you're done?**

**Identify concrete milestones**

**Specify deliverables**

**Don't get bogged down in technical details**

A **proposal is not a scientific article**, it is a *sales document*—you're trying to convince "investors" (the funding agency) to sink money in a speculative project.

And remember that most people reading the proposal and evaluating it probably won't be experts in your narrow field.

**Most funding agencies are risk-averse\***

**Reassure them that you've considered alternative approaches, and your approach is best because...**

- 1. You know the potential obstacles, and if A happens, you'll still be successful because you already have a Plan B**
- 2. You and your team have the perfect combination of experience, expertise, and research infrastructure**

*\*perhaps today more than ever*

The best way to nullify reviewers' objections is to anticipate them and explicitly address them in your project narrative.

## Show how your project will contribute to the funder's mission

Every program announcement contains an "objectives" section; quote their words back to them

Look for programs' mission statements and descriptions on the agency's website

Align your project's goals with the agency's objectives

Emphasize your project's return-on-investment



**Consider the objectives of the agency**, and make it clear that funding your proposal will advance its mission.

Every federal funding agency has a mission statement; every program announcement contains a "program objectives" section. Quote their words back to them and show how your project fulfills these goals.

- Solves an important problem
- Enables new technology
- Strengthens U.S. research capacity and infrastructure
- Develops human resources for science and engineering, particularly among groups who have been traditionally underrepresented in science
- Promotes training of the next generation of U.S. scientists and engineers with skills that will allow them to lead the world.

Be able, in one or two sentences, to convincingly explain why a Congressman should **care** about your project.

**Check a hard copy printed from  
the portal's server**

**Section D. References Cited**

1. Yildiz, A., J.N. Forkey, S.A. McKinney, T. Ha, Y.E. Goldman, and P.R. Selvin, *Myosin V walks hand-over-hand: single fluorophore imaging with 1.5-nm localization*. *Science*, 2003. **300**(5628): p. 2061-5.
2. Yildiz, A., M. Tomishige, R.N. Vale, D.M. and P.N. Selvin, *Kinesin Walks Hand-Over-Hand*. *Science*, 2004. **303**(5727): p. 1469-71.
3. Kural, C., H. Kim, S. Rohde, C.B., F. Zeng, and M.L. Nonet, *Tracking melanosome movement in vivo: a tug-of-war or coordinated movement?* *Proc Natl Acad Sci U S A*, 2009. **106**(11): p. 4611-6.
4. Kural, C., M.L. Nonet, and P.R. Selvin, *Tracking melanosomes inside a cell to study molecular motors and their interaction*. *Proc Natl Acad Sci U S A*, 2007. **104**(11): p. 1511-6.
5. Kural, C., M.L. Nonet, and P.R. Selvin, *FIONA on Caenorhabditis elegans*. *Biochemistry*, 2009. **48**(22): p. 4611-6.

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IN YildizA.,J.N.Forkey,S.A.McKinney,T.Ha,Y.E.Goldman,and P.R.Selvin,Myosin V walks hand-over-hand: single fluorophore imaging with 1.5-nm localization. Science. 2003. 300(5628): p. 2061-5.

RN YildizA.,M.Tomishige,R.N.Vale,D.M.,and P.N.Selvin.Kinesin Walks Hand-Over-Hand. Science. 2004. 303(5727): p. 1469-71.

SN KuralC.,H.Kim,S.Rohde,C.B.,F.Zeng,and M.L.Nonet. Tracking melanosome movement in vivo: a tug-of-war or coordinated movement? Proc Natl Acad Sci U S A. 2009. 106(11): p. 4611-6.

TN KuralC.,M.L.Nonet,SerpinskayaL.Y.,H.Chou,R.D.Goldman,L.V.Gelfand,and P.R.Selvin. Tracking melanosomes inside a cell to study molecular motors and their interaction. Proc Natl Acad Sci U S A. 2007. 104(11): p. 1511-6.

UN RohdeC.,B.,F.ZengL.,R.GonzalezM.,KimL.,NonetM.,L.,and SelvinP.R. Microfluidic system for on-chip high-throughput whole-animal sorting and screening at subcellular resolution. Proc Natl Acad Sci U S A. 2009. 106(11): p. 4611-6.

VN HulmeS.E.,S.S.,and SelvinP.R. A microfabricated array of clamps for immobilizing and imaging C. elegans. Lab Chip. 2007. 7(11): p. 1511-6.

WI KuralC.,M.L.,NonetL.,and SelvinP.R. FIONA on Caenorhabditis elegans. Biochemistry. 2009. 48(22): p. 4611-6.

SN ZhangR.,R.,EnrothenbergL.G.,FruhwithL.I.,GoldingL.T.,NgL.W.,LopesL.,and SelvinP.R. Rapid Two-Photon Imaging with Nanometer Accuracy of Individual Quantum Dots in a Biological Environment. Nature Methods. 2010. 7(1): p. 1-11.

**...and don't use prohibited fonts, either**

You won't know you've uploaded the budget justification in the project-summary slot unless you print out the file from the server.

I've done it all—uploaded the PI biosketch twice, once for the PI and the same one for the co-PI bio; had a 77-page file transfer only the first 38 pages; forgot to upload a section—the permutations of what can go wrong are endless, particularly when you're trying to do everything at the last possible minute.

### **Special caution for proposals submitted to NIH:**

When you “attach” a section of the proposal to the Adobe forms, a copy of the file is actually embedded in the Adobe document; it doesn't just point to the original file on your computer. So if you **change** the original file, you must delete the attachment and re-upload it in the Adobe package. Otherwise, the uncorrected version is what the reviewers get.

**Use the Elliott equation\* to estimate the time it will take**

$$t = 3h + \varepsilon, \quad [1]$$

where ***t*** is the time it actually takes to prepare, check, and submit a proposal, and ***h*** is the number of hours you think any idiot ought to be able to do it in.

**Note that  $\varepsilon$  is not necessarily trivial.**

\*based on >20 years of solid empirical data

One thing I've learned from the physicists is that if you get to this point in a talk and haven't shown an equation yet, you have no credibility at all. So here's the proposal equation.

This expression approximates the time it actually takes to get a proposal written, uploaded, checked, and submitted.

**N.B.** For most federal agencies, you do not submit the proposal to the agency—your business office does. Very often all parts of the final proposal must be submitted for institutional review **days** before the funding agency's deadline.

It **always** takes much longer than you think it will—always. (You heard it here first.)

And things are about to get worse. Grants.gov is jettisoning the Adobe "package" system in December and transitioning to a web-based portal, analogous to PAMS (DOE), NSPIRES (NASA), Fastlane (NSF), and the Commons (NIH).

**Equation 2 represents the time it takes in the event of multiple PIs**

$$t = 3nh + \varepsilon, \quad [2]$$

**where  $t$  is the time,  $n$  is the number of PIs, and  $h$  is the number of hours you think any idiot ought to be able to do it in.**

This equation probably underestimates the time involved.

**Equation 3 represents the time it takes in the event of a collaborative proposal among multiple institutions**

$$t = 12ih + \varepsilon, \quad [3]$$

where ***t*** is the time, ***i*** is the number of institutions involved, and ***h*** is the number of hours you think any idiot ought to be able to do it in.

So does this one.

**Sometimes the “done”  
must trump  
the “perfect”**



**Don't risk having your  
proposal returned without  
review because you missed the deadline**

**Ask for help if you need it—but take chocolate**

**Concentrate on the project summary and the  
budget pages**

**Enlist a proofreader/format checker**

**Resolve to start earlier next time!**

Don't let the quest for perfection and endless revising keep you from actually getting the proposal submitted by the deadline. Sometimes you've just got to say "That's good enough for government work" and move on.

Use templates and farm out as much of the work as you can to non-scientists who can do it competently. We OCD types have our uses when we are off our medication.

Resolve to start earlier next time.



## **Recognize that servers get slower and flakier as a deadline approaches**

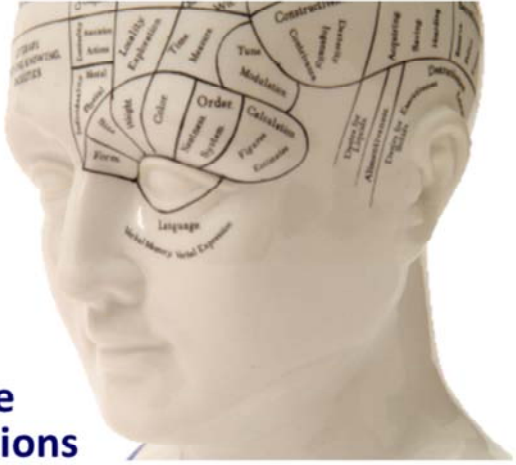


*Everybody else waited until the last  
minute to upload their graphics-heavy,  
50-MB project descriptions, too*

Everybody else waited until the last minute, too, and they're all trying to upload their 24-MB, high-resolution graphics-heavy project descriptions at the same time.

**Most proposals do not fail because of bad science—but because of**

- Failure to follow directions**
- Poor logical organization**
- Lack of persuasive detail**
- Failure to consider the funder's objectives**
- Failure to anticipate reviewers' objections**



**Failure to follow instructions**

- Not submitted by deadline
- Exceeds page or budget limits
- Mandatory information omitted
- Non-compliant with agency formatting and margin requirements

Remember that decisions are made on the margins. Assume that all of the proposals that you're competing with will represent solid science. It's the other elements of the proposal package—the alliance with other funder goals (education and outreach, diversity, tech transfer), the perceived qualifications of the PI and other personnel, the strength of the management plan, the planning for obstacles—that often mean whether a project is funded or not.

And the parts of a proposal that you don't care about—the biosketches, the facilities description, the broader impacts, the narrative budget justification—may well be the tie-breakers.

## If your proposal fails (and some will)...

Read the reviewers' comments

Find out what kinds of projects  
*were* funded

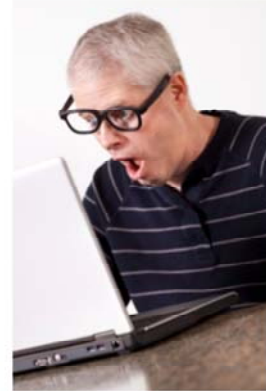
Talk to the program officer  
about resubmitting

Investigate other funding agencies

Rewrite it and submit it again, or—

Recognize that there is no “market” for the  
project, at least for now, and move on

**Don't give up!**



Take a deep breath, put your ego aside, and consider the reviewers' comments objectively. If they didn't understand what you want to do and why it's important, perhaps they really aren't idiots; perhaps you didn't explain it well enough.

**Talk** to the program officer. They are usually very candid and can give you good advice about resubmitting.

“Rejection and Its Discontents,” Michael J. Spires, *The Chronicle of Higher Education*, May 20, 2013

<http://www.chronicle.com/article/RejectionIts-Discontents/139403/>



**Other sources of good advice:**

***“Getting Funded,” Making the Right Moves: A Practical Guide to Scientific Management for Postdocs and New Faculty***  
[http://www.hhmi.org/resources/labmanagement/downloads/moves2\\_ch9.pdf](http://www.hhmi.org/resources/labmanagement/downloads/moves2_ch9.pdf)

**NIH Grant Process YouTube Videos (includes tips)**  
<http://public.csr.nih.gov/aboutcsr/contactcsr/pages/contactervisitcsrpages/nih-grant-review-process-youtube-videos.aspx>

**“NIH Peer Review Revealed”**  
**“NIH Tips for Applicants”**

**NSF Regional Grants Conferences**  
<https://www.nsf.gov/bfa/dias/policy/outreach.jsp>

**How to Prepare an NSF Proposal: The Good, the Bad and the Ugly**  
[https://www.nsf.gov/bfa/dias/policy/outreach/propprep\\_aug2016.pdf](https://www.nsf.gov/bfa/dias/policy/outreach/propprep_aug2016.pdf)

The next NSF regional grants conference will be held in Phoenix, AZ, on November 13 and 14, 2018. Registration opened September 7, and usually fills up quickly.

You can receive email announcements about upcoming NSF grants conferences by going to [nsfgrantsconferences.com](http://nsfgrantsconferences.com) and clicking “Get Notified.”

## To recap...

**READ** the FOA carefully

**Make** a checklist

**Answer** every question of the catechism  
somewhere in your project description

**Make** it easy for a reviewer to pick out  
the answers

**Use** the FOA & catechism to make an outline

**REVIEW** your checklist before you submit



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*<http://physics.illinois.edu/people/Celia/>*

Notes: