

Writing Research Proposals to the National Science Foundation

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What follows is a collection of advice for writing research grants to the National Science Foundation. It includes some guidelines on how to write an NSF proposal and how to get the latest version of the NSF forms. There are some NSF forms, such as the Disclosure of Lobbying Activities, that your grants office will provide for you.

This document focuses on writing proposals to NSF, but the following general advice can be applied to writing any proposal.

General Advice

Always read the RFP (request for proposal) to find out what the funders want. They will give you money only if you can help them reach their goals. The goals of funding agencies (public and private) vary dramatically. A successful proposal to NSF looks nothing like a successful proposal to NASA. Even within an agency, the style of proposals can be different among internal divisions. Find out about the agency, its goals, and its review system.

All proposals should answer the following questions in one form or another.

- What is the problem being addressed? (What is the goal of the research being proposed? What is the hypothesis being tested?)
- Why is the problem important and interesting?
- What will you DO to address the problem? If you complete the plan, will that bring us closer to an answer to the problem?
- Do you have the resources (equipment, grad students, access to industry ...) necessary to complete the research?

Writing NSF Proposals

NSF is organized a lot like a university, except that instead of departments and colleges it has divisions and directorates. The program directors are like professors (and a lot of them are professors on leaves of absence). They have areas of specialization which correspond to the research areas covered by their programs. The division directors are like department chairs. They oversee the broad research areas covered by the programs and deal with administrative issues. The Assistant Directors are like Deans of Colleges. They lead the directorates and are responsible for the major research directions in Engineering, Physical Sciences, etc. The Director of NSF is responsible for the overall direction of Science and Engineering Research. However, unlike a university, NSF reorganizes constantly. This means that you may get to know a program director who may suddenly return to his or her university or may be reassigned to another program — or that your program may be merged with a different program. While this is disconcerting in the short run, in the long run it keeps programs from stagnating and helps NSF keep on the forefront of research areas.

Read the program announcements before you talk to the program director so that your questions will be direct and specific. You can either call or send e-mail to the program director for your program area to discuss the ideas in your proposal. You can the list of telephone numbers and e-mail addresses from the NSF web site (<http://www.nsf.gov/>). Some program directors prefer e-mail; some prefer phone calls. Find out which program supports your research area (it's not always obvious); ask if there are other people you should talk to and what special initiatives might apply to you. Listen to what the program director says. Remember to say "thank you." (Don't be discouraged if they are rough on you. They spend all day on the phone and the rest of the time they're traveling and staying in government-rate hotels.) Treat the program directors as if they are intelligent people (even if you doubt it). The program director will assign the reviewers and will make the final decision. You don't have to be a sycophant, just be polite. (This advice comes from a former NSF program director.)

If you call, you will probably talk to a secretary several times before you get through to the program director. Be polite to the secretaries on the phone too -- They take a lot of grief from unhappy PIs (Principal Investigators). The secretaries (who are not well paid) would appreciate it if you would submit only ONE copy of Appendix III (the demographic information form). Don't put the proposal in special covers -- just staple it together with one staple at the top. Make the NSF cover page the FIRST (TOP) page of your proposal. If you don't do these things, the secretaries have to rip Appendix III out of every copy of your proposal; they have to rip the special covers off; and they have to keep flipping through your proposal to find the cover page which has the information they need. The instructions to proposers get more and more specific every year. **Follow the directions!** (The secretaries are often heard muttering things like: "If they're so smart, why can't they read?")

Assembling the Proposal

The rest of this package duplicates the general flow of forms and text for an NSF proposal. Once you have a rough draft of your proposal, ask someone who is senior to you to read your proposal as if they were an NSF reviewer. The ideal reader is a senior trusted colleague in your field who has had NSF funding, has served on NSF panels, and who will not be used by NSF as a reviewer. (See Section 4.)

1 Project Summary

200 words. This is not an abstract. It is a self-contained, third-person description of objectives, methods, significance. If you are funded, this goes into NSF's *Summary of Awards* publication as well as being published on the NSF Web site. It will be read by your colleagues, the general public, and Congress.

2 Results from Prior NSF Support

If any of the PIs have received NSF support in the past 5 years, you *must* include a summary of the results of previous work. The pages in this section count toward the total 15 pages. You can use this section to discuss your prior research and how it helps to support your current proposal. One of the purposes of this section is to help the reviewers evaluate your track record.

- Award #, amount, period
- Title
- Summary of results
- List of publications acknowledging NSF
- For renewals: relation to proposed work

3 Project Description

The project description has a 15 page limit. Proposals over this limit are thrown out. The formatting requirements are given in the *Grant Proposal Guide*.

3.1 Objectives and Expected Significance

What are the main scientific challenges? Emphasize what the new ideas are. Briefly describe the project's major goals and their impact on the state of the art.

Clearly state the question you will address:

- Why is it important? (What is important varies with the field.)
- Why is it an interesting/difficult/challenging question? It must be neither trivial nor impossible.

3.2 Background and Technical Need

What long-term technical goals will this work serve?

What are the main barriers to progress? What has led to success so far and what limitations remain? What is the missing knowledge?

What aspects of the current state-of-the-art lead to this proposal? Why are these the right issues to be addressing now?

What lessons from past and current research motivate your work. What value will your research provide? What is it that your results will make possible?

What is the relation to the present state of knowledge, to current work here & elsewhere? Cite those whose work you're building on (and whom you would like to have review your proposal). Don't insult anyone. For example, don't say their work is "inadequate." Rather identify the issues they didn't address.

Surprisingly, this section can kill a proposal. You need to be able to put your work in context. Often, a proposal will appear naive because the relevant literature is not cited. If it looks like you are planning to reinvent the wheel (and have no idea that wheels already exist), then no matter how good the research proposal itself is, your proposal won't get funded. If you trash everyone else in your research field, saying their work is no good, you also will not get funded.

You can build your credentials in this section by summarizing other people's work clearly and concisely and by stating how your work uses their ideas and how it differs from theirs.

3.3 Research Description

Broad technical description of research plan: activities, methods, data, and theory.

This should be equivalent to a PhD thesis proposal for the big leagues. Write to convince the best person in your field that your idea deserves funding. Simultaneously, you must convince someone who is very smart but has no background in your sub-area. The goal of your proposal is to *persuade* the reviewers that your ideas are so important that they will take money out of the taxpayers' pockets and hand it to you.

This the part that counts. WHAT will you do? Why is your strategy an appropriate one to pursue? HOW will you achieve your goals? Concisely, coherently, this section should complete the arguments developed earlier and present your initial pass on how to solve the problems posed. Avoid repetitions and digressions.

In general, NSF is more interested in ideas than in deliverables. The question is: What will we *know* when you're done that we don't know now? The question is not: What will we *have* that we don't have now? That is, rather than saying that you will develop a system that will do X, Y and Z, instead say why it is important to be able to do X, Y and Z; why X, Y and Z can't be done now; how you are going to go about making Z, Y and Z possible; and, by the way, you will demonstrate X, Y and Z in a system.

Right now, NSF is more open to application-oriented research. They need to show Congress that the money spent on research benefits the US economy. Ten years ago, the word "applied" was a bad word at NSF. Now it's a good word. The pendulum between focussing on basic or applied research has about a 20 year periodicity. You always need to check to find out where it is at the moment. Check with the program director and knowledgeable colleagues.

3.4 Education and Human Resources

What potential contributions to developing human resources in science & engineering at postdoc, graduate, and undergrad levels?

In the last few years, NSF has started to take educational goals much more seriously. This section used to be boilerplate; it can't be any more. You need to think about what impact your research will have on education. Be specific but don't overstate.

3.5 Plan of work

Present a plan for how you will go about addressing/attacking/solving the questions you have raised.

Discuss expected results and your plan for evaluating the results. How will you measure progress?

Include a discussion of milestones and expected dates of completion. (Six months is the about the smallest time chunk you should include in an NSF proposal.) You are not committed to following this plan - but you must present a FEASIBLE plan to convince the reviewers that you know how to go about getting research results.

For new PIs, this is often the hardest section to write. You don't have to write the plan that you will follow no matter what. Think of it instead as presenting a possible path from where you are now to where you want to be at the end of the research. Give as much detail as you can. (You will always have at least one reviewer who is a stickler for details.)

3.6 Bibliography

Pertinent literature referenced within the project description.

Program directors often look in the bibliography for potential reviewers, and reviewers often look in the bibliography to see if their work is cited. If your bibliography has a lot of peripheral references, your proposal may be sent to reviewers whose work is not directly related to yours and who may not understand your proposal. On the other hand, if you do not cite the relevant literature, your proposal may be sent to reviewers who are not cited and who will criticize you for not knowing the literature. Most of the references in the bibliography will be cited in the Related Work section.

4 Biographical Sketches

Educational background and career, academic essentials only. List the highlights that a reviewer of the proposal needs to know about you.

List up to five relevant publications, patents, copyrights, or software systems, plus up to five other

significant publications.

Graduate students advised and postdocs sponsored in the past five years and total numbers advised & sponsored.

List long-term associates with whom you have collaborated in the past two years plus your graduate and postdoc advisors. This is for conflict-of-interest: NSF will not send your proposal to your close colleagues, your thesis advisor, nor to anyone at your current institution. You may list such people explicitly, if you wish.

Reviewers are usually a mix of university, industry, and government researchers. Almost always, the majority are academics.

5 Budget

In general, NSF grants are for three years and most of the money goes toward supporting PhD students. A typical budget is \$70K-\$90K which will pay for a graduate student (tuition and stipend), about 10% of the professor's time to supervise the student, a little bit of travel, copying, and overhead. However, the grant size varies from division to division. Ask someone in your area what is typical.

Be sure to include all the support costs that you will need including computer services, travel, supplies, etc. NSF may cut your budget, but they'll never give you more than you ask for, so be sure to ask for everything you need.

Describe, justify, and estimate cost of equipment items \$1000 or more. If your equipment needs change between the time you submit the proposal and the time it is granted, you can still buy what you need -- But be sure to talk to the university grants office BEFORE you buy the new equipment. There are special rules about equipment money because it is usually exempt from overhead charges.

Describe travel needs. If you are requesting funds for foreign travel, identify the country. All foreign travel on US government funds requires PRIOR APPROVAL. If a US airline flies your route, you must take a US airline. You cannot be reimbursed for foreign travel if the paper work is not processed before you leave. There is NO escape clause on this rule.

The business manager in your department or grants office will usually help you fill out the budget form once you have identified the direct costs.

6 Current and Pending Support

List all current and pending support on the given forms. Your budget office can probably help with these.

If you have submitted the same proposal to more than one agency, be sure that you declare it on the cover page and in the current and pending support section. If you don't and the same reviewer is picked by both agencies, you won't get funded and your reputation will be damaged. Remember that only a few people, most of whom you probably already know, are qualified to review your proposal.

7 Facilities and Special Considerations

This section should focus on the facilities available to you. If you will rely on any specialized equipment, describe it. The question in the reviewer's mind is: Do you have the necessary resources to carry out the research? In addition, if you are asking for equipment in your proposal, you will want to make clear what equipment you don't have.

OPTIONAL: Special considerations if some work will occur off-campus

What Happens to your Proposal When It Gets to NSF?

The details described here will change once the FastLane (electronic submission) system becomes the dominant method for proposal submission. However, the flow of decisions *etc.* will be essentially the same.

All proposals arrive at the NSF mail room. (99% arrive by express mail.) They are unpacked and given a preliminary sort based on the program announcement number or the NSF division given by the PI. (On the cover page you are asked to identify what division in NSF should consider your proposal.) A program director takes a look at the proposals that don't have an obvious place to go. Before the proposals go to the divisions, the information from the demographic sheet is entered into a database. Then the information from the cover sheet is entered into the main database and the proposal is assigned a number. (The two databases are not associated. No traceable data is kept with the demographic data.)

Next, the proposals are distributed to the divisions. Someone in each division checks to be sure that the proposals belong in that division and decides which program to assign them to. Sometimes, a proposal does not fit neatly into a single program or division. In that case, several program directors may be responsible for a single proposal. The original of the proposal is put in a jacket (a dark brown file folder) and data forms are filed with it. A postcard is sent to the PI stating giving NSF tracking number and the program it has been assigned to. (Save this card!)

Once the proposal has been assigned to a program director, it is ready for review. There are two basic review mechanisms used at NSF: mail review and panel review. Both are single blind peer review mechanisms: that is, the reviewers (who are the PI's peers) know who the PI is, but the PI does not know who the reviewers are.

Mail review: The program director chooses about six reviewers who are knowledgeable in the area of the proposed work. These reviewers are a mix of academics, industry and government reviewers, with academics being the majority. NSF has a database of reviewers and the proposals are assigned to the reviewers in the database. (The PI database, proposal database and reviewer database are all separate databases.) The proposal is mailed to the reviewers with a cover letter, a review form, and background information about the division to which the proposal was submitted. The reviewer is given about two weeks to a month to review the proposal. (The reminder letters for late reviews are generated automatically along with the labels, original cover letters, review forms, etc.) When four or five reviews have been received, the program director reviews the proposal and the reviews, then makes a decision to fund or decline the proposal. The program directors are supposed to exercise judgement. For example, a reviewer might appear to be a perfect match for a proposal — but when the review comes in, it may be obvious that the PI's work conflicts with the reviewers work, and the reviewer is biased.

Panel review: If a program has a large volume of proposals, mail review is not possible. Here's the math: Most reviewers will not review more than 5 proposals a year without revolting (reviewing a proposal is a lot of work). If 150 proposals are submitted to a program, that means 900 review request must be sent out. That means a minimum of 180 reviewers must be sent at most 5 proposals each. Three reviews per person per year is more realistic - so that means the program director must have access to 300 of the proposal writers' peers in order to get the peer review system to work. And that's just for one program. All the other program directors are working with the same numbers — and the expertise of many reviewers overlaps several programs. So instead of using mail review, program directors form panels. A program director will convene a panel of 10 to 15 experts in a field and have them review a set of related proposals. The panelists receive the proposals ahead of time and then come together to discuss which proposals should get funded. Most reviewers find it easier to rank a set of proposals than to write a detailed review of each proposal. The reviews from a panel review are often not as detailed as the ones from a mail review — but they usually are more directed. If one reviewer completely misses the point of a proposal (which they sometimes do), this will come out during the panel discussion so you get fewer

out-in-left-field reviews from panels than from mail review. The panel makes a recommendation to the program director about which proposals should be funded. Again, the program director makes the funding decision.

Often the decision to fund involves deciding whether to fund the proposal at the full or reduced amount. The program director makes the decision based on the program budget, the proposals that have been funded, and the pending proposals. The program director completes a form to support the decision. The proposal goes to the division director who must concur with the decision for it to be official. The decision is entered in the computer. If the proposal is declined, a letter is sent to the PI (cc:d to the grants office), and the file copy of the proposal with its associated reviews and forms is sent to storage. If the proposal is funded, the jacket is sent to the NSF grants office. The grants office deals with all the paper work required to make a grant. (A grant from NSF goes to the institution, not to the PI. But if you change institutions, it is easy to take an NSF grant with you.) After the paper work has been completed, the jacket is returned to the program director. The jacket stays with the program director until the grant is completed, and you have filled out your 98A (final report). Once the final report is received, your jacket is sent off to storage.

Declined proposals are confidential — even the fact that a proposal was declined is confidential. For grants, the titles, abstracts, PIs, funding amounts, .. are public information, but the proposal itself is confidential.

NSF Information On-Line

NSF has a Web page now. The URL is

<http://www.nsf.gov/>

From this page, you can retrieve NSF publications, program descriptions and current deadlines, the phone numbers and e-mail addresses of project directors, etc.

If you don't have access to the Web, you can access NSF through STIS. STIS is an electronic dissemination system which provides access to NSF publications. The full text of publications can be searched online and copied from the system. There is no charge for connect time and no need to register for a password. The service is available 24 hours a day, except for maintenance periods. Up to ten people can be on the system at the same time.

On the Internet, STIS can be accessed by using a single command:

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telnet stis.nsf.gov
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Login: public
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Users may login to STIS with the keyword: public. The user will then key in a personal ID up to eight characters. This will be the users permanent STIS ID for future sessions.

Publications may be searched by using a keyword, by using a phrase or a Boolean inquiry, or by predefined topics. Included in the database are The NSF Bulletin, The Guide to Programs, evaluation reports and studies, program descriptions and announcements, lists of projects funded by NSF, and the NSF telephone directory.

The program is menu driven and uses the arrow keys on the keypad to navigate. You may need to experiment to find the right terminal type.