A Practical Guide to Writing an NSF Grant Proposal (NAN Edition)

Matthew Badger

University of Connecticut

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CAREER ARTICLE

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EARLY CAREER

A Practical Guide to Writing an NSF Grant Proposal

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Your think that your research is going well. You have a shiny new theorem or a novel proof technique or a cool example. You also have some ideas on how to build on your recent research. You want to tell the US mathematics community about your recent successes and share the excitement that you have for your research program. Maybe your faculty advisor, postdoctoral mentor, or colleague suggests that you apply for a grant. Maybe you take the initiative on your own. Whether the reason is to obtain summer salary to support your research, fund travel to conferences, reimburse visitors, pay students, or all of the above, you decide to submit a grant proposal to the National Science Foundation (NSF). This is not something that you have done before—or at least it has been a while since you last prepared a proposal.

What exactly do you have to do?

Plan of the Talk

1. Overview: Types of NSF Grants for Mathematicians
2. Getting Started / Preparing Your Proposal
3. Discussion: What makes a good Project Description?

Disclaimer! Any opinions or recommendations expressed in this talk are my own and do not necessarily reflect the views of the National Science Foundation

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PLEASE ASK QUESTIONS

1. OVERVIEW

NSF Division of Mathematical Sciences at a Glance

- Annual Budget $244 Million (as of Fiscal Year 2021)
- 73% of Funding Goes to Individual PIs (Principal Investigators)
- $\approx$ 6500 Researchers Supported Annually (Undergraduates, Graduate Students, Postdocs, Senior Researchers)
- $\geq$ 3000 Proposals Reviewed Annually, $\approx$ 750 Awards Granted

(Source: Juan C. Meza, AMS Notices, October 2023)

Types of Grants: Standard Grants

Division of Mathematical Sciences (DMS) at NSF is organized into

1. Algebra and Number Theory
2. Analysis
3. Applied Mathematics
4. Combinatorics
5. Computational Mathematics
6. Foundations
7. Geometric Analysis
8. Mathematical Biology
9. Probability
10. Statistics
11. Topology

Standard Grants

- 3 years, up to 2 months of summer salary / year, travel funds, etc.
- Available to researchers employed at US institutions of higher ed
- Postdocs are eligible and have received awards
- If you earned PhD $\leq$ 10 Years ago, then automatically considered an Early-Career Researcher
- Application deadline in fall, varies by program

Types of Grants: Career-Stage Specific Grants

MSPRF: Mathematical Sciences Postdoctoral Research Fellowship

- Salary for 18 Academic Months and 6 Summer Months at an Institution of Your Choice under a Sponsoring Scientist
- Eligibility: US Citizens or Permanent Residents, and PhD Held $<$ 2 Years in January of Year of the Award (Year X+1)
- Applications due in mid October (Year X)

LEAPS: Launching Early-Career Academic Pathways in Mathematical and Physical Sciences

- Elibility: Pre-tenure faculty at institutions that do not traditionally receive significant NSF funding, including minority-serving, predominantly undergraduate, or R2 institutions
- Awards are for 2 Years, Budget up to $250,000
- Applications due in late January

Submission Process at a Glance

1. Proposals are submitted on the research.gov website to one of the **Disciplinary Research Programs** (e.g. Analysis) or in response to a **Program Solicitation** (e.g. MSPRF)

2. The individual who is responsible for carrying out research and other proposed activities is called the **Principal Investigator (PI)**

3. As the PI, you will need to prepare about 10 documents total. Ask university staff or senior colleague for help with financial parts of the proposal

4. Once reviewed by university **Sponsored Projects Office (SPO)**, the proposal is submitted by SPO on your behalf

Exception: The MSPRF is awarded to individuals directly and not a university. Budget is set by the NSF. You get to submit the proposal yourself

NSF Program Officers

What is a Program Officer?

Each of the research programs is overseen by NSF Program Officers, who make the final decisions about which grants to fund

Who are the Program Officers?

They are mathematicians! Names and email addresses of the current program officers for each program are on NSF DMS website

How can they help?

If you have technical questions as you prepare your proposal (“Am I allowed to...?”, “Should I...?”), the best way to get answers is to ask a program officer

Review Process

What happens after you submit your grant proposal?

1. Program officers skim your proposal to determine its topic and group it with similar proposals

2. Proposal sent for review by anonymous experts (mathematicians). **Anyone that you may have a conflict of interest with, including colleagues, collaborators, and former mentors, will not be chosen to review your proposal!**

3. After it is reviewed, your proposal will be ranked by a panel of experts. **Program officers take the ranking into account when deciding whether or not to fund your proposal.** Other considerations such as demographics, geographic diversity, and academic age may also be factored into the decision

4. You will receive reviews of your proposal at the end of the review process, which takes about 6 months

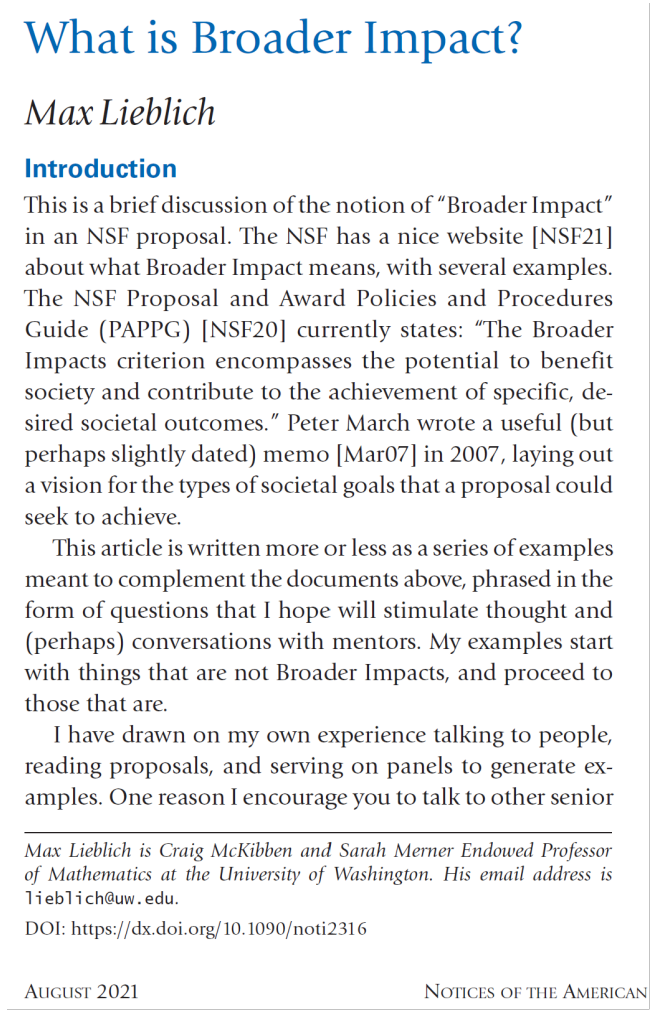
Evaluation Criterion

Intellectual Merit

- Perceived importance of proposed research within contemporary mathematics
- Whether the proposed research is creative, original, or potentially **transformative**
- How well qualified the PI is to carry out the proposed research
- Likelihood that the project can be carried out in the proposed time frame (3 years)

Broader Impacts (to Society)

- Activities in the proposal or carried out by the PI with the potential to benefit society or to achieve specific, desired societal outcomes
- Notably does not include applications to other areas of math or science!



What is Broader Impact?

Max Lieblich

Introduction

This is a brief discussion of the notion of "Broader Impact" in an NSF proposal. The NSF has a nice website [NSF21] about what Broader Impact means, with several examples. The NSF Proposal and Award Policies and Procedures Guide (PAPPG) [NSF20] currently states: "The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes." Peter March wrote a useful (but perhaps slightly dated) memo [Mar07] in 2007, laying out a vision for the types of societal goals that a proposal could seek to achieve.

This article is written more or less as a series of examples meant to complement the documents above, phrased in the form of questions that I hope will stimulate thought and (perhaps) conversations with mentors. My examples start with things that are not Broader Impacts, and proceed to those that are.

I have drawn on my own experience talking to people, reading proposals, and serving on panels to generate examples. One reason I encourage you to talk to other senior

Max Lieblich is Craig McKibben and Sarah Merner Endowed Professor of Mathematics at the University of Washington. His email address is lieblich@uw.edu.

DOI: https://dx.doi.org/10.1090/noti2316

2. GETTING STARTED

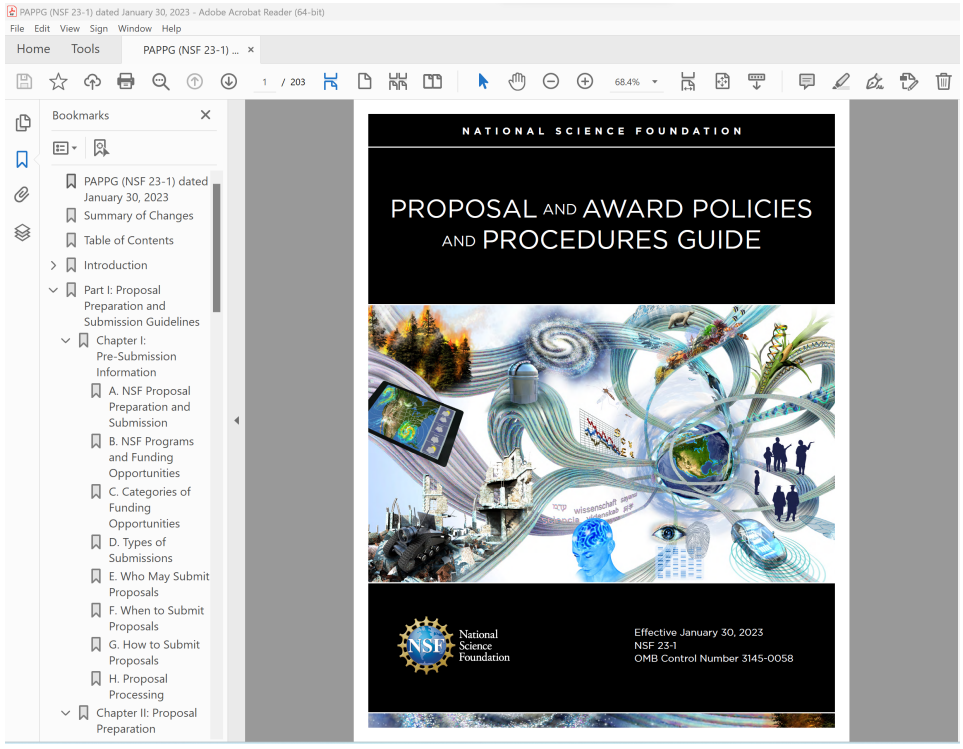
How to Get Started in 5 Steps

1. **Identify the NSF submission deadline.** Before you do anything else, look up the deadline for the program that you want to apply to on NSF website. Ideally, start work ≥ 2 months in advance.

2. **Identify any internal deadlines and reach out to university staff.** University SPO may require an internal submission deadline anywhere between 5 days to 14 days before the NSF deadline. Ask your mentor or supervisor about the local procedure.

How to Get Started in 5 Steps

3. **Create a folder. Download the PAPPG.** Make a separate folder for each proposal that you work on. Download a copy of the current Proposal & Award Policies & Procedures Guide (PAPPG). This is a very long document that specifies the rules for all grant proposals to the NSF. Refer to the PAPPG as you work on each part of the proposal



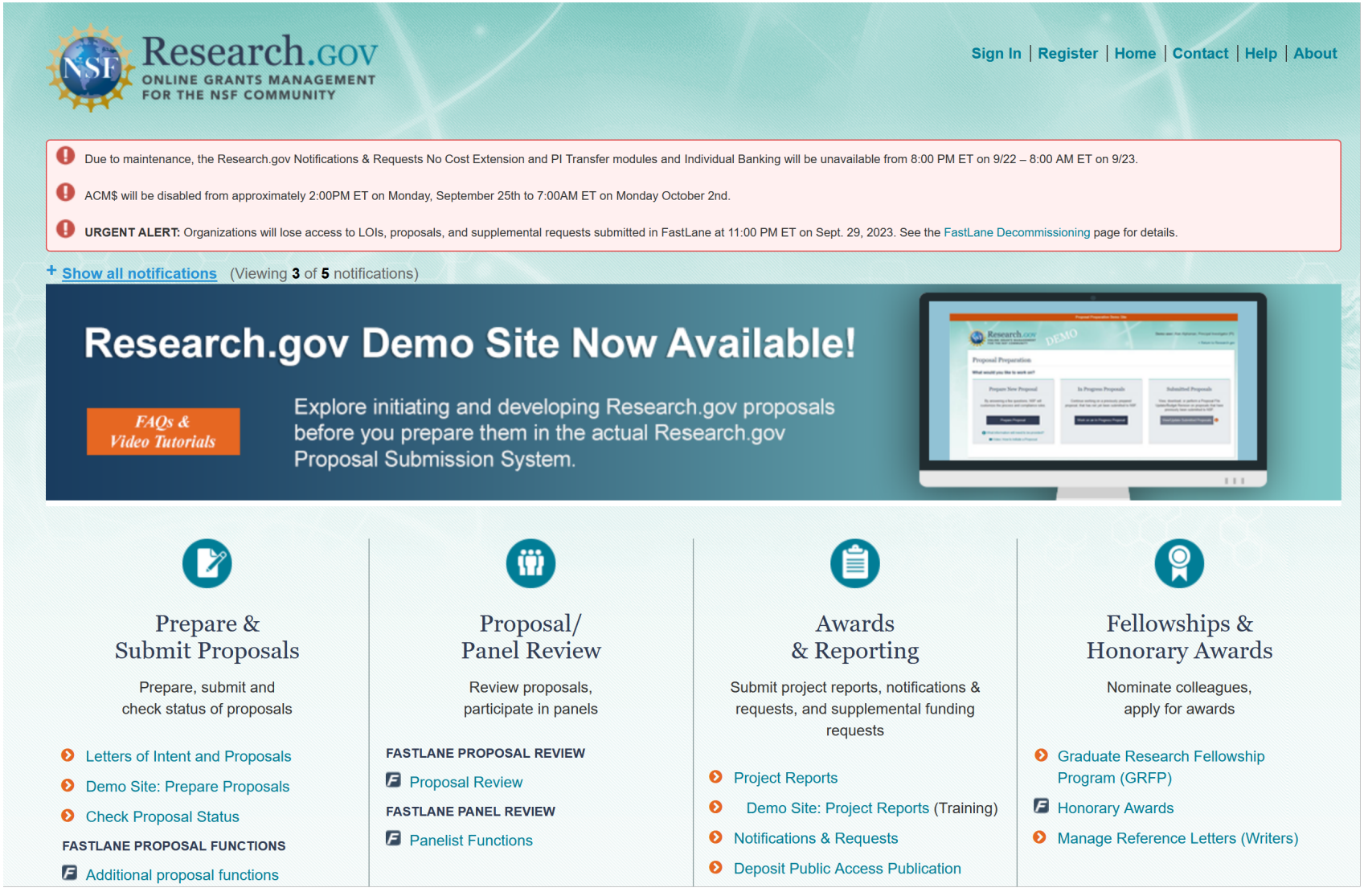
How to Get Started in 5 Steps

4. **Get an NSF ID. Login to research.gov. Start a new proposal.** If you do not already have an NSF ID, you can request one on research.gov. After logging in, find the link to create a new Full Proposal

(screen shots on the next page)

5. **Begin working on the proposal.** Most required documents may be prepared in LaTeX, Google Docs, or Microsoft Word, and uploaded to research.gov as a PDF. Exceptions are the Budget and Cover Sheet, which are entered directly on research.gov, and a trio of Senior Personnel Documents, which are filled-in using NSF supplied templates. It is time to work on these documents.

Start and Submit Your Proposal on Research.gov



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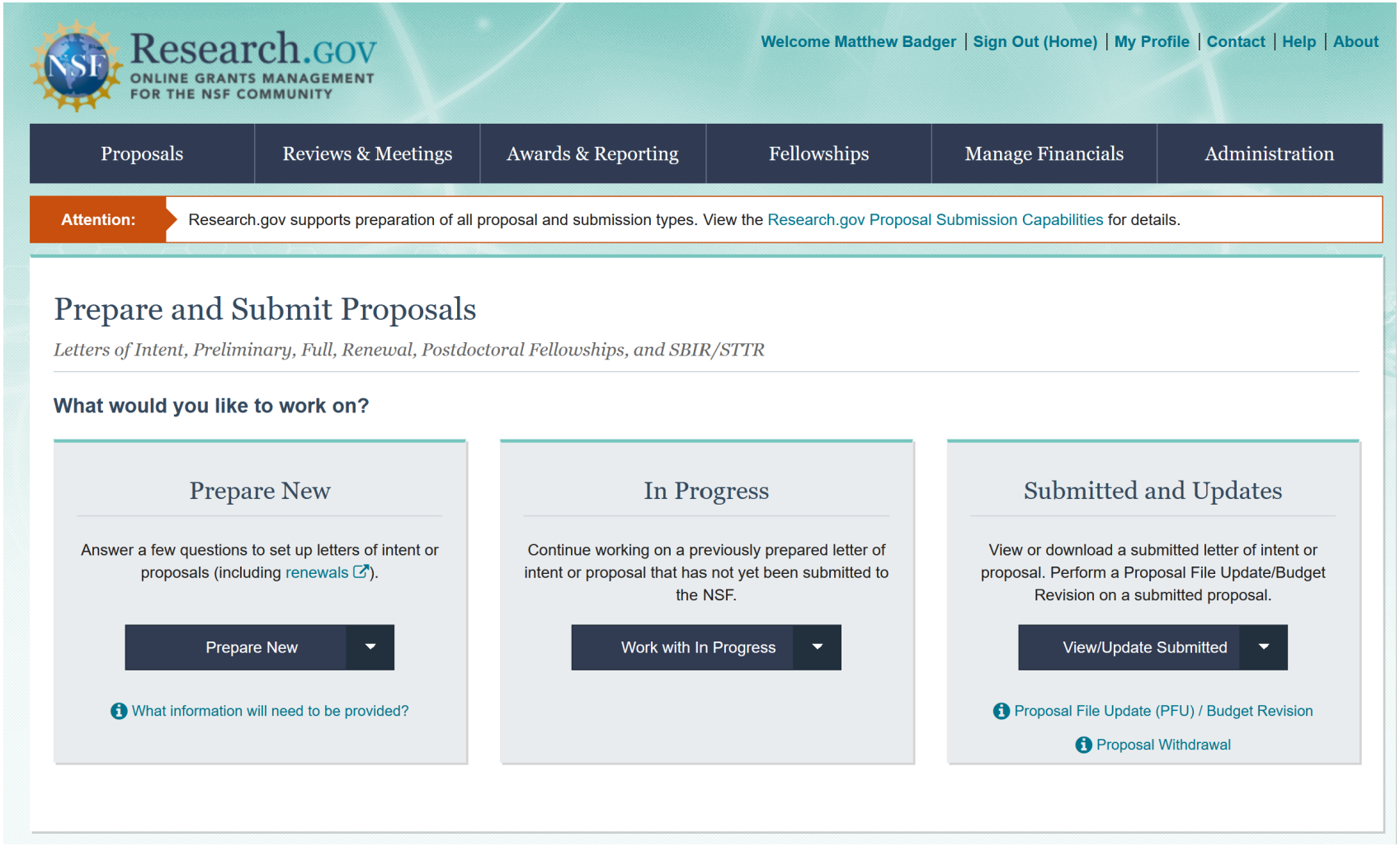

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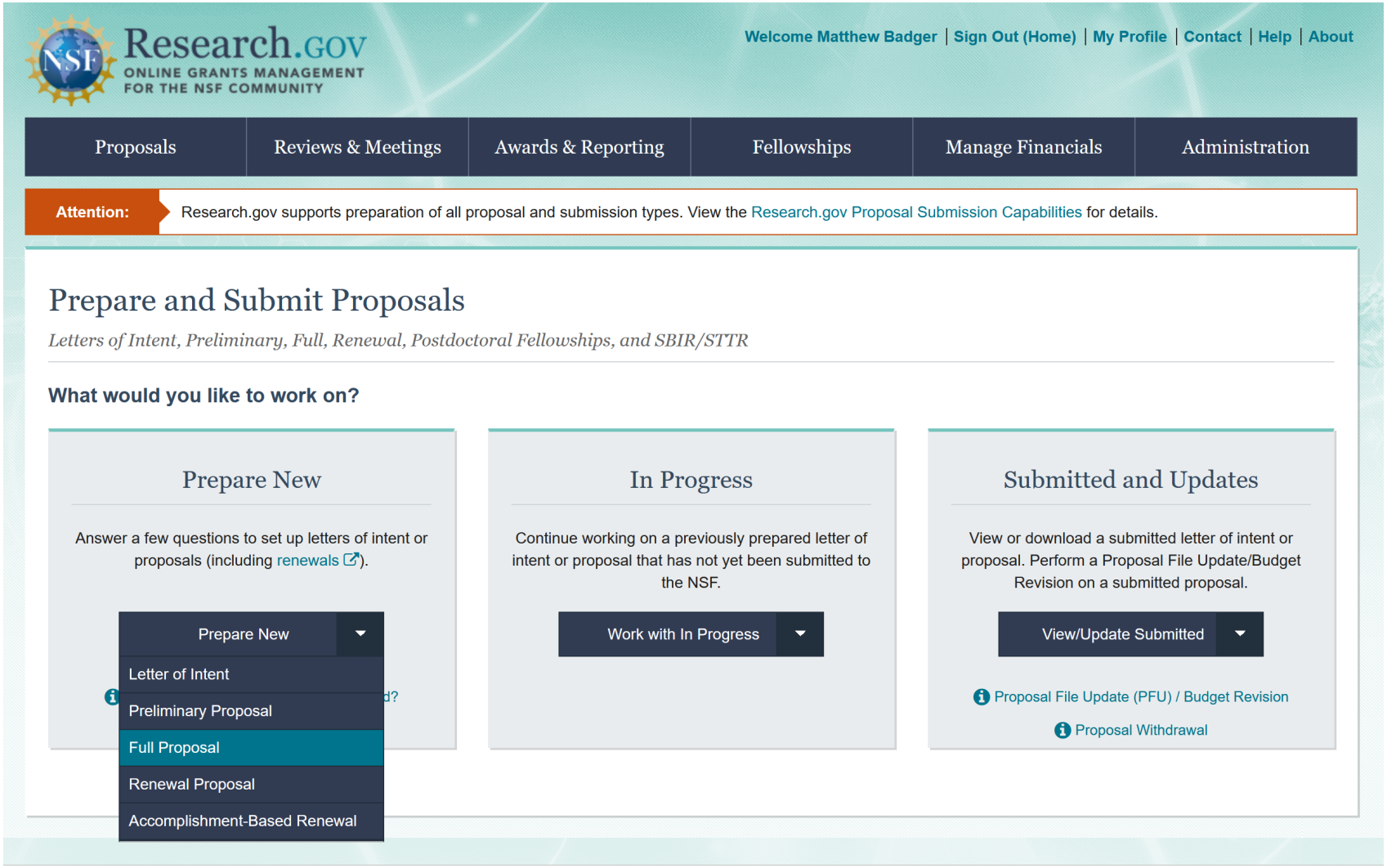

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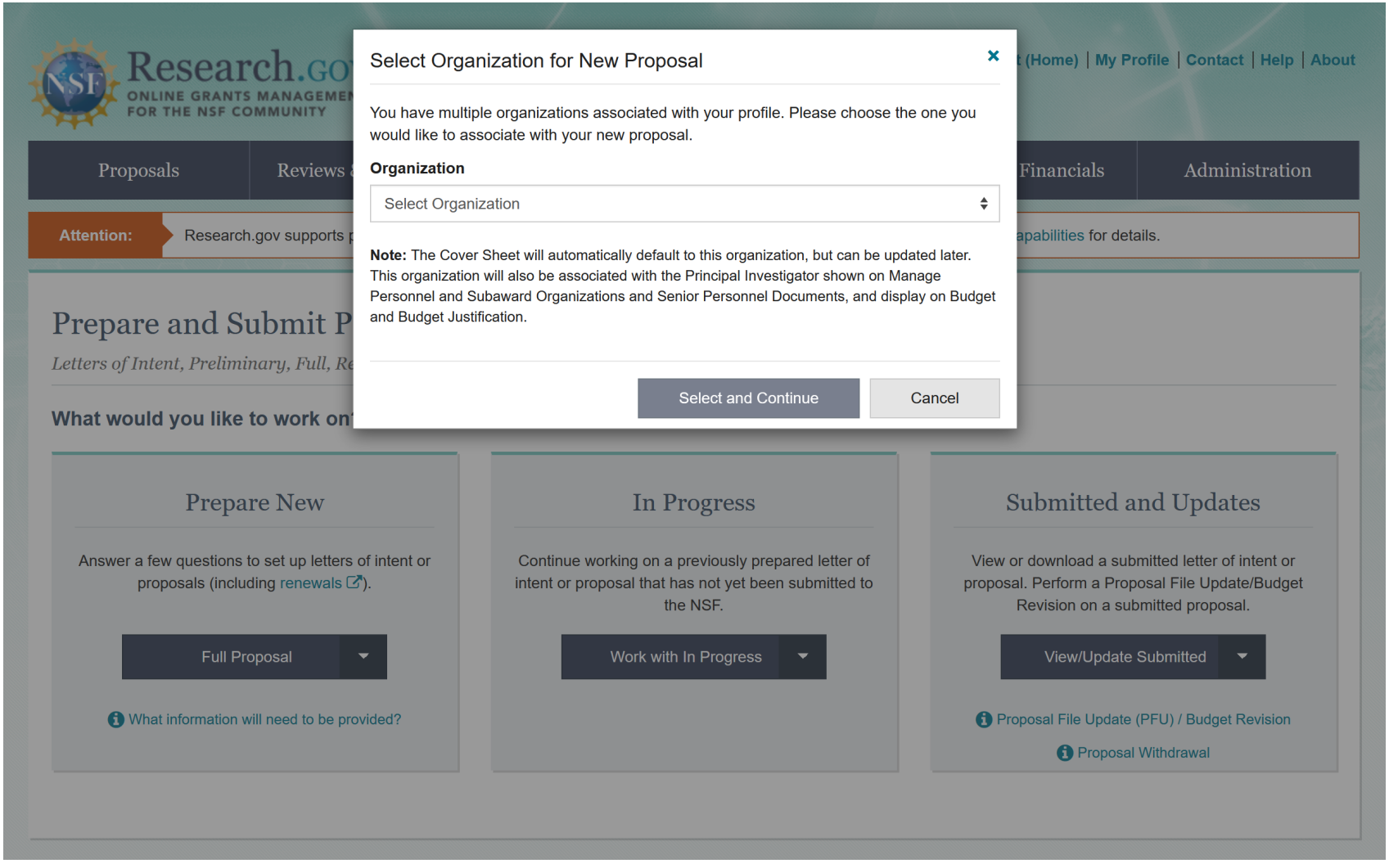

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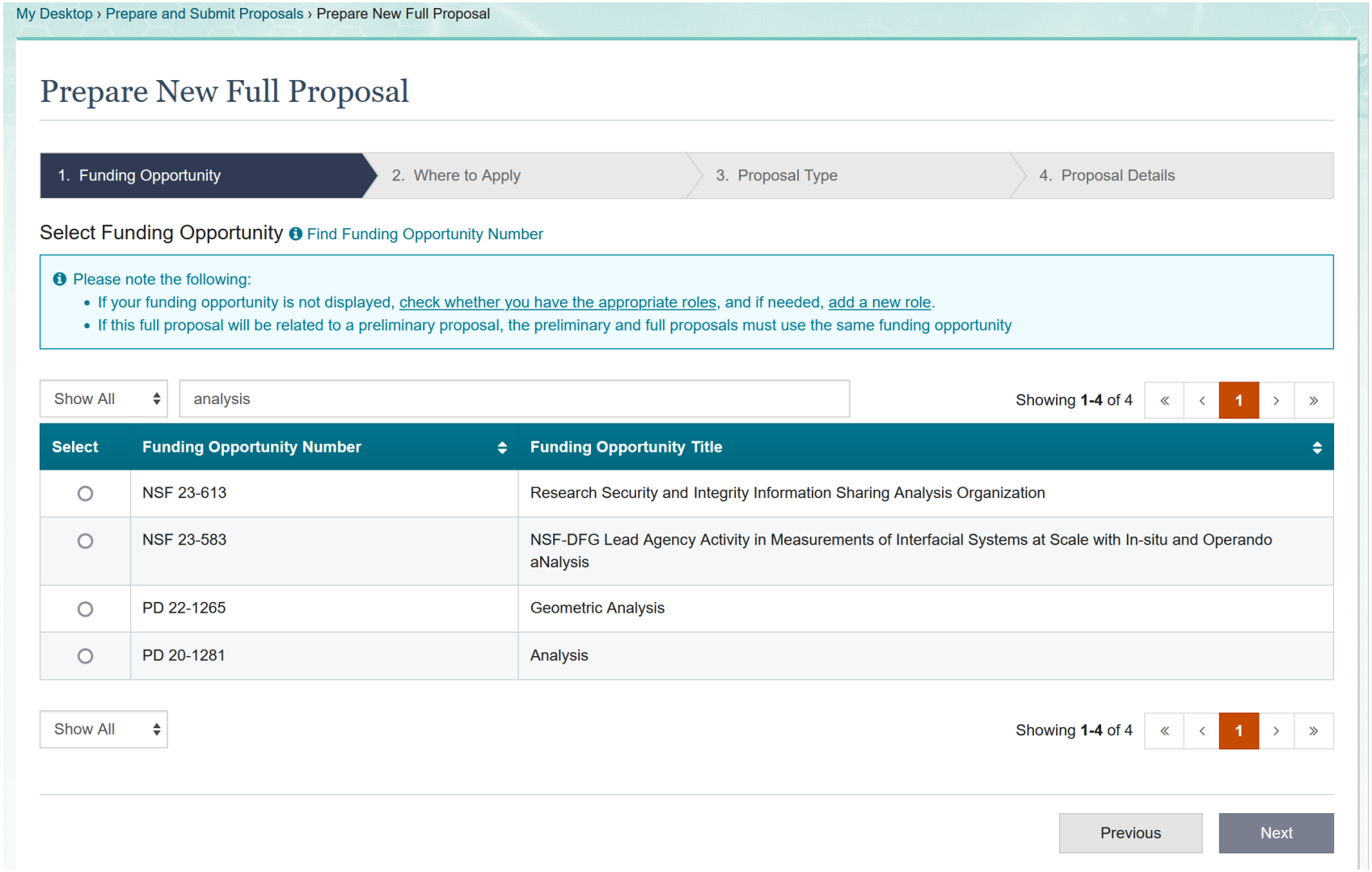

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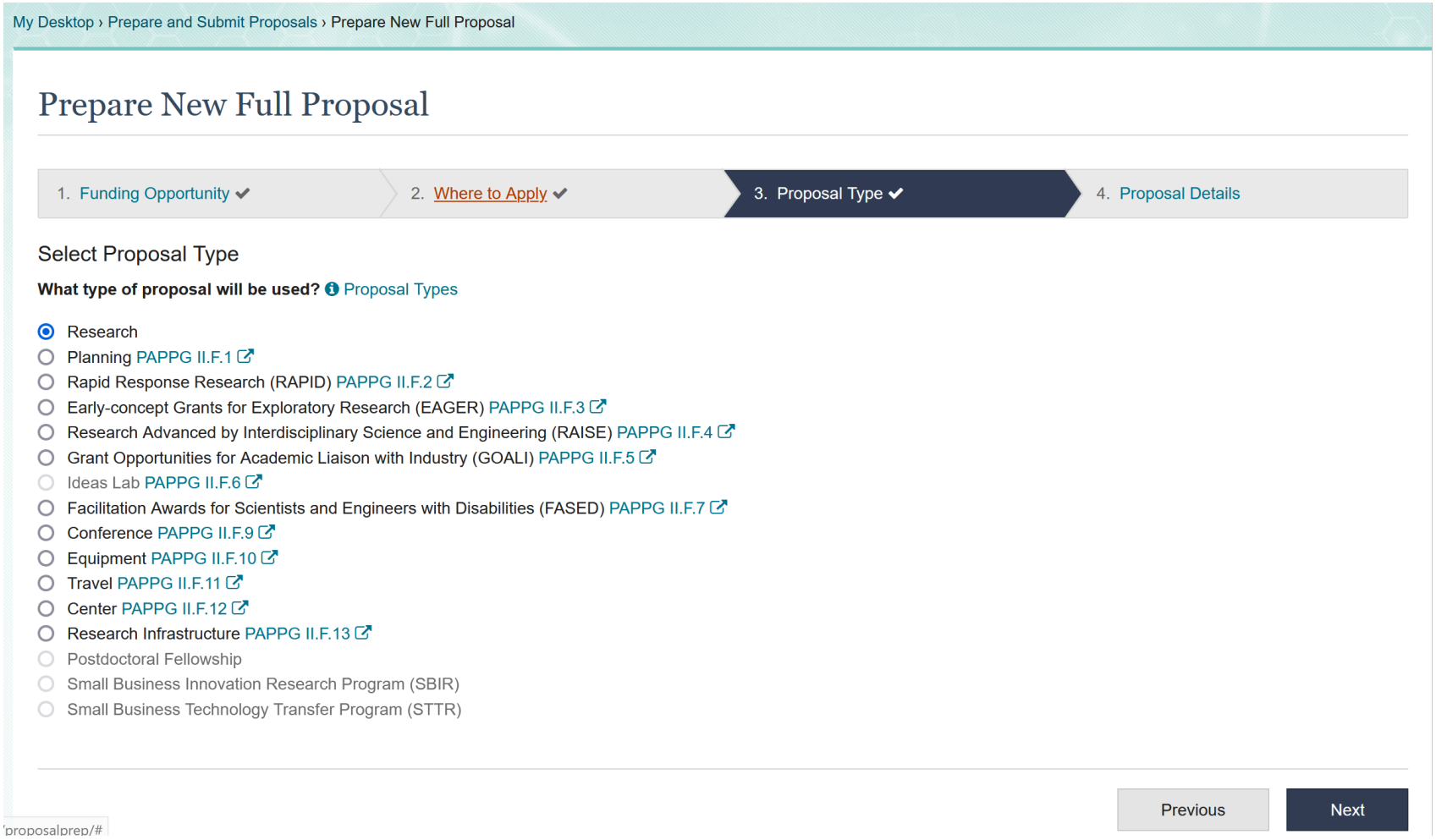

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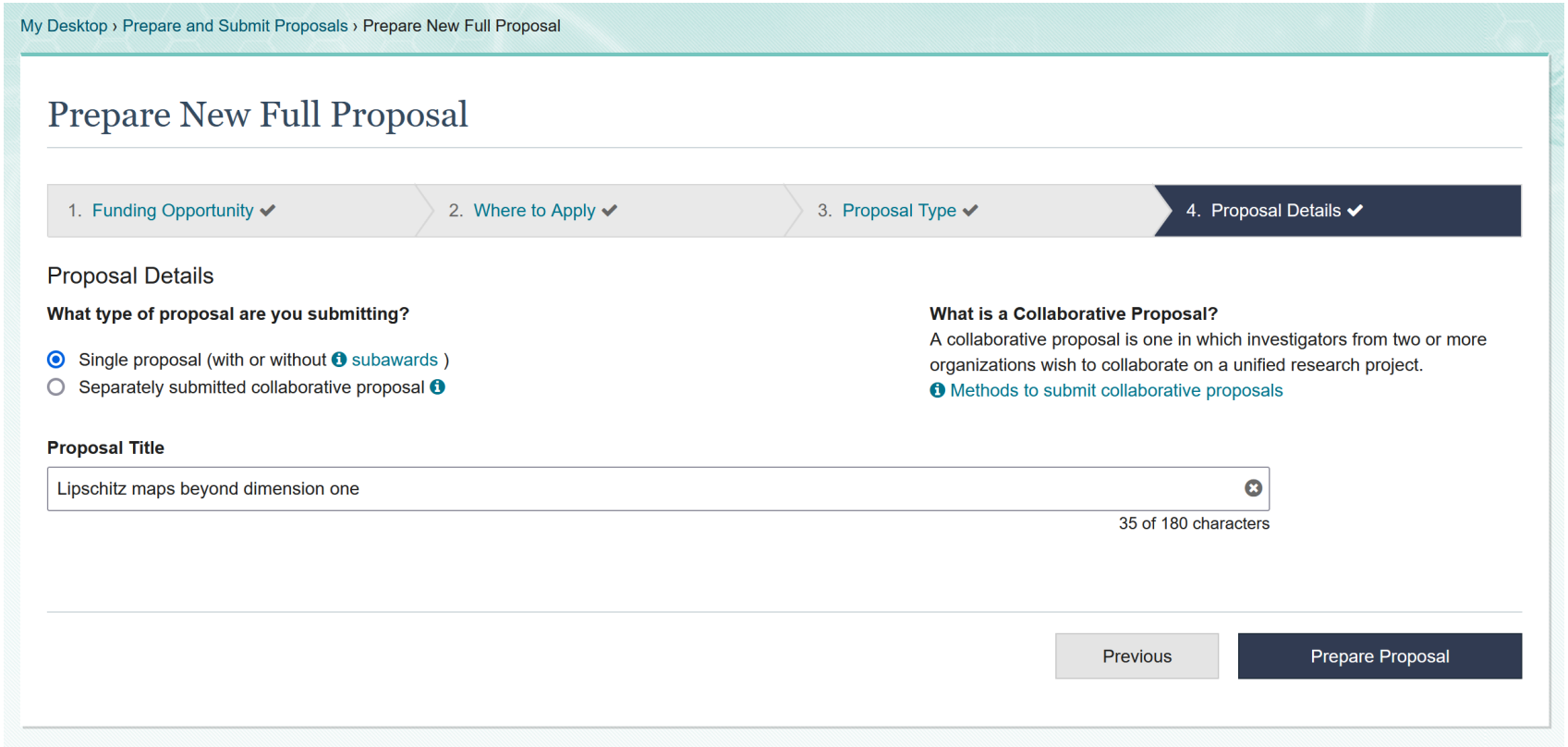

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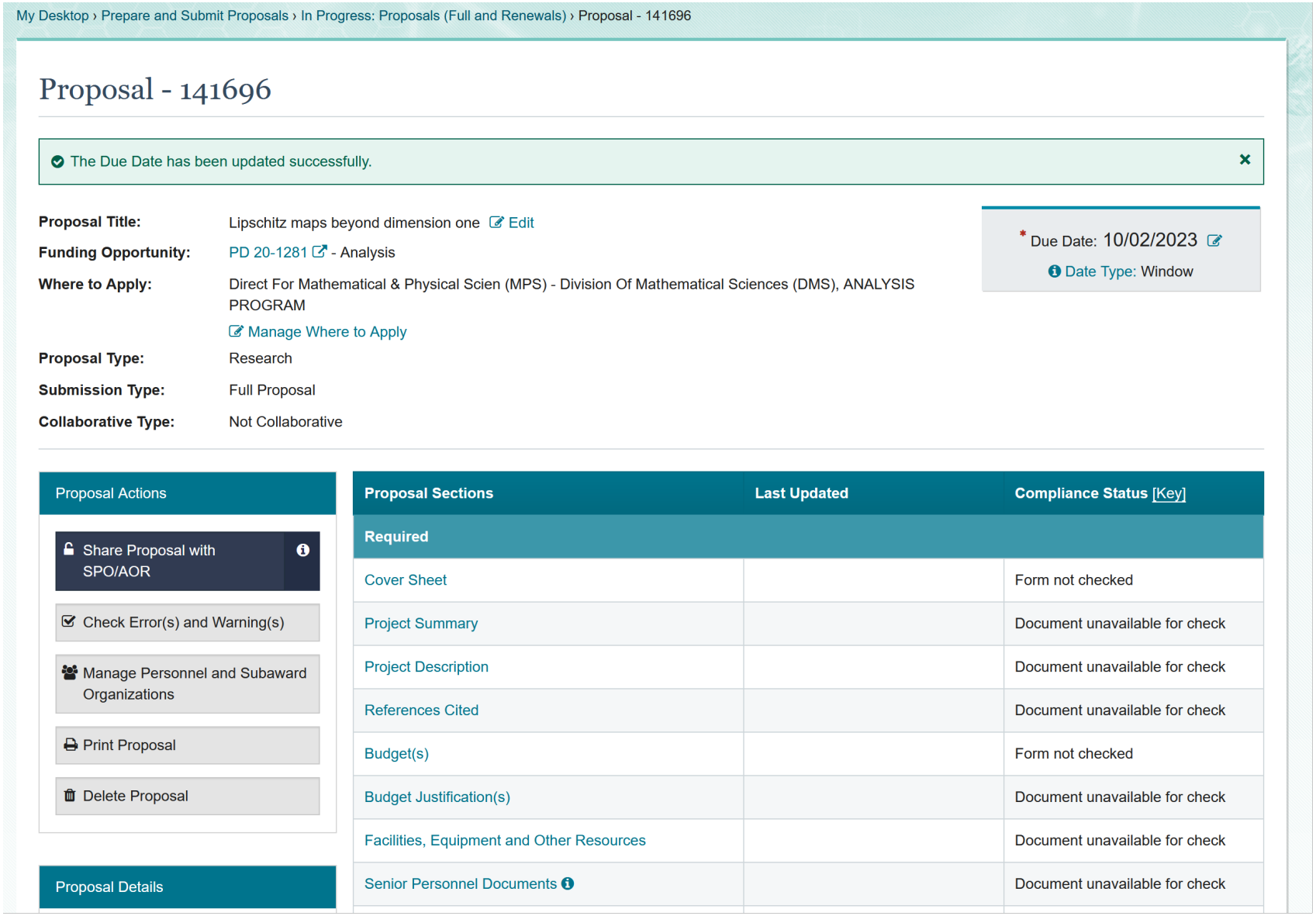

My Desktop › Prepare and Submit Proposals › In Progress: Proposals (Full and Renewals) › Proposal - 141696

Proposal - 141696

The Due Date has been updated successfully.

Proposal Title: Lipschitz maps beyond dimension one Edit

Funding Opportunity: PD 20-1281 - Analysis

Where to Apply: Direct For Mathematical & Physical Scien (MPS) - Division Of Mathematical Sciences (DMS), ANALYSIS PROGRAM

Manage Where to Apply

Proposal Type: Research

Submission Type: Full Proposal

Collaborative Type: Not Collaborative

* Due Date: 10/02/2023

Date Type: Window

Proposal Actions

- Share Proposal with SPO/AOR
- Check Error(s) and Warning(s)
- Manage Personnel and Subaward Organizations
- Print Proposal
- Delete Proposal

Proposal Details

Proposal Sections	Last Updated	Compliance Status [Key]
Required		
Cover Sheet		Form not checked
Project Summary		Document unavailable for check
Project Description		Document unavailable for check
References Cited		Document unavailable for check
Budget(s)		Form not checked
Budget Justification(s)		Document unavailable for check
Facilities, Equipment and Other Resources		Document unavailable for check
Senior Personnel Documents		Document unavailable for check

Required Documents

Project Description & References Cited (75% Effort)

Budget & Budget Justification (10% Effort)

Project Summary (5% Effort)

Senior Personnel Docs (5% Effort)

- Biosketch
- Current and Pending Support
- Collaborators and Other Affiliations

Miscellaneous Docs (4% Effort)

- Data Management Plan
- Facilities, Equipment, and Other Resources

Cover Sheet (1% Effort)

See AMS Notices article for detailed descriptions of each document

3. PROJECT DESCRIPTION

What is the Project Description?

This is the heart of the proposal, where you should say:

- What you want to do
- How you will try to do it
- Why it is important
- Why is it feasible
- What are the broader impacts
  (of the proposal or from other activities by the PI)

Formal Requirements

- 8.5×11 inch paper, 1 inch margins, standard fonts
- 15 pages maximum (5 pages maximum for MSPRF), not including references
- You **must** have a separate section labeled Broader Impacts
- There is not a requirement to have a separate section labeled Intellectual Merit. It is understood that the bulk of your project description will discuss Intellectual Merit.
- (Conditional) If you were supported by an NSF award with an end date in the last 5 years, you must describe the outcomes of this support (Intellectual Merit and Broader Impacts) in ≤ 5 pages
  This section counts against your 15 page limit!

Tips, Tricks & Suggestions

1. Always write for your reviewers. You may imagine these will be mathematicians in the same general area, but not someone who works on the same flavor of problems.

2. Advocate for yourself. Put your work in context and explain why it is important (not in a boastful way).

3. Propose a variety of problems, some easier, some harder, none out of reach ("I will prove the general Kakeya conjecture")

4. Problems can take a variety of forms (question, conjectures, "Prove ... or find a counterexample"). Number them so you and your reviewers can refer to them easily.

5. Write your project description in a highly structured way (see next slide)

Idea: Include Labeled Context & Strategy Paragraphs

Problem 3A. Carry out variations on the theorems of Bourgain and Wolff on the dimension of harmonic measure ω in $\mathbb{R}^n$ with the goal of estimating Bourgain's constant.

Context. The *(upper) Hausdorff dimension* of a measure μ on $\mathbb{X}$ is the least Hausdorff dimension of a set E with full measure in the sense that $\mu(\mathbb{X} \setminus E) = 0$. It is a more refined gauge than the support of a measure that describes the size of the set where the measure "lives". For any $n \geq 2$, define *Bourgain's constant* $b_n \in [0, 1]$ to be the largest number such that the Hausdorff dimension of harmonic measure is at most $n - b_n$ for every domain $\Omega \subset \mathbb{R}^n$. In [Bou87], Bourgain showed that $b_n > 0$ for all $n \geq 3$. It is now known that $b_2 = 1$ by a deep theorem of Jones and Wolff [JW88] (also see Makarov [Mak85] and Wolff [Wol93]) and $b_n < 1$ for all $n \geq 3$ by an incredible example of Wolff [Wol95] (also see [LVV05]). However, the exact value of Bourgain's constant b_n (let alone an explicit lower or upper bound on b_3) has not been determined. Bishop [Bis92] has conjectured that $b_n = 1/(n-1)$, because of $|\nabla u|^{(n-2)/(n-1)}$ is subharmonic when u is harmonic and $(n-1) + (n-2)/(n-1) = n - 1/(n-1)$, but there has been no meaningful progress to date. Recently, the PI and Genschaw [BG21] implemented Bourgain's theorem for caloric measure on arbitrary domains in $\mathbb{R}^{n+1}$, which have given the PI insight into the proof. The PI and Genschaw discovered

Strategy. The first task that must be accomplished is to track through all constants in the proofs of Frostman's lemma, Bourgain's estimate (Lemma 1) and Bourgain's alternative (Lemma 2) in [Bou87] in the case $n = 3$ in order to get an explicit lower bound on b_3 to use as a benchmark. The PI and Genschaw already wrote a sharper version of the "dimension lemma" at the end of Bourgain's paper in [BG21]. The proof of Lemma 2 uses a crude alternative (Bourgain's underlying idea is ingenious): either (i) some great-grandchild of an m-adic cube has small net content or (ii) every great-grandchild has large content. If (i), then you get a weak estimate on net content relative to the scale of the children. If (ii), it is difficult for Brownian motions to penetrate the center of the cube without hitting the boundary near the outside of the cube. The PI wants to try introducing

Tips, Tricks & Suggestions

6. Write in the third person and refer to yourself as “the PI”

7. To tell a better story, use Author-Year Citation Labels [Bad12], [BET17] instead of numerical labels [11], [15]

8. Despite appearances, there is a lot of freedom in the organization and tone of your Project Description. Write something that you would want to read if you were a reviewer

9. Mathematics is about the details, but try to keep it simple. If you have to display a complicated formula, you must also explain what it means. Remember your reviewers are **adjacent** to you

10. Include a picture (this is a personal bias)

A Parting Thought

Virtually every researcher who has been funded by the NSF has also had a grant proposal rejected

- There are more worthy proposals than the NSF budget can support
- Review panels and the other competing proposals change each year

Moral: If you don't get an award one year, then it may be worthy trying again the next year. (By induction...)

Thank’s for your attention!

Questions? Comments?