Strategies for Planning, Developing, and Writing Large Team Grants

Mike Cronan

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What all faculty and research professionals need to know about writing center-level proposals in a team environment

This book is a step-by-step guide for faculty and research professionals transitioning to large team grants

Parts

Introduction to Team Grants
Strategic Planning
Proposal Planning and Production
Writing the Project Description
Writing Key Narrative Sections
Characteristics of Successful Narratives
Red Teaming and Writing for Reviewers

This book addresses the challenges facing faculty and research offices in transitioning from smaller research grants to large team grants. While the term "team science" will be used throughout this book, it is not a book about the theory of team science but rather a "how to" for practitioners challenged with actually planning, developing, and writing LTGs—both faculty and the research offices that support them.

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About the Book

This book was published by ***Academic Research Funding Strategies, LLC***, a consulting firm that specializes in helping faculty and universities compete more successfully for research funding. We also publish a monthly research newsletter, ***Research Development & Grant Writing News***, and a companion eBook, ***New Faculty Guide to Competing for Research Funding***, all available on our web site.

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Part 1, Introduction

Center-level and large team research grants (**LTGs**) can range in funding from a few million dollars to tens of millions of dollars with award durations from a few years to ten years or more, often with the option of continued funding based on performance. The major federal research agencies, such as the National Science Foundation (NSF), National Institutes of Health (NIH), Department of Defense (DoD), and the Department of Energy (DOE), among others, fund LTGs. The Engineering Research Centers (ERC) and Science and Technology Centers (STC) funded for decades by NSF are well-known examples of LTGs.

There are multiple reasons why federal research agencies fund LTGs. The origins for these grants may begin with national research reports from the National Academies that define a national research grand challenge, perhaps in genomics, materials, energy, climate change, biological systems, education and workforce training, among numerous others. In other cases, LTGs may originate within a specific federal agency, or, in the case of NIH, within a specific Institute's research road map or strategic research plan. ***The common denominator of LTGs***, however, relates to the complexity of the scientific problem being addressed, disciplines required to address the problem, value-added benefits team research brings to solving the problem, capacity of the team research approach to bring multidisciplinary integration and synergistic solutions to the problem, and the capacity for the development of new technologies, scientific innovation, and commercialization.

The scale and scope of LTGs are characterized in several ways that differentiate them from smaller grants with only a few Principal Investigators (PI) working in a more narrow disciplinary domain or range. ***LTGs represent premier agency investments***, more dollars over more years, more disciplines, components and moving parts (i.e., complexity), more team members and team dynamics, more partnered institutions, more time needed to plan, develop and write, more interdisciplinarity and synergy required to demonstrate the value-added benefits of team research, and, unfortunately, more development challenges for the PIs.

Moreover, LTGs are unique and more complex to plan, develop, and write than are smaller grants. Successful LTGs must communicate a compelling research vision; demonstrate major value-added benefits to the team structure; achieve research synthesis, integration, and synergy; address multiple program components that build on the research core; offer a management plan that enables the research vision; propose a convincing research strategic plan over a five or ten-year performance period; convince program officers and reviewers that the proposed research is transformational and not merely incremental; and navigate multiple review gates to funding success.

Existing faculty research teams and research affinity groups can position themselves for potential LTG opportunities by using an existing research team with a track record of collaboration in place, creating a strategic plan for the team, defining the significance of the team's research capacities and research synergies, identifying potential funding opportunities, mapping the team's research expertise and interests to possible funding opportunities, becoming knowledgeable about the agency specific background, context, and rationale for specific LTG opportunities (e.g., through agency reports, workshops, and examination of more

recently funded LTGs), and by anticipating future LTG funding directions and opportunities while positioning the team to compete for them.

There are many benefits to building research teams and research affinity groups guided by a strategic plan to lay the competitive foundation needed to succeed in responding to LTG opportunities that occur, both with and without the benefit of a long time horizon before the due date. Regardless, team strategic planning helps build a competitive configuration of research capacities, collaborative experiences, and successes to serve as the foundation of a future LTG. Moreover, team strategic planning serves as a generator of new research ideas and helps test the validity of existing research directions in the context of LTG opportunities. Well-configured teams guided by a team strategic plan offer the depth and breadth of expertise to address complex, multidimensional research problems in an integrative and synergistic way, a feature that lies at the heart of a successful LTG.

The development of team proposals also serves the long-term interests of an emerging research partnership by moving it towards a more competitive configuration better positioned and experienced for new research horizons, which are the usual domain of LTGs. Additionally, the team process of strategic planning will help prepare the research partnership for the possible submission of smaller, more focused research grants (building blocks of LTGs) that will provide an important research component for the future, i.e., components required for a research center, particularly since center-level awards often are built on a strategic configuration of successful small research grants that de facto form the core research framework of a future center. At NSF, for example, the long-standing ERC and SRC programs in part represent a forward-looking aggregate of many smaller programs funded by the agency, whereby the center structure itself enables a synergistic benefit not possible without the center serving as the integrator, and not just for the research but for other actives as well, e.g., education and training, technology development, innovation, commercialization, etc.

It is important to keep in mind when considering LTGs that ***many successful LTGs are awarded on resubmission rather than on first submission***, and hence the submission of an LTG, even if declined, provides an important long-term learning experience for the research team. Developing and writing an LTG and receiving reviewer comments should the grant be declined does advance the research team towards its goal of a funded center on a second or third or fourth attempt, if the team learns from the review comments and discussions with program officers.

Of course, an informed decision to submit an LTG must be grounded on a ***candid self-assessment*** of the capacity to perform and to develop a competitive proposal in the time allotted. LTGs represent a major commitment of time and resources—the decision to submit or not to submit is a critical one. Several factors need to be assessed in making a determination of the readiness of the team to submit, foremost among them the team research vision and a strategic plan that will guide the research goals and objectives. There needs to be an assessment of whether or not a competitive team configuration is in place and sufficiently mature for a submittal, and whether the existing team needs to be complemented by additional partnerships that will bring additional competitive benefits to the effort. In making this determination, the research team should be able to demonstrate a history of collaborative success, for example, by funded projects and publications that validate the team's research credentials.

This process of team self-assessment is further advanced by the capacity to understand the funding agency's vision and rationale for the program and the specific way in which the program will advance the agency's mission. In turn, this requires that the research team map its research vision to that of the agency offering the specific LTG opportunity. In this critical step, the team's research vision must map tightly to the agency's vision and motivation for funding the program, and the team's research expertise and experience should position them to plan, develop, and write a competitive LTG. Of course, for this to work, there must be a committed team comprised of a committed PI and committed team members.

As equally important as team self-assessment is the team's detailed understanding of the agency's motivations and rationale for funding a specific LTG. For example, the team must understand why the agency is funding the LTG program; how and why the program began and evolved over time; what specific influences transformed the program over time; the agency's vision for the program going forward; how the program fits the national research context; the reports, workshops, conferences, etc. that have examined the program; how the program fits the agency's strategic plan; and whether other agency-funded programs exist at different scales.

This process of strategic planning and self-assessment will help ensure that the configuration of the research team is appropriate for the LTG opportunity, something that will be key to its competitiveness. Each collaborator or team member, for example, must bring specific expertise to the project and take a distinct and well-defined role with clear relevance to the research goals and objectives defined in the solicitation. Moreover, it is critical that the budget should be performance based on the value-added contributions by each team member, and each member of the team should benefit from the project long term.

One key to a successful LTG is that it be lead by a successful PI. A successful PI is characterized by many factors, chief among them an appropriate record of research funding and publications relevant to the LTG opportunity. However, other important characteristics of a successful LTG PI go beyond just research credentials. For example, the ***PI must have strong project management and strategic planning skills***, understand the funding agency's expectations for the LTG, function as a strong team builder with the respect and trust of the team members, possess strong planning and organizational skills, have the ability to manage team dynamics and keep the team focused, have strong scientific and technical communication skills, have strong team communication skills, possess the capacity to communicate a compelling research vision for the LTG, know how each team member's expertise fits the vision and contributes to the competitiveness of the LTG, and have the ability to advance the project from research silos to research synergy.

This book addresses the challenges facing faculty and research offices in transition from smaller research grants to large team grants. While the term "team science" will be used throughout this book, it does not address the theory of team science but offers a "how to" for the practitioners challenged with actually planning, developing, and writing LTGs—both faculty and the research offices that support them.

The book is organized around seven key topics representing the seven parts of the book. A range of topics is addressed in detail, including such example topics as:

What makes for a successful LTG research team

- History of successful research collaborations
- History of component "building block" grants
- History of team performance and trust
- Shared research vision
- Integrated rather than a siloed understanding of the research, e.g., an understanding of each team member's role in the project
- Collaborative working style in which each member deepens the synergy and contributes value-added benefits to the project

What makes a good LTG team member

- Effective communicator
- Skilled integrator
- Experienced researcher in individual expertise
- Successful recipient of an agency's funds
- Careful reader of the solicitation
- Skilled and prompt producer of contributions to group projects
- Skilled in offering broader impacts, societal benefits expertise, innovation expertise, etc.

Forming your LTG research development team

- Select those who can help you anticipate potential pitfalls and find a way around them.
- Seek support from those with a "corporate memory" of how best to achieve the significant competitive advantage that comes from a well-planned proposal production effort.

Leadership Styles that Derail LTGs

- Absentee leadership—unavailable or insufficiently involved in the planning, developing and writing of the proposal; not available when critical decisions need to be made in a timely fashion.
- Inhibited leadership—avoids making the hard team decisions, particularly related to ensuring that team dynamics are positive and productive; reluctant to confront difficult team members
- Defensive leadership—unresponsive to concerns of team members

The "center journey" requires:

- Tolerance for conceptual chaos
- Comfort with the illusion of linearity
- Knowledge of what can be controlled
- Knowledge of and planning for what can't be controlled
- Ability to follow through with the "center journey" that typically begins with chaos, uncertainty, vagueness, ambiguity, and indecision about how to best respond to the solicitation.

Review what others have done—don't reinvent the flat tire

- Review abstracts of funded centers
- Explore web sites of funded centers
- Talk to the PI of successful centers
- Talk to the center deputy director for operations
- Review centers' posted proposals, strategic plans, annual performance reviews, and documentation on the center web site for pdf download.

A long and winding road—some possible LTG waypoints

- A "center ready" research team is created
- A research opportunity is identified
- A continuously evolving strategic plan is in place
- Preparation has been made for multiple potential funding gates
- White paper/concept paper has been produced
- Letter of intent has been written
- Preliminary proposal/preapplication has been completed
- Red team review (RTR) has occurred
- Full proposal (w/RTR) has been completed
- Reverse site visit (w/RTR) has occurred
- Site visit (w/RTR) has been completed
- Annual performance reviews and a long-term strategic plan have been created.

Focus and persistence over time is required on LTGs

- Prepare to resubmit
- Prepare to converge on success after repeated attempts
- Learn from reviews, especially thoughtful critical reviews
- Learn from mistakes

LTG solicitation strategies

- Find a solicitation (the easy part); understand the solicitation and develop a competitive proposal (the challenging part)
- ***Avoid timidity in dealing with an agency; avoid ambiguity in writing the narrative. If*** you don't know, ask for clarification until you are certain you understand the answer.
- ***Understand that interpreting the RFP is a team endeavor.*** Consider seriously red teaming the RFP.
- Make absolutely sure that you understand the RFP's requirements and the role they play in structuring a competitive research narrative.

What is transformational research

- NSF, for example, uses this term to describe a range of endeavors, which promise extraordinary outcomes, such as, revolutionizing entire disciplines, creating entirely new fields, or disrupting accepted theories and perspectives.

- NSF focuses on the frontier of scientific discovery. It is important to distinguish what the frontier is and is not. The frontier is risky, so if the proposal represents "safe science," NSF should not fund it. The frontier is murky and without definition, so if there are no big unanswered questions in a proposal, NSF should pass it up.

What is synergy?

- Team research, especially interdisciplinary research, is characterized by synergies among experts that can transform both scholars and scholarship;
- Synergy occurs when various scientists exchange information and ideas, yielding results that any one of them working alone could not achieve.

NSF working definition of transformative research

- Transformative research involves ideas, discoveries, or tools that radically change our understanding of an important existing scientific or engineering concept or educational practice, or leads to the creation of a new paradigm or field of science, engineering, or education. Such research challenges current understanding or provides pathways to new frontiers.
- Transformative research results often do not fit within established models or theories and may initially be unexpected or difficult to interpret; their transformative nature and utility might not be recognized until years later.
- Characteristics of transformative research are that it:
    - challenges conventional wisdom,
    - leads to unexpected insights that enable new techniques or methodologies, and/or
    - redefines the boundaries of science, engineering, or education.

Team science is a strategic endeavor

- The foundation for success is a transformational idea.
- The strategy for success to is make sure your idea is not disguised by being poorly communicated.
- The strategic framework for success is to focus on the accumulation of marginal advantage.
- Developing, planning, and writing a successful proposal is a knowledge-based enterprise. It is foremost about the research idea, but it also depends upon the successful presentation of that idea.

What motivates agency LTGs

- National research grand challenges
- Agency research grand challenges
- Agency partnership grand challenges, e.g., Materials Genome Initiative

Define your research vision

The inability to define a compelling center vision (its *raison d'être*) is often the Achilles' heel of LTG efforts. This difficulty often reveals itself to the inattentive too close to the due date to allow an appropriate response. The justification for proposing a center requires crafting a clear, compelling, and persuasive vision statement that conveys to the funding agency the synergistic and value-added benefits of a center structure.

The following parts of this book will explore these and many other topics in detail.

Part 2
Strategic Planning

Understanding the Funding Agency
Submitting for the Right Reasons with the Right PI
The Role of Self-Assessment in Large Team Grant Success
The Transition to Writing Large Team Grants
The Strategic Planning Role of the Funding Solicitation
Red Teaming the Solicitation
Know the Context of Your Research
A Case Study: NSF Science and Technology Centers
Strategies for Developing Competitive Partnership Proposals
Optimizing the Proposal Planning and Development Process
Budgeting Strategies for Team Proposals
The Role of Research Support Offices on Team Grants

Understanding the Funding Agency

Large Team Grants (LTGs)_ represent major, long-term investments by funding agencies that focus on the mission-critical research of the agency or that advance the agency strategic research plans and roadmaps in significant ways. Authors planning to submit LTGs must therefore understand the agency mission, culture, and investment priorities underlying the agency's reasons for funding the grant in the first place. In many cases, the LTG funding solicitation will reference or provide URLs to strategic plans, workshops, reports and other documents that the agency sees as important to better understand its vision, goals, and objectives in funding a specific program. Authors of LTGs should familiarize themselves with these agency documents in order to make more competitive arguments for funding expressed with an awareness of the agency's mission.

Moreover, many of the core strategies for successfully planning LTGs are fairly generic across federal research agencies, as well as academic disciplines. For example, in one key planning strategy of a competitive proposal, PIs develop a clear and nuanced understanding of the mission and culture ***of the specific agency*** to which the LTG will be submitted. Writing successful LTGs, and increasing your success rate over time, requires the accumulation of marginal advantage achieved by doing everything right, or as nearly as perfectly as possible. You can find such a marginal advantage in a ***studied understanding of the mission and culture of the funding agency***. How well your proposal maps to the objectives and review criteria of any research solicitation determines your competitiveness at any federal agency. To better ensure your LTG's success, you must also map your research to the mission and culture of the agency, particularly since these provide the underpinnings and context for all funding solicitations. Your understanding of the mission and culture of the agency will significantly affect how you write the proposal narrative that will be judged for funding.

Many avenues lead to gaining a more substantive and nuanced understanding of the mission and culture of the funding agency, as well as the particular LTG opportunity, including:

- Visiting the agency web site and reviewing the mission, strategic plans, research, and educational roadmaps of both the agency and the programmatic areas within the agency;
- Exploring the web site, reports, publications, etc. of funded LTGs (e.g., NSF ERCs and STCs) to get a sense of what constitutes a successful LTG;
- Reviewing online postings of agency reports, presentations, and research and/or educational workshops given by agency program officers;
- Talking to colleagues that have been funded by the agency;
- Identifying and talking with researchers on your campus that have served as agency program officers;
- Identifying and talking to researchers on your campus that have served as reviewers for specific agencies and programs;
- Reading agency online abstracts of currently funded projects and asking whether the PI is willing to talk to you about the agency and program;

- Reading current agency solicitations in your disciplinary area and identifying any reports, presentations, or technical workshops noted in the solicitation as motivating the agency's funding of particular research areas;
- Subscribing to agency RSS feeds and email alerts that keep you current on new solicitations, reports, presentations, technical workshops and general agency news related to mission and research priorities.

Keep in mind that funding agencies do not fund research projects disconnected from a long-term, well-thought-out research agenda. Instead, agencies see themselves as leaders in a national dialogue on research topics and directions, and as key players in defining and driving that national research and educational agenda. LTGs play a major role in this context. Moreover, funding agencies fund those projects that fall within the scope of their mission. This can be a source of frustration to some applicants, who may believe that a good idea alone will merit funding, regardless whether it connects to a particular agency's investment priorities. However, ***agencies fund only very good ideas that are clearly developed and tightly linked to their mission, vision, and strategic plan*.** If your LTG does not advance the mission-critical priorities of the agency or the disciplinary field in some significant way, it will not be funded.

Therefore, the more knowledgeable you are about a funding agency's mission, strategic plans, research culture, investment priorities, and their rationales, the better able you will be to weave a compelling and competitive LTG narrative. This agency-specific knowledge allows you to more convincingly describe how your proposed research connects to the research objectives spelled out in the solicitation, which, in turn, will advance the agency's larger strategic plan and mission priorities. How well you convince program officers and reviewers that your research can play a key role in advancing the agency's objectives, thus contributing to the success of its larger strategic plan, will be a determining factor in the decision whether to fund your LTG.

Keep in mind that many LTG research programs funded by federal agencies grow out of an evolving consensus within the national research community, e.g., National Academies, on the most promising future directions in specific research topic areas. These directions and priorities, in turn, are translated into funding opportunities at the agencies, or are incorporated into an agency's strategic plans and given an investment priority, or mission-critical focus in LTGs.

In addition, particularly when submitting LTGs to NSF, educational programs targeted at universities, e.g., curriculum reform, diversity, or undergraduate research, are often developed through the same national process. It is not uncommon, for example, for reports of the National Academies, the American Association for the Advancement of Science, or similar associations to significantly influence funding directions at one or more agencies, and for those reports to form the underpinnings of subsequent LTG solicitations. ***Understanding the origins, underpinnings, and rationale behind LTG funding solicitations will help you better frame your claims of research merit and thereby better position you to write a successful research narrative***.

Large agencies, such as the National Science Foundation and National Institutes of Health, are composed of directorates and divisions, or institutes and centers, and these, too, have defined missions, strategic plans, investment priorities, and cultures. At times, these act as nearly autonomous funding agencies in themselves. Therefore, particularly in the case of

LTGs, it is necessary to understand not only the overall culture of an agency but also the ***mission, culture, and priorities of the particular organizational unit to which you will be submitting your proposal.***

A strong LTG allows the funding agency to form a partnership with the submitting institution and principal investigators that will help carry out the agency's vision, mission, and strategic goals. The LTG proposers must understand the nature of this partnership and the expectations of the funding agency, both during proposal development and throughout a funded project. ***Analyzing the funding agency at a general and specific level will help you better understand several key elements common to every successful proposal narrative:***

- Who is the audience (e.g., agency program officers and reviewers) and how are they best characterized in terms of the expertise they bring to the review process?
- What is the best way to address them?
- What is a fundable idea, and how does it support the agency's research investment priorities, or mission-critical objectives?
- How are claims of research uniqueness and innovation best supported in the proposal text, and how well do those claims map to the agency's research vision, goals and objectives, or mission-critical focus?
- How do you best communicate your passion, excitement, commitment, and capacity to perform the proposed research to review panels and program officers using the language of the funding agency?

Much of this can be derived by analyzing background information gathered from the funding agency related to a range of topics, including the following available on the agency's web site: ***mission statement, strategic plan, investment priorities, agency language/ technical dialect, management structure, organizational chart, program officers, reports, publications, leadership speeches, public testimony, review process, project abstracts, funded projects, and current solicitations***.

However, with LTGs it is important to understand how the various funding agencies differ based on characteristics such as mission, strategic plan, investment priorities, and culture. Since LTGs are most often interdisciplinary, the research team will likely be comprised of those whose past research funding comes from various agencies. It is, therefore, crucial that all team members understand the mission and culture of the specific agency to which the LTG will be submitted. For instance, team researchers in the physical, computational, biological, and social and behavioral sciences, etc., may have past funding success at two or more agencies, e.g., NIH, NSF, DOD, DOE, NASA, and EPA, but these agencies differ in many ways, including the following:

- Research focus within disciplines
- Mission focus
- Research classified as basic, applied, or application driven
- Research scope and performance time horizon
- Exploratory, open-ended research, or research targeted to technology development and deployment

- Research that is multidisciplinary or interdisciplinary
- Independent research, or dependent linkages to the agency mission, e.g., health care, education, economic development, defense, mission agency workforce objectives.

It is also important to differentiate between basic research agencies (e.g., NSF, NIH) and mission-focused agencies (e.g. DOD, NASA, USDA, DOE, NOAA, EPA), as well as to differentiate between hypothesis-driven research and needs- or application-driven research at the agencies. One of the most important differences between these types of agencies is the degree of autonomy they can exercise in setting their investment priorities. Basic research agencies, such as NSF and NIH, generally set long-term goals and are less influenced by the President or U.S. Congress than are mission agencies. Mission-oriented agencies, such as the Department of Defense or NASA, are highly influenced by the priorities of the President and Congress. Therefore, the focus and priorities at mission agencies can change rapidly with changes in political leadership, climate, or national issues, and this can significantly impact LTG opportunities. ***This means that researchers who apply to these mission agencies for LTG funding are well advised to constantly monitor these agencies for changes in direction.***

In most cases, this information can be obtained on the internet by visiting the agency web site. Perusing the web site gives the applicant a sense of how the funding agency views itself and the role it sees itself playing in the national research enterprise. This information can be found in the agency mission statement or strategic plan, for example. In other cases, particularly with regard to private foundations, the applicant will find the annual report a source of useful information about an agency's mission and agenda. An annual report gives the applicant a profile of funded projects, award amounts, and results.

Submitting for the Right Reasons with the Right PI

Writing Large Team Grants (**LTGs**) is an arduous process that often becomes more difficult as the due date nears. This is the point at which a seamless integration of multiple LTG research objectives must take place. Funding success on LTGs hinges on how well you gain an accumulation of marginal competitive advantages in crafting a compelling proposal narrative. LTGs are complex proposals to plan, develop, and write, thereby offering many opportunities to get the narrative right, ***or to get it wrong***, which will dramatically impact your chances of success. Below we will address ***what to do right*** and, equally important, ***what not to do***!

You must get two things right to develop a successful LTG:

- ***Submit the proposal for the right reasons***
- **A*gree on the right principal investigator to lead the effort*.**

The Right Reasons

You submit a proposal for the right reasons when an established history of successful team research collaborations exists that clearly meets the research interests of the funding agency's center solicitation. There are many wrong reasons for submitting, any one of which will likely result in failure, principally because they make it difficult to develop a compelling vision for the LTG, including:

- "Top down" administrative directives to submit a center-level proposal in a search for money and institutional prestige but without a successful history of research capacities in the topic areas required, or perhaps with only a "thin veneer" of institutional capacities;
- Attempts to "force fit" heretofore disconnected researchers lacking a history of, or interest in, research collaborations in the form of an LTG structure. The result is the so-called "shotgun center proposal";
- Attempts to cobble together preexisting research partnerships that only partially meet the intent of the solicitation, followed by the forming of hasty "marriages of convenience" with other possible research partners designed to overcome deficits. This approach is the research version of speed dating.

Developing an LTG center proposal represents a major commitment of resources and a significant commitment of team members' time and effort. It is important to make an informed decision about whether or not to go forward before making this commitment. An informed decision must be grounded in candid self-assessment of the capacity to perform and develop a competitive LTG in the time allotted. While there are many wrong reasons for submitting an LTG center proposal, a few of which were listed above, there are also good reasons for submitting an LTG center proposal with an emerging rather than mature research partnership in which competitiveness holds future but perhaps not immediate potential. ***Good reasons for submitting include***:

- The development and writing of the LTG center proposal will serve the long-term interests of an emerging research partnership by moving it towards a more competitive configuration;
- The process will help prepare the research partnership for the possible submission of smaller, more focused research grants (building block grants) that will provide an important research component of any future research center structure;

- The acknowledgement that many, if not most, funded center-level efforts are awarded on the second and third submittal, and hence developing a center proposal will prove an important exercise over the long term for committed team members;
- The recognition that developing and writing a center proposal and getting reviewer comments should it be declined holds the potential to advance the research team towards its goal of a funded center on a second or third attempt.

The Right PI

The principal investigator of an LTG center proposal is, in ideal circumstances, an obvious choice. It is someone who has an established research track record in the center topic areas and a person who is already seen as the de facto leader of existing research collaborations in these areas. In some cases, there may be more than one obvious choice as principal investigator, particularly in multidisciplinary research collaborations comprised of several research strands. However, successful leaders of center proposals possess several key attributes. The right PI:

- Has the capacity to define an overarching vision for the center;
- Has the expertise to manage a center-level research project;
- Is able to lead and inspire by describing a vision that engages other researchers and partner institutions;
- Is respected by center participants for her research and management abilities, and is ***skilled in managing team dynamics***;
- Can clearly state why the integration of the research strands proposed under a center structure achieves a more compelling research vision and **clearly stated synergy** not possible were the research strands funded as separate projects;
- Possesses the integrative research skills required to meld the center's multiple research components into an aligned and coordinated effort within a multifaceted center structure;
- Appreciates the importance of all agency-required center components in addition to the core research, something particularly important at NSF where broader impacts, integration of research and education, diversity, etc., are key factors in success;
- Possesses strong organizational skills and the capacity to communicate across participating disciplines and research teams;
- Has the capacity to inspire based on a research track record in the center research topic area that is respected and acknowledged by the center development team members; and
- Is fully engaged, accessible, and passionate, and, through strong leadership skills, can inspire in the center development team a feeling of confidence in the likely success of the effort.

Importantly, the inability to define a compelling center vision (its *raison d'être*) is often the Achilles heel of center efforts. ***It is a mischievous difficulty that often reveals itself to the inattentive too near the due date to allow an appropriate response.***

The Role of Self-Assessment in Large Team Grant Success

We have no way of knowing with certainty whether or not Socrates' maxim "***Know Thyself***" originated as part of a peripatetic workshop on LTG grant writing. However, while scholars may debate the maxim's origins, it still stands today as excellent advice for those developing and writing research grants to federal agencies and foundations. ***The role of self-assessment in grant success cannot be overstated.*** It motivates and informs every aspect of planning, developing, and writing a successful LTG.

The team's capacity for self-assessment will inform every part of competitive grant writing, particularly in answering such questions as listed below, keeping in mind the old geologists' adage "***if you don't ask the right questions, the rock won't answer***." You want to ask the right questions because when you submit a proposal ***you want the reviewers to acknowledge you answered the right questions in your research narrative*** and to say "Yes, fund it!"

Moreover, successful LTG grant writing is essentially a knowledge-based enterprise. The more your team knows about what characterizes a successful LTG, the more successful your team will be in securing research funding to advance your long-term research plans. You will, that is, answer the questions reviewers want answered in order to recommend funding. This requires exceptional expertise in your team's chosen research domain; in your team's capacity to plan, develop, and write successful proposals; and in your team's capacity to conduct a very frank, open, and clear-headed self-assessment of the team's capacity to map your research expertise to the research vision, goals, and objectives of the sponsoring agency.

As Richard Feynman famously observed in his lectures on physics at Caltech, "Science is a way of trying not to fool yourself. The first principle is that you must not fool yourself, ***and you are the easiest person to fool***." So if Plato, Socrates, and Feynman all argue for realistic self-assessment, it certainly behooves those who write LTGs, as well as those who support them in that process, to make sure you have identified a series of self-assessment questions to guide your quest to plan, develop, and write successful LTGs. Some common questions on this LTG self-assessment list include the examples given below, although many others will come to mind as you begin the self-assessment process.

1. Is our team research of interest to this particular funding agency?

1.1. Does our research expertise fit the goals and objectives of a specific solicitation?

1.1.1. How well do we understand the agency's goals and objectives in the solicitation?

1.1.2. Can we address all the research goals and objectives required by the solicitation?

1.1.2.1. Do we need additional research collaborators for a competitive submission?

1.1.3. Are we understanding the solicitation for what it is--***not what we want it to be***?

1.1.4. Is there sufficient time to plan, develop, and write a competitive LTG?

1.2. Can we make a compelling case for the significance of our research to the solicitation?

1.2.1. Why is our research significant?

1.2.1.1. Why should an agency want to fund our research?

1.2.1.1.1. Can we explain why our research is exciting and novel?

1.2.2. What are the team's research objectives?

1.2.2.1. Is our research hypothesis-driven?

1.2.2.2. If so, can we state the hypothesis clearly?

1.2.2.3. How will our research lead to new knowledge?
1.2.2.4. Is our proposed research based on prior research support?
1.2.2.5. Do we have preliminary data that bolster our case for funding?
1.2.3. Do we have a realistic research plan?
1.2.3.1. Can we make clear what we propose to do (without jargon)?
1.2.3.2. Can we make clear why we propose to do it?
1.2.3.3. Can we make clear why it is important to do it?
1.2.3.4. Can we make clear that the team has the expertise to do it?
1.2.3.5. Can we demonstrate that our research plan is believable and not overly ambitious?
1.2.3.6. Can we present a research plan based on a stepwise logic and approach?
1.2.3.7. Can we instill in reviewers a confidence in our capacity to perform?
1.2.4. Is our research basic or applied?
1.2.4.1. Do we know the difference between basic and applied research?
1.2.4.2. Is the agency a basic research agency or a mission agency?
1.2.4.3. Do we know the difference between a basic and a mission agency?
1.2.4.4. Do we know how this distinction is made at the agency of interest?
1.2.5. Are we considering the appropriate agency program for our research?
1.2.5.1. Is there more than one agency program for which our research is fitted?
1.3. What are the team's research strengths?
1.3.1. How do we most effectively emphasize our research strengths?
1.3.1.1. Can we do this succinctly, clearly, and simply (without jargon)?
1.3.1.2. Can we make a convincing case to a nonexpert in our field?
1.3.2. What is the significance of our research expertise to the agency and program?
1.3.3. Is our area of expertise addressed in the agency strategic plan?
1.3.3.1. How would our research advance the agency strategic plan?
1.3.4. Does our research bring value-added benefits to the agency and program?
1.3.5. Does our research advance the mission priorities of the agency?
1.4. What are the research weaknesses of our team?
1.4.1. Do we lack preliminary data; if so, how will we address that?
1.4.2. Do we lack experience and expertise in some aspects of the field; if so, how will we address that?
1.4.3. Do we need additional research collaborators; if so, how will we address that?
1.4.4. Are we trying to force fit our team expertise onto a solicitation that it does not fit?
1.5. Should we talk to a program officer?
1.5.1. Do we have specific, well-thought-out questions we want answered?
1.5.2. Have we read and reread the solicitation ***as a team***?
1.5.3. Have we informed ourselves about the agency's mission and culture?
1.5.4. Have we informed ourselves about the mission and culture of the program area?
1.5.5. Have we carefully read information posted to the agency web site?
1.5.6. Do we have an idea whose appropriateness we want to discuss with the agency?
1.5.7. Do we understand we will not be asking about the likelihood of being funded?
1.5.8. Do we understand the call will not be a meandering fishing expedition?

1.6. Do we have a strategic plan for our team research?
  1.6.1. What are our goals and how do we achieve them?
    1.6.1.1. Why is it important that we do this research?
  1.6.2. How do we best characterize the significance of our team's current research/expertise
    1.6.2.1. To the field?
    1.6.2.2. To the agency?
    1.6.2.3. To an agency mission?
  1.6.3. Where will our research be in five years, or even ten or twenty years?

2. **Do we understand how the agency will review our LTG?**
  2.1. Do we understand the overarching review criteria used by the agency?
    2.1.1. Do we understand how basic research agencies review proposals?
    2.1.2. Do we understand how mission agencies review proposals?
      2.1.2.1. Do we understand the role of mission-critical priorities in the review process?
  2.2. Do we understand the program or solicitation's specific review criteria?
  2.3. Do we understand the role of the program officer in the review process?
    2.3.1. Are reviews binding on the program officer?
    2.3.2. Can the program officer consider some reviews advisory only?
  2.4. Will our proposal be peer reviewed and by what format?
    2.4.1. Will there be a panel review?
    2.4.2. Will there be a mail review?
    2.4.3. Will some other process be used?

The Transition to Writing Large Team Grants

Creating a strategically planned pathway from smaller to larger grants, such as moving from an NSF CAREER award to an NSF center award, typically occurs over decades rather than years. The path becomes increasingly complex over time, requiring a more multifaceted proposal development and grant-writing expertise beyond the core research expertise of a single-PI proposal. While an NSF path is used here for illustration, the path could have early career starting points at many agencies, terminating in a major center proposal a decade or two later to the same or other federal research agencies, e.g., NIH, DoD, DOE, NSF. The path, however, starts with an early career researcher who makes several transitions of scale on research proposals, starting with single-PI initiatives, to multiple-PI initiatives, to multi- and transdisciplinary initiatives, to major center proposals and other LTGs.

In its optimal form, the path represents a strategic assessment of a researcher's current and projected position in a decades-long research career. While serving as the PI/Director of a major research center, such as an NSF, ERC, or STC may represent the major achievement of a research career, it is important at the start of that career to navigate several waypoints, including gaining the expertise needed to develop and lead research initiatives viewed as the "building blocks" for eventual success at the level of LTGs or a major national center proposal.

Once you have the successful building blocks in place, strategically selected for integration, you will have in place the competitive components needed to pursue LTG funding at the center level. ***Synergy and integration in LTGs is the equivalent of what in architecture would be called the keystone that holds all the building blocks of a stone arch together***. In LTGs and center-level proposals, synergy and integration hold together the center research and its related components.

By analogy, a stonemason will develop the geometric reasoning, understanding of materials, and expertise to cut and fit stone to build a complex arch only after first starting out building more rectilinear structures. Since stone is extraordinarily strong in compression, but very weak in resisting tensile stresses, the geometry of the stone arch is designed to put the stone building blocks in compression and the keystone ties everything together. Similarly, the path from early career research proposals to later career research center proposals resembles that taken by a stonemason who must gradually acquire the knowledge and skills to build a complex arch. It requires continuously expanding your knowledge and expertise base in order to develop and write proposals representing increasingly more complex configurations or geometries of research disciplines and other programmatic components.

For example, solicitations for a major research center often feature components resembling smaller research grants funded by the agency over a period of time (again, thinking of these components as center building blocks is helpful). These smaller research building blocks represent one good starting point for success in building a suite of connected grants funded by one or more agencies that, in aggregate, give you the research and management experience needed to compete for a national center. At some point of your choosing, you and your center research team will have gained the needed expertise through a strategic configuration of research grants that position you to compete for a center solicitation and ***align your research capacities to achieve a significant research synergy and value-added benefits under a center structure***. This is a key attribute of all successful LTGs.

Moreover, most often these building blocks include elements in addition to the core research areas to be integrated under a center structure. Configuring center building blocks may require a capacity to integrate the core research objectives of a project with complementary programmatic objectives that represent priorities of the particular funding agency. These may include such essential program components as innovation and commercialization, international research experiences for graduate students, K-12 education and outreach, undergraduate research, societal dimensions and impacts, STEM diversity K-PhD, advancing faculty diversity, and program evaluation and assessment, among many others. The more experience and success you and your research team have gained in forming teams requiring you to integrate the experience and expertise gained on both small and large grants, the more competitive you will be for the very largest grants at the LTG and center level.

To compete successfully for a center grant requires, above all, the capacity to present an integrated research team vision and the proven research management experience to clearly demonstrate the likelihood of achieving that vision.

Therefore, to continue the analogy of the center proposal as the keystone, you might think of these small and large research programs at funding agencies as the quarry holding the component pieces, or building blocks, required to eventually build a research center. Of course, center solicitations from all agencies are continuously evolving, and no one can predict how they will evolve over the coming years. However, you are well advised to plan strategically and anticipate the research waypoints that will make your dream of a center proposal more competitive when opportunity presents itself, particularly since you can assume that, in the near term, such an opportunity will grow out of existing research priorities and smaller-scale solicitations at individual agencies, or perhaps reconfigured LTGs.

In addition to recognizing that responses to specific research solicitations can serve as building blocks for future center funding, you must also understand the importance of "***thematic building blocks***" to specific agencies. Take, for example, the thematic objectives that NSF defines as important to Gen-3 ERCs, as listed below. The below represent key themes that cut across all funding at NSF in one way or another, but are all-inclusive at the center level. Each of the thematic areas listed below also represents discrete funding opportunities at NSF, but ***in aggregate, these thematic building blocks also represent a culture, community, and climate for team research and education that NSF sees as important. The future PI of a successful LTG or center proposal must therefore understand and achieve fluency (note agency key words/tags), experience, and expertise in incorporating these themes into larger, more complex research projects as appropriate to any specific solicitation.***

1. Advance discovery and ***build bridges*** from science-based discovery to technological innovation as a means to realize transformational engineered systems;
2. Develop a culture in academe that ***joins research, education, and innovation*** to create and sustain an ***innovation ecosystem*** to enable the center vision;
3. Provide ***international opportunities*** for research and education collaboration that will prepare U.S. engineering graduates for innovation leadership in in a global economy;
4. Form teams of ***diverse*** and talented faculty who will prepare diverse and talented domestic and international graduates to function effectively in a global world where research, design, and production efforts cross national borders;

5. Function with ***transformational engineering education programs*** that rest on partnerships with precollege institutions to attract students to engineering and university departments. Strategically develop in engineering graduates the capacity to create and exploit knowledge for ***technological innovation***; and
6. Build and sustain a culture that ***links discovery to innovation***, i.e., the ***innovation ecosystem***, which will include partnerships with member firms/practitioners to strengthen the center and streamline ***technology transfer***; translational research partnerships with small firms to ***accelerate commercialization*** of high-risk ERC advancements; and innovation partnerships with local organizations to stimulate entrepreneurship and job creation and enable technological innovation.

Faculty can use the themes embedded in this list to construct thematic research building blocks for a center-level award. Moreover, it is important in this process to have a good understanding of the meaning of the key words used by the agency, as noted above in bold, and of how to describe your research using the agency's language.

Moreover, researchers on a pathway to a center proposal will need to ***build a strategically planned configuration of key successes in proposals of various scales*** that, in turn, will give them the experience and multifaceted expertise to eventually win a major research center. This expertise includes early research success in developing research proposals followed by a transition to larger, more ambitious proposals such as LTGs and centers. A key waypoint in this path is success in developing and writing LTGs that are large, integrated research efforts of several millions of dollars or more, but not yet at the scope and scale of a major center. These LTGs can serve as the training ground for eventual success at the level of a national center.

How might you imagine traveling the pathway from smaller or single to few-PI grants to larger, more complex research grants such as LTGs? **Consider the elements below in understanding the transition from small grants to LTGs:**

LTGs Mean More Dollars. With more dollars comes larger proposals, often with more research objectives and "***more moving parts"***, i.e., complexity. The development, writing, and, if successful, management of a small, single-PI grant is similar to juggling one ball in the air at a time. As the award size increases, so does the number of balls the PI must juggle. It is reasonable to anticipate that you will be required to juggle an additional ball for every $1 million increase in the size of a research proposal. So, by the time you are ready to compete for LTGs or a center proposal at the national level, it will be important to demonstrate that you have experience juggling five, ten, or fifteen balls at a time before attempting to juggle the twenty or more required of a PI/Director of a major research center over a five- or ten-year award period.

LTGs Involve More Disciplines. Larger proposals typically mean that the sponsor will require meeting a larger number of disciplinary objectives. ***Gaining experience managing the integration of multiple disciplines in a research proposal will equip the PI with a critical skill.*** Centers rely upon disciplinary synthesis and integration. ***The keystone to a successful center proposal is the research vision, synergy, and value-added benefits described in the research narrative***. Those critical attributes are grounded on the capacity of the PI and the research team to understand, integrate, and then explain to reviewers how multiple disciplines will

intersect and spark significant scientific advances in the particular field. Furthermore, the PI of such a proposal must be sufficiently fluent in the disciplinary topic areas of the proposal to be able to write a compelling, and hence integrative, research narrative. If the PI lacks this experience, it can lead to a research narrative reading more like a collection of complementary journal articles than an integrated project narrative. Integrating disciplines is a learned skill that can be practiced and strengthened through a series of grants awarded for amounts smaller than those of a center.

LTGs Involve More Participants. Larger proposals with more disciplines mean more disciplinary participants. ***With more participants comes more team dynamics***. In the end, it falls to the PI to make the team dynamics work in a way that allows a competitive proposal to be developed and written. This is also a learned skill, as is becoming a good team member. For example, a good team member does what she says she will do, does it well, does it on time, and remains fully engaged and available for team communications. Also, it is often small actions that, in aggregate, create good team dynamics and lead to a successful proposal. ***On a team proposal, for example, every member must*** (1) read and understand the solicitation in detail, (2) understand that budget allocations are based on value-adding contributions to the research by each team member and not just by dividing the total budget by N team members, and (3) understand the research contributions of other team members sufficiently well to allow an integrated narrative to be written. Of course, not only for centers but also for any team-based research grant such as LTGs, regardless of scale, ***a history of team collaboration is a key ingredient to success.***

LTGs Require More Management Expertise. As grants grow larger, they typically grow in research and programmatic objectives, as well as in the relational complexity of multiple research strands to one another and to other program components. They also grow in the relational dynamics among team members, and in complexity of the budget, among many other factors, ***all of which require a high level of research management experience to navigate well***.

Of course, the core attributes determining a PI's success in managing the development and writing of a large proposal is that the ***team members respect the PI's*** (1) research expertise, (2) planning and organizational skills, (3) fairness and skill in managing team dynamics, (4) communication skills, (5) capacity to define an overarching vision for the research narrative, (6) ability to lead and inspire by describing a research vision that engages other researchers and partner institutions, (7) ability to explain why the integration of the proposed research strands in the narrative achieves a more compelling research vision and clearly stated synergy not possible were the research strands funded as separate projects, (8) understanding of and appreciation for the importance of all agency-required program components in addition to the core research (something particularly important at NSF where broader impacts, integration of research and education, diversity, etc., are key factors in success), (9) full engagement and passion for the project, and (10) ability to inspire in the research development team a feeling of confidence in the project's likely success.

LTGs Require More to Plan. Large research proposals take more planning, time, and scheduling to do well. The prospective PI must master the ability to plan the developmental waypoints for a successful proposal.

LTGs Require More Involvement in Disciplinary Domains Outside Your Expertise. Large team proposals require the PI to become sufficiently informed on partnered disciplinary areas to ensure that competitive decisions are made and the right partners and collaborators are invited to join the proposal during the development and writing stages. This skill will be important to success on any major center proposal. Most importantly, the PI needs to assess the quality of anyone brought on the proposal to meet a particular requirement of the solicitation. This should include not only research partners but collaborators in any major component of the proposal. It is critical that the PI of a large proposal take the time to sufficiently judge the expertise of each potential partner before inviting him to join the effort.

Once a person has been invited to join a proposal, it becomes awkward for the PI to disinvite that person, and it can become a significant distraction to the PI should the disinvited person decide to make the parting a messy one.

Many research PI's, particularly for large NSF proposals, need to have a working understanding of areas of broader impacts, such as innovation, commercialization, diversity, education and outreach, STEM education K-PhD, research community and climate, societal benefits and impacts, evaluation and assessment and mentoring. Many LTGs may include some of these topics, but at the center level, the PI may need to address them all, and more. ***The PI must be sufficiently fluent in these topic domains to know that, if several partners are included in the proposal to address these issues, then what is proposed will likely be considered meritorious by the funding agency***. It is always important to understand these topic areas in order to best explain in the research narrative how they bring value-added benefits to the proposal. In terms of the bottom line, it is also important for the PI to know who performs good work in these areas and who may not. Just because someone has a two- or three-page write-up of his expertise in a broader impacts or societal impacts area does not mean that that person is necessarily qualified to be on the proposal, or that the proposed broader impacts work gives a complementary synergy to the proposal. ***The PI needs to be informed enough, or have team members informed enough, to make this important judgment***.

The Strategic Planning Role of the Funding Solicitation

The funding solicitation plays a key role in planning, developing, and writing successful LTGs, just as it does for smaller grants; however, just as LTGs and center proposals are more complex and challenging to write than smaller research grants, RFPs for LTGs are more complex and challenging to review, analyze, and, often, interpret, than are smaller grants. For example, RFPs for LTGs often reference numerous reports and documents that help the proposer better understand the research motivations and goals behind the program. NSF's 3-plane diagram [Google search] required of every Engineering Research Center is a legendary reference.

The RFP at its most basic is an invitation by a funding agency to ***submit proposals on research topics of interest to the agency***. It contains the key information needed to develop and write a successful LTG. To be competitive, your proposal must be **fully responsive** to an agency's submission process, program objectives, review criteria, budget guidelines, and other requirements specific to the program. It is important that each member of the team read the RFP carefully and in its entirety, including review criteria and all referenced documents. Writing a competitive proposal requires the team to understand the RFP for what it is--*an expression of agency interest in a specific domain*--and not what the team or an individual team member might wish it to be. It is almost never a perfect mirror of your interests. From the funding agency's perspective, the RFP is a **non-negotiable listing of performance expectations** reflecting the agency's goals, objectives, and investment priorities that **you must meet** to be funded. The RFP is ***not meant as a menu or smorgasbord offering you a choice*** of addressing some topics and review criteria but not others.

The competitiveness of an LTG will depend on how well the team understands the RFP as an expression of an agency's interest in a topic. Once the team clearly understands the agency's objectives, the next step is to map the team's expertise to the RFP. If your interests and expertise do not map tightly to an RFP, it is wise not to submit and wait for a more appropriate solicitation. Invest your team's time, resources, and energy wisely—they are your most valuable assets and they must not be squandered. A good idea is a necessary **but not a sufficient condition** for successful funding. Funding agencies are seeking exciting ideas clearly stated that ***make a compelling case that your team's expertise will advance the priorities of the sponsor and do so in ways not possible on grants of one or a few PIs***.

Moreover, the RFP needs to be closely analyzed and understood as an integrated whole, again **by the team and not just the PI**. Every responsible team member must take the time to fully understand the funding solicitation, thereby avoiding wasting team time by advancing ideas of no interest to the agency or program, or by writing narrative contributions only vaguely addressing the agency's research goals. This team member obligation includes understanding the agency's research objectives, desired outcomes or deliverables, how those research objectives will be reviewed, and any referenced strategic plans or research roadmaps that define the research context in more detail.

RFPs are written documents and, like all written documents, they are not always perfectly clear. Any uncertainties the team has regarding the meaning or intent of any portion of the RFP need to be resolved early in the proposal process to ensure the research narrative fully responds to the guidelines. Uncertainties can often be resolved through repeated, closer readings of the RFP, discussions with colleagues who have been funded by the agency in similar research areas, or by contacting the program officer directly. The latter is often the best option

for LTGs given the complexity of typical solicitations. In other cases, take advantage of agency webinars specific to LTG opportunities to gain a better understanding of agency expectations. ***NSF, for example, does a good job of scheduling webinars sufficiently prior to the due date of many of their LTG and center-level funding opportunities***.

Never hesitate to contact a program officer—**timidity is never rewarded in the competitive proposal process*, and ambiguities in the research narrative are <u>always</u> punished.*** You cannot write a competitive proposal narrative based on an ambiguous understanding of any portion of the RFP, and this problem can compound itself on complex LTGs. ***If you don't clarify ambiguities in the RFP, they will metastasize to the research narrative and almost certainly result in a declined proposal.*** Program officers usually are happy to respond to queries by potential applicants, especially questions that are thoughtful, clearly stated, and focused on the research topic. Do not ask the program officer to make speculative comments on the likelihood that your proposal will be funded, or to engage in similarly inappropriate discussions. But **do call them to resolve any ambiguities you feel exist in the RFP**, or to develop a more nuanced understanding of the agency's intent.

As stated, LTGs are collaborative research efforts involving one or more disciplines and multiple PIs. It is important that **all potential team members** understand the RFP. To be successful, these proposals have to be an integrated effort representing a research team and not a vehicle to advance individual research interests **that do not add value to the effort**, or do not map to the agency's research objectives. For this to happen, all participants must take the time to read and understand the RFP in detail to keep the research development discussions focused on the agency's interests as defined in the RFP. ***There is usually sufficient disorder in the initial research development discussions on LTGs without amplifying it with opinions uninformed by the sponsor's research objectives as detailed in the RFP.***

Role of the Solicitation in Large Team Grants Organization

A poorly organized LTG will be a declined LTG.

The RFP plays a key role in proposal organization by establishing the order, required level of detail, and focus of the research narrative. It is a good idea to simply copy and paste the RFP's key sections, research objectives, and review criteria into a beginning draft narrative. This allows the RFP to serve as an **organizational template** and a reference point for the full proposal to ensure that subsequent draft iterations of the narrative are **continuously calibrated to the guidelines**. For example, an RFP will often contain a detailed description defining the agency's objectives for the program (e.g., goals, objectives, performance timeline, outcomes, research management, evaluation, etc.) that must be addressed in the proposal narrative. This detail, including review criteria, can be selectively copied and pasted into the first draft of the proposal itself. This statement can provide initial section and subsection headings under which the applicant can draft out preliminary written responses to every requested item in the guidelines, thereby ensuring that the first draft of the proposal fully mirrors the program solicitation requirements in every way.

This copy and paste process of transforming the RFP into a narrative template helps ensure that several elements key to a successful proposal are addressed at the beginning, and adhered to throughout the writing process, even though ideas and approaches may change as they mature during the proposal development process. Using this approach, you will ensure that the proposal narrative:

- fully responds to all requested information,
- offers information in the order requested,
- provides the required detail,
- integrates review criteria into the narrative, and
- remains on track and in sequence.

If the RFP refers to any publications, reports, or workshops, it is important to read those materials, analyze how that work has influenced the agency's vision of the program, and cite those publications in the proposal in a way that illustrates that you have read and absorbed the ideas behind those publications.

Red Teaming the Solicitation

Red teaming LTGs offers significant competitive advantages to ensure that a submitted research narrative responds fully to the agency solicitation and makes the most compelling case possible to persuade program officers and reviewers to recommend funding. Equally important to red teaming the proposal is ***red teaming the solicitation***, a process that needs to start immediately upon publication of a funding solicitation of potential interest. There are several points in the planning, development, and writing of LTGs at which the red teaming process plays an important role in enhancing the competitiveness of the proposal. LTG funding solicitations are often lengthy and complex, and at times ambiguous and nuanced, in stating the funding agency's research goals and objectives as well as its review criteria, and in referencing national reports, workshops, and other documents that influenced the agency's plans to create and fund a specific LTG opportunity. Red teaming the solicitation is a critical first step needed to inform each team member where the team needs to go and how to get there to be successful.

The term "**red team**" derives from government and industrial evaluations that use a group—a red team—to review, assess, test, or vet plans, operations, concepts, capabilities, or proposals. ***Red teaming very thoroughly reviews and evaluates a proposal***. They provide the means by which successful proposals approach excellence through repeated revisions that eradicate ambiguities and bring focus, specificity, and clarity to the proposal. Narratives relying on excessive generalities and unsupported claims rather than specific and validating detail that advances a research vision will quickly lose reviewers' attention and confidence. The red teaming process can help assure this does not happen.

Importantly, red teaming is a scalable process. The step-by-step red team review process can be adapted to solicitations as well. A***pplying a variant of the red teaming process to analyze the solicitation is the first critical step in making several key strategic decisions that will determine the success or failure of a proposal***. Of course, the first critical decision to make is whether or not to submit a proposal based on a candid assessment of your competitiveness as you map your capacities to the research goals defined in the solicitation. Once that analysis is complete, and in the event a decision is made to submit a proposal, the solicitation and the team's understanding of the solicitation becomes to the development and writing of a successful proposal what the North Star was to ancient navigators.

Correctly analyzing a solicitation prior to developing the proposal amounts to the critical first step in your effort's ultimate success. Solicitations by their nature tend towards the prescriptive rather than the open ended, as illustrated by Lewis Carroll's observation in *Alice in Wonderland*: "If you don't know where you are going, any road will get you there." That will not work in proposal writing***. Solicitations, by analogy, place significant, exacting, and often nuanced initial conditions on the logical structure of your proposal***, e.g., what you propose, how you propose it, and the rationale and arguments you make for the significance of your research to the field or the mission-critical objectives of the funding agency.

Moreover, because solicitations are written documents used to convey an often complex set of sponsor instructions and expectations (e.g., vision, goals, objectives, outcomes, etc.), sometimes well written and sometimes not, they can often result in ambiguity and misdirection. This ambiguity typically arises from several sources, often concurrently, including:

- lack of clarify in some portions of the solicitation itself (talk to the program officer),

- failure on your part to thoroughly and accurately analyze the solicitation (read it; read it again),
- failure of team members to closely read the solicitation before advancing ideas (put them in in-school suspension),
- failure of you or your team members to sufficiently understand the research culture and mission objectives of the agency in a way that allows you to gain a deeper and more nuanced insight into the solicitation (e.g., the capacity to "read between the lines" or "understand the subtext")
- unfamiliarity with the agency's language used to describe its research vision, goals, and objectives at various scales, from the solicitation to the entire agency.

Given the importance of an insightful reading of the solicitation to the ultimate success of a proposal, particularly given that small misinterpretations of the solicitation early on may well be amplified into missed opportunities during the writing of the research narrative, putting together a solicitation red team to analyze the solicitation together rather than separately, offers another opportunity to weight the outcome to your advantage.

Given this, a good way to conduct a red team review of a solicitation is to get the key members of the LTG team in the same room to discuss every aspect of the solicitation and come to a common team understanding of the agency's goals, objectives, review criteria, and major referenced documents. All of the team members need to have carefully read and re-read the solicitation prior to the meeting. The PI can lead this discussion with a PowerPoint presentation using an abbreviated version of the solicitation that allows a point-by-point discussion among the group of each key factor that, in aggregate, defines the agency vision for the LTG. This red team process needs to address the core question of how, after reading the funding solicitation, the team's research capacities clearly map to every research objective addressed by the sponsor in the solicitation. Every research objective and every question raised by the sponsor in the solicitation must be addressed and answered by the solicitation red team sufficiently well to make a competitive proposal possible.

The bottom line is that LTGs are a team effort and every member of the team needs to be fully informed on the funding agency's expectations, both explicit and implicit, put forward in the solicitation.

Know the Context of Your Research

If the mantra of real estate is "location, location," then the mantra of proposal development and grant writing is "***research context, research context***." Moreover, when it comes to LTGs, knowing the context of your research is all the more important. It is very common for LTG funding solicitations to reference the agency's strategic plans and research road maps, national academy reports, agency-sponsored research workshops, and similar documents all of which will play a key role in helping you better frame the proposal narrative in the most competitive context possible. For example, the NSF "Three-Plane Diagram" that sets the context within which all successful Engineering Research Centers must fit is legendary [**Google search**: *NSF ERC Three Plane Diagram*]. Reviewing, understanding, and incorporating these "contextualizing documents" into your project narrative makes for a more competitive proposal that better addresses the importance and significance of your research in the context of the funding agency's overall research objectives. When you successfully characterize the importance of your research to the agency's research objectives, you will have achieved an important competitive advantage.

Moreover, reviewing strategic plans and research road maps, along with other research reports in your domain, helps you better match your research direction with the investment priorities of the funding agency. Successful proposals represent an accumulation of marginal advantages that complement the core research idea put forward in the research narrative. This is important because funding success at federal research agencies occurs at the boundaries of excellence, particularly in the peer-review process. ***In this environment, a good proposal is not good enough***. An excellent proposal narrative that can compete for funding requires getting everything right, including a persuasive argument describing how your research advances the research objectives of the funding agency, from the finely- grained context (specific goals and objectives in the solicitation) to the larger contexts (agency-wide and national research strategic plans). Clearly stated and persuasive arguments placing your research and ***its significance*** in these important contexts represents just one more key element needed to gain a competitive advantage. It is here that you must make the key distinction between describing the nature of ***your research and describing the significance of your research.*** Moreover, in the case of LTGs, a competitive submittal will need to demonstrate the significance and value-added benefits of the research at several scales—at the program level, agency level, and the national context where the proposed research impacts the field and its direction.

Your key objective in mapping the significance and impact of your research to a broader research context, either basic or mission-critical, depending on the agency, is to give program officers and review panelists a clear understanding of the value of your research to the research context(s) most important to that agency. It would be difficult, for example, to make credible claims for the uniqueness and innovation of your research without using contextual references that help the reviewers make that judgment. Do not expect reviewers to invent their own understanding of the impact of your research on their agency's mission. It is your job to make that argument for them.

Why context is important—

- First off, most LTG solicitations set the stage for the agency motivations that led to the solicitation in the first place by extensively referencing key documents that provide the

conceptual underpinnings guiding the agency's goals, objectives, and rationale for the program. Viewing an LTG funding solicitation without understanding the critical background that served as the genesis of the program would be like a biologist still believing in spontaneous generation. Bottom line: LTGs do not spontaneously generate themselves on Grants.gov, but originate from a very deliberate and thoughtful process from within and without the funding agency concerning the need for LTG investment. If you don't know where and why LTGs come from, it is highly unlikely that you will win one because your narrative arguments will be uninformed about the context out of which the LTG has emerged.

- Understanding the research culture and context of the funding agency helps you to more successfully embed your proposed research plan within the research focus and context of the agency solicitation.
- Understanding the context of an agency's mission-critical areas, strategic plan, research culture, investment priorities, and the rationale behind them helps you write a more persuasive and competitive proposal narrative.
- Understanding context helps you better describe how your research plan matches the research goals detailed in the solicitation and advances the agency's larger research plan.
- Convincing program officers and reviewers that your research advances the agency's research objectives is a key factor in the decision to fund or not fund your proposal.
- The more knowledgeable you are about the ***rationale behind a funding agency's research mission***, strategic plans, research culture, and investment priorities, the better able you will be to plan, develop, and write highly competitive, high-impact responses to the funding solicitation.
- Understanding research context helps you better understand several key elements common to every competitive proposal narrative:
    - Who is the audience?
    - How do you best address that audience?
    - What is a fundable idea within the context of the agency's research priorities?
    - How are claims of research uniqueness and innovation best supported in the proposal text?
    - What arguments are likely to be most compelling in communicating your capacity to perform the proposed research to reviewers and program officers?
- ***A good idea is necessary but not sufficient.*** Agencies fund only good ideas that are clearly developed and tightly linked to their mission, vision, and strategic plan as represented by the research objectives stated in the solicitation and in the broader context of agency strategic plans and research road maps, which in turn are embedded in the context of the national research enterprise.

A Case Study: NSF Science and Technology Centers

In the past, under NSF's ***Science and Technology Centers: Integrative Partnerships*** solicitation [**Google**: *NSF Science and Technology Centers (STCs): Integrative Partnerships*], roughly 250 preliminary proposals were submitted, of which 40 to 50 were invited to submit a full proposal, and about 10 of which were site visited. At the end of the process, NSF typically makes around 6 STC awards. Regardless of the exact submission numbers for any specific competition, it is always a highly competitive process involving ***several key review gates***, typically starting with a preliminary proposal. When planning the submission of an STC preliminary proposal, or any required LTG preliminary proposal, it is important to keep in mind that ***very good is not good enough***. Success is contingent on having in place the key foundational strategies for planning, developing, and writing a successful STC or LTG preliminary proposal. Two key sections of both the preliminary proposal and the full proposal (typically by invitation based on a review of a required preliminary proposal) will be pivotal to success:

- Project summary
- Project description

Your description (written succinctly in the project summary and in more detail in the project description) of a compelling ***vision and rationale for the center will become the keystone locking together the entire proposal***. It needs to be as close to perfect as you can make it. It will likely be forged in continuous discussion and crafted through repeated iterations of narrative text. A competitive vision and rationale statement do not come about from epiphanies but rather from the ***hard and persistent work of convergence on perfection.*** Every narrative component section of an STC, both the preliminary and full proposals, must be ***built around the two core requirements typically addressed in the solicitation described below.***

There are typically multiple programmatic and operational requirements in any solicitation for LTG research centers related to the goals and objectives of your proposed center , each of which requires conceptual and narrative excellence; however, you must first convince reviewers and program officers that your vision and rationale for the center will foster excellence and innovation in research and education through ***future-focused strategies for advancing beyond the frontiers of current knowledge***. Any LTG by definition represents a significant investment of resources over many years by a funding agency; transformational research rather than incremental research advancement is the core expectation of the funder.

While the STC is used as an example here (it is a decades-long program that has evolved and matured over the years, much like the NSF ERC [**Google**: *NSF Engineering Research Centers*]), it is important to see in this STC example some of the common denominator characteristics of what makes for a competitive center proposal regardless of discipline or agency. Specifically, the project description of any required preliminary proposal must ***articulate your vision*** for the proposed LTG that clearly outlines the research grand challenges being addressed or breakthroughs being sought. The proposed research should be sufficiently complex, large scale, and long term ***to justify a center-level investment by the agency*** and flexible enough to permit change as the research proceeds. The proposed approaches must be innovative, and it must be made clear how they will transform or significantly impact the research area. ***Also, it is important to understand how preliminary proposals will be***

reviewed, particularly since they are, hopefully, a first successful gate passed on the way to receiving an invitation to submit a full proposal, and eventually a site visit.

In most proposals for LTG research centers, reviewers will be asked to consider the vision and potential impact of the research proposed, along with the need for the center funding mechanism. ***They will typically ask themselves the following generic questions:***

- Is the vision for the project sufficiently compelling, ambitious, and complex to justify the large-scale focus of resources that can only be provided by a center mode of support?
- Are the intended approaches to address the scientific and/or technological questions innovative, promising, and flexible enough to permit change as the research proceeds?
- Is the team of partner organizations and personnel assembled for the proposed Center appropriate and essential to the planned project?
- Are there potential legacies in people, ideas, and (if applicable) promising new instrumentation or technologies that might have significant impact to warrant a large center investment?

A key narrative section in any LTG center proposal must make a compelling case justifying the center approach. Explain the unique opportunities that an integrated LTG research center will provide and describe what will be achieved in the center mode and through a center structure that could not be achieved with group or individual support. Basically, ***answer the "why a center?" question*** by explaining the value-added benefits that will derive from the funding agency investing in one large center rather than making several smaller, disconnected research awards to several PIs. Moreover, in answering ***the "why a center?" question,*** be sure to state ***the overall vision and long-range research goal***s of your proposed LTG research center. Always keep in mind that the LTG center path is one that begins with research silos and progresses to research synergy. This progression occurs by describing how the proposed research areas/themes integrate with each other in realizing the proposed center's research vision.

In thinking about your response to the above, keep in mind the expectation for research centers that are typically defined in the ***agency's strategic plan, for example at NSF***: "*Discovery increasingly requires the expertise of individuals with different perspectives –from different disciplines and often from different nations—working together to accommodate the extraordinary complexity of today's science and engineering challenges. The convergence of disciplines and the cross-fertilization that characterizes contemporary science and engineering have made collaboration a centerpiece of the science and engineering enterprise.*" Demonstrating your understanding of an agency's strategic plan and how your proposed research advances the agency mission or field is an important part of your successful research narrative, either at the preliminary or full proposal stage, as well as during a site visit or reverse site visit planned by the agency.

To consider the NSF example, over the past decades of NSF research center funding, both STCs and ERCs, the complexity of the solicitations and the required research and educational goals and objectives have changed dramatically. Research visions have evolved along a path from disciplinary to multidisciplinary to interdisciplinary to what is now referred to as **transdisciplinary**. It is important for any successful LTG center proposal, at NSF or elsewhere, to know where that path is leading. As hockey great Wayne Gretzky once noted, "***I***

skate to where the puck is going to be, not where it has been." That is excellent advice for any team considering the submission of an LTG.

Considering the above as setting the stage for developing any LTG required preliminary proposal, it is important to plan, develop, and write the project summary and project description for the preliminary proposal while keeping in mind ***those corresponding sections in the full proposal***. In many ways, ***the preliminary proposal will form the conceptual and relational underpinnings for the full proposal***, and, in the case of a successful preliminary proposal, i.e., you are invited to submit a full proposal, it will be the starting point of the fully developed proposal, written to reflect any important comments from reviewers and program officers, that will help the team successfully move the proposal to the next level of excellence. So when reading a solicitation that includes instructions for the submission of both a required preliminary proposal and an invited full proposal, focus on the entire pathway you must successfully navigate by becoming fully informed on the expectations of what goes in both a preliminary and full proposal and how those requirements need to be integrated. ***Do not view them as siloed requirements.***

As discussed, two key questions typically must be addressed at each review gate of any LTG research center, most often starting with the required preliminary proposal. Specifically, successful applicants must define both a compelling (1) ***vision*** and (2) ***rationale*** for the proposed LTG center. It may seem simple enough, but it most often proves to be an elusive and humbling task for many reasons. In some cases, the leadership team becomes stymied in its efforts to configure and clearly explain the integrative nature and added value of the proposed center partnership. This may be because the various research components and proposed partnerships have been only loosely aligned in the past, or disconnected prior to bringing them together for the submission of an LTG preliminary proposal. This is not to say that the multiple research strands and the partnership itself that would form the LTG research center lack compelling significance in and of themselves, but that the conceptual work of melding and weaving these research strands together to meet the funding agency's expectations has yet to be done.

Defining the vision and rationale for any research center must begin very early in the development process, and, in fact, should help inform the decision whether or not to submit a preliminary proposal, given the extraordinary amount of time, resources, and effort it takes to compete in the center process, particularly over the long period of time required to successfully pass through multiple gates—preliminary proposal, full proposal, and site visit. The vision and rationale for the center will naturally evolve over the development period. However, ***it is important to start the process early*** so that the ***vision you articulate*** at each proposal gate is woven into the fabric of the narrative describing how the proposed center clearly outlines the important research challenges you will address and the breakthroughs you will seek to accomplish.

Moreover, to find current examples of successful LTG research centers, it is helpful to conduct a Google search for the web sites of recently funded centers. The first step for this is going to the funding agency web site and getting a list of the more current awards and then following those links. It is surprising how many sites actually post copies of their successful proposals, annual reports, and strategic plans online that can be helpful in planning your own LTG research center. Further, most PIs and operational directors of funded centers are very

open to discussing the center process with those considering grants. After all, the PI of a funded STC or ERC will not be entering a new competition, and so is most often very generous with advice to those thinking of going forward in new competitions.

Not surprisingly, it is worth noting that an LTG research center preliminary proposal merits scheduling a red team review as part of the development and writing process. Red teaming a preliminary proposal is particularly helpful for LTGs that represent a significant institutional investment of resources, time, and effort to develop and write. These large, multimillion dollar proposals are typically written in response to complex solicitations with multifaceted research and/or educational objectives, as noted above. Moreover, these proposals are evaluated under extensive, detailed, and searching agency review criteria designed to assess the applicant's capacity to meet the performance goals and objectives of the funding agency.

A project narrative for an LTG is correspondingly complex to develop and write, and often has page limits in excess of the typical research proposal. To compete against similar proposals, the applicant must present a clear, integrated vision of the rationale, goals, objectives, and focus of the proposed project. This clarity will typically require that the proposal articulate the benefits of funding a large center structure intended to support multiple research strands rather than a series of discretely proposed, disconnected research projects. Writing an integrative research vision statement and supporting narrative presents a major challenge, particularly, as is often the case, when multiple contributors compose the research narrative. In early drafts of the proposal narrative, contributions from multiple authors may be siloed or stove piped, ***whereas the goal of the competitive LTG narrative is research integration, synthesis, and synergy***. However, this approach will make the task of producing a polished project narrative much more difficult, hence the value of the red team in bringing a new perspective to the narrative to ensure it is as perfectly written as possible. Ultimately, the research narrative of LTGs must be flawless if it is to succeed, since only a few awards may be made in a competition that is national in scope. ***Too often, the first – and final – substantive outside review of these large team proposals occurs when the funding agency makes the funding decision***. Make sure that does not happen to your LTG preliminary proposal.

In this respect, keep in mind when writing an LTG preliminary proposal that you are positioning yourself for the submission of a full proposal, most likely ***by invitation***. You might think of the preliminary proposal as the opportunity to describe to program officers and reviewers ***in an abbreviated way*** the ***conceptual and relational core*** of the proposed LTG center and the configuration of center operational components that create the value-added synergy required for a successful submittal. In particular, you will have to address your ***future-focused strategies*** for advancing your research.

It is therefore important to get a general sense of the value the funding agency assigns to the various narrative components in a ***full proposal*** as a function of space allocation. In the example case here of the NSF STC, for instance, of the 25 pages allocated to the project description in the full proposal, the center rationale is allocated 1 page, the research objectives 10 pages, education 5 pages, diversity objectives 3 pages, knowledge transfer 3 pages, and management objectives 3 pages. The take-away message here is not so much the page allocations themselves but that those allocations should reflect the overall weighting of the core research goals and objectives most important to the funding agency***.*** Consequently, a competitive 25-page narrative in the full proposal will not be written as discrete program

components only marginally melded, i.e., so-called stove-piped sections, but as component sections woven together into a seamless fabric. In this case, it will start with the center rationale and radiate out from there, so that each subsequent section of the project description becomes absorbed into and illuminated by the rationale, starting with the research objectives.

The next step in this process, i.e., before developing and drafting the preliminary proposal, is to read the review criteria for the ***preliminary proposal*** (gate 1), the ***full proposal*** (gate 2), and the ***site visits*** (gate 3). Such is the competitive horizon of the typical LTG center! But this is the path, some might say gauntlet, you have to keep in mind while developing the preliminary proposal. The requirements attending each step of this process must be anticipated at every stage of the drafting process to create a truly integrated narrative that will pass through each STC review gate. Of course, some LTGs will have fewer than three gates and others may have more, but three gates are typical and serve for illustrative purposes.

Guiding this entire process will be an agency LTG solicitation that characterizes what the agency expects to see in a center proposal. It is difficult to write any successful proposal, let alone an LTG center proposal, without first translating your research objectives into the agency context. The below points from an NSF center solicitation are an example of the agency context within which you must frame your research narrative. In this case, the proposed center characteristics include:

- innovative, potentially ***transformative***, complex research and education projects
- significant investigations at the ***interfaces of discipline***s
- discovery, innovation and education that advances ***beyond the frontiers of current knowledge***
- integrated education and research that creates bonds between learning and inquiry, so that ***discovery and creativity fully support the learning process***.

To bring these center characteristics into better focus takes more of an effort than merely reading the solicitation as a stand-alone document. It should not be read as if disconnected from an in-depth understanding of the funding agency mission, culture, language, and investment priorities. It requires a more expansive reading of agency reports, workshops, strategic plans, and roadmaps in which these terms are used. Reading these terms in these several contexts will enable you to develop a better working definition of their meaning, and a better fluency in their use as you craft the narrative.

For example, in its 2007 report, [Google: *Enhancing Support of Transformative Research at the National Science Foundation*], the National Science Board presented its findings and recommendations by which NSF can enhance its ability to identify and fund ***transformative research***. Based on this report**, NSF subsequently adopted the following working definition**: "*Transformative research involves ideas, discoveries, or tools that radically change our understanding of an important existing scientific or engineering concept or educational practice or leads to the creation of a new paradigm or field of science, engineering, or education. Such research challenges current understanding or provides pathways to new frontiers.*"

Once you are fairly comfortable with a working definition of the terms an agency uses to characterize its vision of a center, there still remains the difficulty of using them in a substantive rather than superficial way in the proposal narrative. For example, since the title of the STC solicitation contains the term "***Integrative Partnerships,***" you will have to explain why your

proposal is integrative, and following from that, you will have to make claims for the ***synergy*** that arises from exploratory research at, as NSF states, "***the interfaces of disciplines.***"

In fact, synergy is objective number one for an NSF STC, as defined in the agency solicitation: "*Support research and education of the highest quality in a Center-based environment* ***in which the whole is greater than the sum of its parts."*** Of course, the importance of achieving research synergy is not exclusively the domain of NSF and NIH centers, but is ubiquitous across federal research agencies. However, synergy is one of those elusive terms that sounds impressive when used as a proclamation without further elaboration, but quickly deflates under even the most modest critical request for specific details. Therefore, in drafting your LTG center proposal, you will have to address the issue of synergy by presenting clear and compelling arguments grounded in specific detail about how you expect to achieve it with your proposed center structure. ***You cannot substitute slogans for ideas when describing the research synergy inherent in your planned center***. It has to be real! Unfortunately, stove-piped disciplinary perspectives can be an artifact of prior research that haunts the development process of LTG centers unless one or more members of the research team is able clearly to explain how the center structure will achieve integration and synergy. Of course you must answer a core question as you write: "***How will synergy happen and why***?" Be sure to ground the answer in specificity and detail, rather than superficialities.

Strategies for Developing Competitive Partnership Proposals

Multi-institutional and multidisciplinary partnerships for LTG center proposals have become an increasingly important and a much larger component of university external funding portfolios. Partnership proposals offer significant advantages over single-PI grants or grants with a few coPIs. Most importantly, the capacity to develop successful research and educational partnerships ***expands your funding opportunities enormously.*** The trend towards team-based research solicitations has been increasing significantly at federal research agencies whose investment priorities include addressing complex problems that require transinstitutional and transdisciplinary approaches.

Of the many reasons to explore and develop research partnership configurations, chief among them is their potential to open up new research funding opportunities and thereby offer researchers the potential to advance their own and their colleagues' interests. Other reasons to collaborate in the planning, development and writing of LTGs include:

- Collaborators may bring needed research knowledge, skills, or resources to a project requiring the integration of multiple research and/or educational strands to meet the overarching goal and multiple objectives defined in the funding solicitation.
- Collaborators may have a stronger track record or connections with an agency, or across a few agencies, that strengthen a proposal's competitiveness.
- Collaborators may offer institutional characteristics that better suit a project for funding, e.g., partnerships with predominantly undergraduate institutions, community colleges, minority-serving institutions, tribal colleges, Hispanic-serving institutions, K-12 schools, or outreach partners such as museums, science centers, and informal learning centers that disseminate research to the public domain to promote social benefit.
- Multidisciplinary projects are becoming more common and necessary to address transformative science and engineering. These solicitations are often funded at greater dollar amounts over longer periods of time than are single-PI or single-institution grants, hence offering funding opportunities to a range of disciplinary areas.
- Partnership proposals often have research requirements or educational, workforce diversity, and public outreach, benefits to society beyond the core research focus of the project. These benefits can expand the research opportunities for faculty whose disciplinary expertise alone may offer fewer chances for funding outside the partnership structure.
- Partnerships are typically essential for center and center-level proposals. As with all LTGs, competitiveness is a function of your capacity to demonstrate a partnership with a history of research collaborations.

However, LTGs require a much more strategic, complex, detailed, and informed research development and grant-writing process than do single-institution grants or grants with only a few PI/coPIs. LTGs require an experienced development team for their success along with careful attention to planning, scheduling, writing, and team dynamics. Most importantly, ***partnership proposals take significantly more development time***, which seems to increase exponentially as a function of the number of partners and disciplines represented on the effort. Moreover, LTGs:

- Represent a much more complex and resource-intensive research development and writing effort than do single-PI grants, particularly when it comes to the writing of multiple research strands and their integration;
- Must address composition of leadership team and roles, including selecting the PI early in the development process, since the capacity to develop and manage a major partnership grant is one indicator of the PI's capacity to manage a funded research grant;
- Must give clear and compelling reasons why the partnership has ***value-added benefits and synergy*** that impact the funding agency mission or strategic plan and research roadmaps;
- **Must determine early on who will write the grant**, who will serve as lead author on various sections of the grant, and who will act as the "***integrating author,***" weaving narrative sections into a seamless whole as if written by a single author;
- Must have the capacity to develop a ***performance-based budget*** and not merely a budget arrived at by "dividing the pie equally." A total budget amount simply divided by N-partners will be the Achilles' heel of a partnership effort.

The configuration of the LTG research partnership is key to its competitiveness. Consideration needs to be given to the following:

- Each collaborator must bring specific expertise to the project and take a distinct and well-defined role with clear relevance to the solicitation.
- The budget should be divided according to effort and project needs (discuss division of resources early), and tightly mapped to, ***as well as in balance and scale with***, the research goals and objectives defined in the solicitation.
- Expected outputs must be specified when planning the project (what results do you expect over the performance period; what new knowledge will be created; what papers will you produce and who will be the authors, etc.?).
- Each member of the collaboration should benefit along with the other partners on the grant.
- Communication protocols among members of the research team must be established early on in the process to ensure team integration. Clear and consistent communication will determine the success or failure of the proposal development process **and** the subsequent implementation of the research.

The attributes and characteristics of LTGs will determine the funding success. For example, characteristics of partnerships ***likely to be <u>uncompetitive</u> for funding*** might include:

- "***Top down***" administrative directives to submit a proposal for money and institutional prestige, but without a **successful history** of research capacities in the topic areas at the specific agency, or perhaps with only a "thin veneer" of institutional research capacities;
- Attempts to "***force fit***" previously disconnected researchers **lacking a history** of collaboration into a center-level proposal. This amounts to a research version of a shotgun marriage.

- Attempts to cobble together preexisting research partnerships that, at best, only partially meet the intent of the solicitation, followed by the forming of hasty "marriages of convenience" with other possible research partners designed to overcome significant deficits. This is the research version of speed dating.
- Poorly considered partnership configurations, poorly managed proposal development efforts, poorly written proposals, and proposals with poorly defined visions, goals, and objectives, or proposals cobbled by poor and uncommunicative team dynamics are ***sure to fail and squander all the valuable time and resources put into the effort.***

An informed decision to submit an LTG proposal must be grounded on a candid self-assessment of the capacity to perform and develop a competitive proposal in the time allotted. Partnership proposals represent a major commitment of time and resources.

By contrast, successful LTGs succeed by virtue of good team dynamics grounded on good reasons to submit, including:

- The development and writing of the proposal will serve the ***long-term interests of an emerging research partnership or research affinity group*** by moving it towards a more competitive configuration;
- The process will help prepare the research partnership for the possible submission of ***smaller, more focused research grants that will provide an important research component for the future***, i.e., components required for a research center, particularly since center-level awards often are built on a strategic configuration of successful small research grants that ***de facto form the core research framework of a future center***;
- The acknowledgement that many, if not most, funded center-level efforts are awarded on the second and third submittal, and hence the development of a center proposal will prove an important exercise for committed team members for the long term;
- The recognition that developing and writing a center proposal and getting reviewer comments if it is declined holds the potential to advance the research team towards its goal of a funded center on a second or third attempt.

The foundation or underpinnings of successful team dynamics includes the following key characteristics of each team member:

- Earns trust of other team members
- Demonstrates a capacity to perform
- Respects team development principles
- Earns the confidence of partners
- Proves to be reliable (e.g., meets deadlines, high-quality contributions to team effort)
- Remains fully and consistently engaged in the research development effort
- Stays informed (e.g., reads the RFP and understands her or his role in it)
- Brings expertise as a value-added benefit to the proposal
- Acts as an effective communicator
- Plays well with others…not looking for a free ride.

In addition, a successful LTG proposal must have a well-suited PI with relevant research credentials, management skills, and the capacity to state a clear and compelling vision for the partnership.

- The principal investigator of a major partnership proposal is, in ideal circumstances, an obvious choice. This candidate has an established research track record in the research topic areas and is already seen as the de facto leader of existing research collaborations in these areas.
- In some cases, there may be more than one obvious choice as PI, particularly in multidisciplinary research collaborations comprised of several research strands. However, successful leaders of center proposals possess several key attributes, among them:
    - Respected by colleagues;
    - Able to define an overarching, integrative vision
    - Possesses strong organizational skills and the **capacity to communicate** across participating disciplines and research teams
    - Skilled in **managing team dynamics**
    - Able to clearly state why the integration of the research strands proposed under a partnership structure achieves a more compelling research vision and **clear synergy** (**value added**) not possible in research strands funded as separate projects
    - Fully engaged, passionate, and ***available to team members (not a PI in absentia)***
    - Inspires the team with a feeling of confidence in the project's likely success.

Once the right PI and the right team configuration is in place, the process of team-based planning, development, and writing of the proposal will likely include answers to the key questions below:

- Who is responsible for the first and subsequent drafts of the ***integrative sections*** of the project description section, e.g., executive summary, vision statement, rationale for the partnership or center, goals and objectives, research focus areas integration plan, benefits of the partnership or center, expected research synergies, etc.? **This is not a trivial task** and lies at the heart of the competitive research proposal.
- Are lead authors, perhaps coPIs, assigned for each of the research focus areas?
- Have contributing authors from partner institutions been carefully selected?
- Who will write the management plan?
- Who will write the five-year strategic plan for goals and objectives?
- Who is best able to produce milestone charts, graphics, illustrations, tables, and other visuals that complement the text and communicate the partnership configuration?
- Who will be responsible for reading or quickly reviewing ***all the documents cited by the sponsor in the solicitation***, typically by URL, as having relevance to the program, e.g., agency strategic plans, national academy reports, agency reports and workshops, etc. ***This is a critical role,*** since making competitive arguments for the significance of your

research without being fully informed of the agency's research vision, mission, and research investment agenda is ***often a fatal flaw in the proposal narrative***.

- Who will be the lead author of the ***education and outreach component***, , and who will serve as contributing authors, e.g., for undergraduate research, postdoctoral mentoring, research experiences for teachers, etc.?
- Who will be responsible for **assessment and evaluation**? Does the capacity for this exist in-house or will an external evaluator have to be included in the budget to write that section of the narrative?
- If the proposal requires ***institutional data***, e.g., STEM degrees granted in total and to women and minorities by academic department, who will take responsibility for gathering those data and putting them in the format specified in the solicitation? Who keeps the data? Are data kept by colleges and departments, or by an office of institutional research? Are the data accessible to queries that meet the sponsor requests? Who collects data from partner institutions and from whom?

Visuals are key to a strong partnership proposal

Competitive collaborative proposals need to address the integration of multiple research and educational strands, roles of multiple co-PIs and senior personnel, roles of multiple institutions, and related topics such as evaluation, dissemination, communications, outcomes, and a long-term vision based on a strategic plan—***all of which benefit greatly by complementing the narrative text with visuals, such as***:

- Milestone charts
- Tables
- Graphics
- Pictures
- Org charts
- Diagrams

Writing the management section

- Identify the multi-institutional partners and the contribution of each to the project, i.e., **value added/team science**
- Identify key members of the research team and what they bring to the project, i.e., **value added/team science**
- Clarify who is responsible for each research strand and how multiple strands are managed, particularly to gain the synergy that defines the vision of the project
- Clarify how the team members will work together, particularly through communications across the partnership.

Generic strategies for partnership competitiveness

- Define your research home at the agency
- Map your research to that domain
- Learn the grant cycles
- Understand the agency mission, culture, and research priorities
- Understand the review process/role of program officers

- Talk to program officers
- Talk to colleagues funded by the agency
- **Subscribe to agency RSS frees and email alerts**
- Read agency strategic plans and other documents.

Optimizing the Proposal Planning and Development Process

If you think of your available time and resources as investment capital and the writing of a proposal as an expenditure of time and resources, then faculty and those research professionals assisting them, will want to pursue an efficient proposal development process. This becomes a critical aspect of developing and writing LTGs. Too often, however, those planning LTGs do not anticipate, in a detailed and realistic way, the time and resources needed to develop and write a competitive proposal. Finding the time and resources needed to produce a competitive proposal represents a significant time management problem not only for faculty already committed to teaching, research, and service but also for the research offices that may assist them in this process.

Of course, "*competitive*" is the operative word here, ***as any time and resources invested in a noncompetitive proposal have been squandered***. Keep in mind that a competitive proposal (as opposed to a noncompetitive one) may not be funded on the first submission, something quite common for LTGs, but, even though declined, will be sufficiently competitive to merit a resubmission with realistic expectations of funding. Therefore, developing an accurate and realistic assessment of the time and resource expenditures required to develop and write a competitive proposal is a critical step in deciding whether or not to pursue a solicitation. Here again, a competitive proposal is reviewed positively enough to produce either a recommendation for funding or a recommendation sufficiently close to the funding boundary to encourage a resubmission.

How should faculty incorporate time for proposal development and grant writing into their other academic obligations? To make a reasonable estimate of the requirements for developing a competitive proposal, the faculty member must learn how to develop an accurate sense of the time required to write a competitive grant. If that time is not available, then any time committed to a likely noncompetitive grant is wasted. Submitting a proposal is easy, but submitting a competitive proposal that will rank in the top ten or fifteen percentile of all reviewed grants is difficult. So the decision to submit or not submit must be based on a realistic assessment of the time and effort available to complete the task at a high level of effort.

You can arrive at a reasonable estimate of a proposal's time requirements by determining how long it will take to write one page of a competitive proposal based on a review of the solicitation. This procedure will help whether you are writing every page of a 15-page proposal or writing a 5-page contribution to a 25-page proposal, or a 40-page proposal. If you use this method and adapt it to your personal performance metrics, you will converge over time on a fairly accurate estimation of how much time you will need to write or participate in the writing of a competitive proposal.

Of course, determining the unit of time required to produce one submission-ready page of a competitive proposal will be a ball park estimate, but it should be possible to answer with more certainty than the question that perplexed medieval theologians wondering how many angels could dance on the head of a pin. If you are the PI and a principal author of a proposal, it may be prudent to plan to allocate eight hours to produce one page of a competitive research narrative, and the time allocation per page of such highly competitive LTGs such as NSF's Engineering Research Centers of Science and Technology Centers may be substantially higher.

This may seem inflated at first glance, but the unit of time you assign to producing each page of the research narrative will be filled by answering many questions unanticipated when

estimating your proposal production time. Keyboard skills are not relevant to this calculation, but many other factors are, including the time you spend before even putting a word to the first page of the project description. For example, you must be prepared to

- analyze the solicitation and any referenced documents,
- discuss the solicitation with possible research partners,
- make the decision to submit or not to submit,
- configure any research collaborations,
- hold research development meetings,
- identify your research vision, goals, and objectives and map them to the solicitation,
- work with research and sponsored project offices,
- plan, organize, and develop the proposal production schedule, and
- outline the proposal as a template that fully responds to all of the solicitation's questions, objectives, and review criteria.

Simply addressing these common questions that lay the groundwork for writing the research narrative may require an investment of two hours per page, thereby leaving perhaps six hours per page for the remaining tasks required to finalize a competitive proposal. The remaining six hours of time per page will likely be consumed by completing such key tasks as,

- using the proposal template to draft responses to all the solicitation requirements,
- writing the initial complete first draft of the project narrative from this template,
- sending the draft out for review and edits and rewrites,
- writing a second complete draft of the project narrative based on review comments,
- sending the second draft out for review, edits, and rewrites,
- writing a near final draft of the proposal and continuing to fine tune iterations until due,
- writing the project summary,
- writing and compiling components required in supplemental documents, e.g., letters of commitment, data management plan, postdoc mentoring plan, biographical sketches, current and pending support, required support data, etc.,
- compiling references,
- completing the budget, and
- writing the budget justification.

Using the above examples, you can see many of the hidden costs that must be identified and accounted for before accurately determining the time it actually takes to produce one page of a research narrative. However, with experience, you will converge on your own personal metric of the time commitment you must make to either lead or participate on a proposal. For example, if you are serving as the PI of the proposal and the sole or principal author, you may have to increase your time unit cost per page of final narrative. Additionally, your allocation of this time commitment must account for other academic obligations as well, and must be scheduled over sufficient time to ensure that the proposal development activities do not distort your other obligations.

Regardless, whether you allocate six hours per page or ten hours per page for producing a competitive LTG research narrative, the important point is to have a realistic understanding

before embarking on the LTG journey, some may say LTG gauntlet, of the dimensions of the commitment you and your team members will need to make to be competitive. After all, when it comes to LTGs, such as NSF's Engineering Research Centers, for every hundred universities that "*go big*" by starting the ERC gauntlet with a preliminary proposal, historically about 98 universities will "*go home*" without an award. While the "*Hail Mary pass*" is exciting to watch in college football (e.g., Doug Flutie of Boston College at Miami in 1984), it does not translate well into a strategy for allocating research development resources on LTGs. Being able to estimate the time needed to produce a competitive LTG is a critical strategic planning skill that must be mastered.

However, it is also important to realize that if you are a coPI on a proposal and responsible for a narrative contribution of several pages addressing the role your research will play in the project, you may need to increase your assessment of the time required to bring competitive value-added benefits to the proposal. In this situation, an off-the-shelf-contribution of something you have written in the past, perhaps as part of another proposal, to explain your research topic will likely ***not represent a value-added benefit to the success of the proposed effort***. In this situation, the hidden time costs of your participation as a team member bringing added value to the proposal may include:

- reading and understanding the solicitation and referenced documents,
- attending proposal development meetings,
- working with other coPIs to fully understand the role of their research in the project,
- understanding how your research complements and contributes to the proposed research,
- understanding how the research of other coPIs complements your research,
- drafting narrative text contributions written specifically for the current effort,
- making other contributions to the project as required for competitiveness, and
- providing high quality narrative and other contributions to the project on schedule.

As General Colin Powell once observed: "Everyone has a plan until they are shot at." While no one is actually shot at during the writing of a LTG, it may, nonetheless, feel as if you are. Everyone will likely use different personal metrics to describe the actual unit cost of time per page of final competitive narrative text. To ensure that you have accurately assessed your own metric, identify the hidden time costs associated with developing and writing a successful proposal and avoid the temptation to underestimate the time required. To stop production on a proposal or to submit a proposal that clearly cannot compete represents opportunity squandered and valuable time and resources lost.

Determining your time cost per page for developing and writing a competitive proposal is one helpful strategy for optimizing your proposal planning and development capacities.

Budgeting Strategies for Team Proposals

Every LTG must answer a key budget question: ***Who gets how much money and why?*** The "*why*" part of the budget equation lies at the heart of the matter. In the case of LTG budgets, "*how much*" and "*why*" are not metaphysical questions. These questions are answerable under a straightforward budget allocation rubric that asks "***what specific value-added benefits does each team member's research bring to the overall project***?" Of course, determining the relative or proportional importance of each team member's contribution to the proposal's success can test the collegiality of the team, particularly newly formed teams still developing the foundations and dynamics of a collaborative research relationship based on trust. Moreover, this important "***value-added question***" as the determinate of budget allocations mirrors the question program officers and reviewers will pose in evaluating your proposal's contribution to the agency's mission objectives.

The basic requirements of the budget process originate in two principal domains, ***both highly prescriptive, but neither playing a role in assigning budget allocations among team members***: (1) the funding agency specific domain where the budget requirements are published by the agency, both in the solicitation itself and in other documentation typically referenced in the solicitation; and (2) the institutionally specific budget domain typically governed by various campus research offices and associated units, e.g., sponsored projects, pre- and postaward, and research development. All of these units play various roles in the processing and preparing of the proposal budget, including offering guidance for obtaining matching funds, cost sharing, and other key institutional commitments that impact the budget.

However, as in all cases where a transition is made from single-PI to multiple-PI proposals such as LTGs, the process of planning, developing, and writing these larger collaborative research proposals becomes more complex as a function of team size, and, in many cases, the institutional distribution of those team members who may be operating under different institutional protocols and processes for budgeting. While the coPIs on LTGs must navigate the highly prescriptive budget requirements of both the funding agency and the PI's home institution, most often with the assistance of professional staff, the real challenge in determining allocations for team budgets is not so much the agency or institutional regulations and process requirements as it is the challenge of addressing the fundamental question: "***what specific value-added benefits does each team member's research bring to the overall project, and how is that reflected in the appropriate proportionality of the budget allocations for the entire team***?"

Fortunately, in most cases, this can be answered in a way that achieves team consensus if some basic strategies related to managing team budgeting dynamics are followed:

1. **Allocate the budget based on the value-added contributions of each team member**. It raises a red flag when team proposal participants begin project discussions by suggesting that budget allocations should be made by dividing the project's total allowed costs by the number of team members (T$/N). An equally divided "pie" is an appropriate initial "allocation" if you are hosting an after dinner dessert gathering, ***but it is not for team budgeting purposes***. The fundamental goal of team budget allocations is to proportionally fund project components as a function of their contribution to the overall competitiveness of the proposed project.

2. **Engage the team in the budget process**. Once the project narrative has developed sufficiently to start the budgeting process, each team member responsible for specific project activities in the narrative will need to make an initial determination of the costs associated with those activities. The aggregate of these initial budget numbers will comprise a first rough draft project budget for the team. This draft budget will almost certainly be revised many times, often downward to conform to the budget guidelines published in the solicitation. It is a rare initial budget that comes in below the maximum funding level set by the sponsor.
3. **Keep the budget allocation process open and transparent**. Budget discussions that evaluate the value-added contributions of each team member and the proportional importance of those contributions to the competitiveness of the process are best achieved through an iterative process of consensus among all the team members. Another red flag will appear if budget allocations are developed as silos and in any way ensuring that only the PI, and not the team as a whole, can know the final allocations.
4. **Converge on the final budget allocations as a team**. The team will converge on a final team budget concurrent with the research narrative converging on the final narrative. That is, the final budget and the final narrative must mutually inform and support one another.
5. **Ensure that all team members understand the budget requirements**. It is important that team members understand allowed budget categories as well as eligible and noneligible budget costs.
6. **Keep the budget open and fluid as the proposal develops**. Making specific commitments to exact budget allocations prematurely can effectively lock down the budget before the ideas motivating the project are fully developed. Another red flag will fly should anyone request a budget allocation commitment before participating in project development discussions that sufficiently describe the scope and objectives of the project and the role of each team member in proposed project activities.
7. **Make realistic budget requests to the agency**. Inflated budgets send the wrong signal to program officers and reviewers. Likewise, budgets clearly attempting to "low ball" the project in hopes of securing a better chance at funding will result in disappointing outcomes, both for the agency and for you. If funding is insufficient to complete the project, the agency loses and you lose as well in terms of reputation and prospects for future funding.
8. **Ensure that budget proportionality reflects project narrative commitments**. Each team member needs to review the research narrative to identify proposed activities with budget implications. It is critical to look for "***unfunded mandates***" described in the project narrative but absent from any budget category funding that activity.
9. **Get the budget justification right**. Trivializing the importance of the budget justification will miss an opportunity to submit a more competitive proposal convincing the program officers and reviewers of your effectiveness and efficiency as a manager of funding agency resources, particularly in terms of achieving significant research results for reasonable costs.
10. **Repeatedly review as a team the budget guidelines included in the solicitation**. Just as it is important in writing the project narrative to keep the funding agency's goals and

objectives in sight by continuously calibrating the narrative to the solicitation and review criteria, so it is equally important to keep the budget guidelines detailed in the solicitation in mind by continuously calibrating the budget. In the end, the project narrative, budget narrative, and budget must converge to a point of proportional, value-added "equilibrium" whereby a convincing case is made for funding the proposed project and your chances of success are optimized by the synthesis of these three key sections of the proposal.

The Role of Research Support Offices on Team Grants

Professionals working in the area of academic research development and grant writing can use various skill sets to assist faculty seeking LTG research funding from federal agencies. The basic goal is to help faculty become more successful in securing external funding, particularly in a team environment. The experienced research development professional brings several key attributes to the role of assisting faculty and faculty teams in ways that enhance the overall quality of proposals. This is particularly the case in planning large team proposals that present organizational challenges to the PI. Key attributes that motivate the success of research professionals in this domain include curiosity and persistence in gaining new knowledge and ***acquiring a keen understanding of the generic competitive strategies that lie at the heart of the successful proposal***.

Research development and grant writing expertise is fundamentally a self-taught, knowledge-based enterprise. It can be complemented by a strong disciplinary expertise that allows the practitioner to continuously learn, grow, and gain a more nuanced understanding of the academic research enterprise. Large team proposals benefit significantly from the planning, scheduling, and narrative production skills that research professionals bring to the table. Research teams benefit from contacting research development professionals early in the LTG process to take advantage of their "corporate memory" of what needs to go right and what can go wrong on large team efforts. In this regard, the experienced research development professionals offer faculty a "***comprehensive corporate memory***" based on years of experience and success in contributing to faculty proposals ***that gave those proposals a competitive advantage in the review process***.

Experienced research development professionals have gained ***a keen strategic understanding of the competitive arguments*** faculty teams can put forward to demonstrate the significance and impact of their research on a specific agency, or program areas within an agency. Over time, the research development professional builds a robust suite of skills, expertise, and strategic insight that ***offer faculty who ask for assistance a clear competitive advantage in doing so***, particularly as it relates to offering substantive advice on the developing and writing of the project narrative, the keystone that determines funding success or failure. Faculty planning an LTG proposal should scour the research offices on their campus to find those with the experience to enhance the competitiveness of their planned proposal, and, once found, enlist them in the effort.

An important advantage of engaging research development professionals in your LTG is that ***over time they will likely have been an engaged team member on numerous proposals of all types submitted to a broad range of federal research agencies***. In many cases, faculty transitioning from single-PI/small proposals to the leadership of LTGs may need strategic planning, logistics, and writing support from someone that has been a development team member on numerous center or center-level proposals.

Be sure to seek out experienced research development support on your campus if you are planning an LTG.

Part 3, Proposal Planning and Production

Role of the Solicitation in Proposal Planning and Organization
The Schedule and Task Assignment Table
Asking Yourself the Right Questions

Role of the Solicitation in Proposal Planning and Organization

A flawed understanding of the requirements of the program funding solicitation and the role it plays in planning, developing, and writing a successful research narrative is one of the common reasons proposals are poorly reviewed and declined by funding agencies. Proposal planning must always be guided by an understanding that the program solicitation is an invitation by the funding agency to submit proposals on ***research topics of interest to the agenc***y addressed in the context of the agency's mission. The funding solicitation contains or references all the key information proposal planners will need to develop and write a successful proposal.

In the case of LTGs, the solicitation can seem like a formidable document. LTG solicitations often run to 50 pages or more, such as the 65-page Funding Opportunity Announcement for the Department of Energy's *Energy Frontier Research Centers (EFRC)* for September 2014 awards. Information on the key LTG submission gates will be included in the solicitation. For example, details on what to include in a letter of intent, the narrative requirements of a preliminary proposal, the narrative requirements of the full proposal, agency reports and documents that must be referenced in the research narrative, extensive details about the review process and how reviewers will be instructed to review the proposal. Moreover, solicitations for LTGs typically include agency expectations for the research synergy that will result from the funded project or center.

To be competitive, therefore, an LTG proposal must ***fully respond*** to an agency's submission process, program objectives, review criteria, budget guidelines, and other requirements specific to the program as elaborated upon in the solicitation and any referenced documents. This is particularly important in planning the submission of an LTG given the complexity of coordinating and managing all facets of proposal production. The key to a successful planning process is that ***all team members*** must read the funding solicitation carefully and in its entirety, including the review criteria and relevant referenced documents. This is critical because successful LTGs require that the integration and synthesis of collaborative research contributions from multiple team members be clearly described in the research narrative in a way that demonstrates a significant synergy will arise from the research team interactions should the LTG be funded. ***Achieving research synergy is the "gold standard" of successful LTGs.*** It cannot be achieved unless it is carefully planned for in the proposal development process. Planning will ensure that a project description is written not as multiple research silos but rather as integrated research strands.

To be successful, LTGs have to demonstrate a cooperative effort representing a research **team** rather than serving as a vehicle for advancing individual research interests ***that do not add value to the team effort***, or do not map to the agency's research objectives. For this to happen, all participants must take the time to read and understand the solicitation in detail to keep the planning discussions focused on the agency's interests. ***There is usually sufficient disorder in the initial research planning discussions that applicants will not want to risk amplifying it by including opinions uninformed by the sponsor's research objectives as detailed in the solicitation.***

Moreover, writing a successful LTG requires that the team understand the funding solicitation for what it is--***an expression of agency interest in a specific research domain***--and not what the team might wish it to be. Funding solicitations are rarely a perfect mirror of a

team's research interests, but by thoughtful planning, it is often possible to configure a team's research interest to fit the funding agency's interests. From the funding agency's perspective, the solicitation is a ***non-negotiable listing of performance expectations*** reflecting the agency's goals, objectives, and investment priorities that the team must meet to be funded. The solicitation is ***not meant as a menu or smorgasbord offering a choice*** of addressing some topics and review criteria but not others. That is the reason it is important in LTG planning to always keep the "***submit or not submit***" option open as the team gains a better and more realistic understanding of how well the team's research interests map to the funding agency's interests.

The competitiveness of an LTG will depend on how well the team understands the funding solicitation as an expression of an agency's mission-driven interest in specific research topics and then applies that understanding to the planning process. Once the team clearly understands the agency's research objectives within the context of the agency mission, a key planning step is to map the team's research experience and expertise to the research goals stated in the solicitations. However, if the team's interests and expertise do not map tightly to a the agency solicitation, or if a force fit is required, it is wise not to submit and wait for a more appropriate solicitation. Most of all, teams must invest their time, resources, and energy wisely—these are valuable assets that must not be squandered but reserved for those opportunities where the chances of funding success are highest. Here, it is important to keep in mind that having a good idea is a necessary **but not a sufficient condition** for successful funding. Funding agencies are seeking exciting ideas clearly stated that make a compelling case that your expertise will advance the sponsor's priorities. ***This is significantly amplified in the case of LTGs where the agency investments are large and spread over many years.***

The funding solicitation needs to be closely analyzed and understood as an integrated whole during the proposal planning process. This includes understanding the agency's research objectives, desired outcomes or deliverables, the way in which those research objectives will be reviewed, and any referenced strategic plans or research roadmaps that define the research context in more detail. Solicitations are written documents and, like all written documents, they are not always perfectly clear. Any uncertainties you have regarding the meaning or intent of any portion of the solicitation need to be resolved early in the proposal planning process to ensure your proposal research narrative fully responds to the guidelines. You can often resolve uncertainties through repeated, closer readings of the solicitation, discussions with colleagues who have been funded by the agency in similar research areas, or by contacting the program officer directly. The latter is often the best option.

Never hesitate to contact a program officer—**timidity is never rewarded in the competitive proposal process*, and ambiguities in the research narrative are <u>always</u> punished.*** You cannot write a competitive proposal narrative based on an ambiguous understanding of any portion of the RFP. ***If you don't clarify ambiguities in the RFP, they will metastasize to the research narrative and almost certainly result in a declined proposal.*** Program officers usually are happy to respond to queries by potential applicants, especially questions that are thoughtful, clearly stated, and focused on the research topic. Do not ask the program officer to make speculative comments on the likelihood that your proposal will be funded, or engage in similarly inappropriate discussions. But **do call them to resolve any ambiguities you feel exist in the solicitation**, or to develop a more nuanced understanding of the agency's intent. In fact,

for LTGs, it is not a bad idea to discuss the solicitation with the program officer, or, in the case of many center-level proposals, watch agency webinars specific to an LTG. NSF often holds webinars on major center proposals sufficiently before the due date to allow potential applicants to gain a deeper and more nuanced understanding of the solicitation.

Role of the Solicitation in Proposal Organization

The solicitation plays a key role in proposal organization by establishing the order, required level of detail, and focus of the research narrative. It is a good idea to simply copy and paste the solicitation's key sections, research objectives, and review criteria into a beginning draft narrative. This allows the solicitation to serve as an **organizational template** for the full proposal and a reference point to ensure that subsequent draft iterations of the narrative are **continuously calibrated to the guidelines**. For example, a solicitation will often contain a detailed and extensive description defining the agency's objectives and expectations for the program (e.g., goals, objectives, performance timeline, outcomes, research management, evaluation, etc.) that must be addressed in the proposal narrative. This detail, including review criteria, can be selectively copied and pasted into the first draft of the proposal itself. This statement can provide initial section and subsection headings under which the applicant can draft out preliminary written responses to every requested item in the guidelines, thereby ensuring that the first draft of the proposal fully mirrors the program solicitation requirements in every way.

This copy-and-paste process of transforming the funding solicitation into a narrative template helps ensure that several elements key to a successful proposal are addressed at the beginning, and adhered to throughout the writing process, even though ideas and approaches may change as they mature during the proposal development process. Using this approach, you will ensure that the proposal narrative:

- fully responds to all requested information,
- offers information in the order requested,
- provides the required detail,
- integrates review criteria into the narrative, and
- remains on track and in sequence.

If the solicitation refers to any publications, reports, or workshops, it is important to read those materials, analyze how that work has influenced the agency's vision of the program, and cite those publications in the proposal in a way that illustrates that you have read and absorbed the ideas behind those publications.

Schedule and Task Assignment Table for Proposal Production

A poorly planned proposal has little likelihood of success. Walt Kelly's Pogo once famously observed, "We have met the enemy and he is us!" That observation perfectly fits a poorly planned proposal development effort. But preparation can save you from becoming your proposal's enemy. A well-planned proposal development effort cannot turn ideas of modest importance into ideas of compelling significance, but it can give your ideas a chance to be realized through a well-crafted proposal rather than disguised by a poorly crafted one.

The program solicitation is the starting point for developing a ***Schedule and Task Assignment Table*** (**STAT**) that coordinates the production of an entire proposal, from the cover page to the last page. The larger the proposal, the more critical the schedule and task assignment table becomes to success. For LTGs, the STAT is the organizational linchpin of the entire effort, and a principal factor in potential success.

Moreover, other factors may make the scheduling and tasking of development assignments more difficult and complex. On large proposals, the number of partner institutions involved in the project where subcontracts or subawards need to be negotiated and finalized specific to research and/or educational roles requires advance scheduling. Another layer of complexity may result when subcontracts need to be in place for outreach institutions unfamiliar with the subcontract or subaward process (e.g., K-12 school districts, museums or science centers, community colleges, and other institutions lacking research and grant contract offices).

Fortunately, many LTGs funded by federal agencies operate on annual or biennial schedules, or otherwise announce their deadlines far in advance to allow a well-planned submission process, although this is not always the case. Regardless, as soon as the solicitation becomes available, it needs to be transformed into a development template for the proposal narrative and a corresponding schedule and task assignment table. These will serve as the key organizational documents ensuring that a competitive proposal is developed, written, and submitted to the funding agency on time.

Of course, the first step in this process is demonstrating an established history of successful research that clearly meets the research interests and/or mission of the funding agency as defined in the solicitation. Once the PIs feel confident that a competitive proposal can be developed and make the decision to go forward, then this core team forms the nucleus of the proposal development effort and decides how the core group will expand to bring on board the range of expertise needed to respond fully to each item in the solicitation. When this point in the process has been reached, it is time to start the development of the proposal production infrastructures that will support and guide the effort over the coming months. Representative components of the proposal production infrastructure are described and discussed below. A generic example of a ***Schedule and Task Assignment Table*** is located at the conclusion.

Create a Proposal Narrative Template

The most common reasons funding agencies assign a poor review to a proposal can be traced to the proposer's flawed understanding of the sponsor's goals and objectives as defined in the solicitation, together with the role these play in structuring a competitive narrative that maps the applicant's expertise to the funding agency requirements. To create the narrative

template, simply copy and paste, in detail, the program solicitation's key sections, research objectives, and review criteria into a beginning draft narrative, typically under a proposal section entitled "***Project Description***."

This allows the solicitation to serve as an **organizational template** for the full proposal and a reference point to ensure that subsequent draft iterations of the narrative are **continuously calibrated to the guidelines**. A detailed narrative template is easily constructed in a few hours by a member of the research team, or an experienced grant writer assisting the PI on the proposal. It is then distributed electronically to everyone contributing to the effort and serves as a navigational compass to keep the proposal continuously on course during proposal development meetings and drafts of the narrative.

Create a Schedule and Task Assignment Table

A version of the narrative template will serve as a component of the ***Schedule and Task Assignment Table*** (see following example STAT), particularly since the section of the proposal typically entitled ***Project Description*** functions as the conceptual heart of the proposal. As you will see below, the STAT embeds that critical research narrative in a larger table that lists all information and related documentation requested by the sponsor, assigns a member of the proposal team responsibility for producing and tracking that information, and assigns an internal due date for completion of that task. Internal completion dates will occur well before all of the component pieces of the proposal are assembled into the final document for submittal on, or even better, a day prior to the due date. In the case of the research narrative and other key narrative sections, a series of draft due dates that allow the proposal to ***converge on excellence through multiple iterations and multiple reviews must be scheduled*** .

Moreover, this production schedule for the narrative should incorporate a red team review. ***The first substantive outside review and competitive assessment of a large proposal should be made by a red team, not when the funding agency review panel makes the funding decision.*** The red team process may seem like a brutal ordeal to some, but using a red team willing and able to play the role of a surrogate review panel will prove an invaluable asset to the competitiveness of an LTG.

The research description section is typically authored by the research team of principal investigators, along with contributing authors who may write specialized narrative sections, e.g., evaluation and assessment, commercialization, plan for meeting diversity objectives, and research training for future faculty. A research development professional with disciplinary expertise relevant to the LTG and experience as a team member on many large proposals will prove invaluable to the principal investigators.

In many ways, the production LTG is akin to competing in the Iditarod dog sled race, an often grueling event that can be helped enormously by a research development professional "***who knows the trail***" and can help the PI and coPIs ***anticipate potential pitfalls*** and find a way around them. In the end, a host of pitfalls can degrade the competitiveness of a proposal if not anticipated and corrected. A research professional with experience on many center-level proposals will likely have encountered many of the possible pitfalls and can help alert the research team to them. While those pitfalls may come as a surprise to some on the research team new to center development, they should not surprise a person who has served on the team of many LTGs directed to many agencies over many years and hence possesses a

knowledge base or "corporate memory" of how best to achieve the ***significant competitive advantage that results from a well-planned proposal production effort.***

Identify the Proposal Production Team

The core production team of principal investigators, hopefully assisted by an experienced research development professional, that first develops the narrative template will have to ***expand that team*** to produce the comprehensive *Schedule and Task Assignment Table.* The first team members to be brought on board will likely include ***personnel from your office of research services or sponsored projects office***. They will play a key role in producing the budget, budget justification, subawards, etc., and will carry out various process tasks, such as routing for institutional signatures. **These tasks, and others, are key items in the STAT**.

While the capacities and roles of these offices vary by institution, most institutions will likely provide a core of proposal support services. Selected staff will need to join this planning process and the production team. Proposal support services staff need to become fully engaged early on in the process, and kept in the informational loop on development plans that impact their offices. Don't surprise them with new requirements, if at all possible, and be mindful that uploading a major proposal is a major task that takes time. Research staff should not pay the price for poorly planned and poorly scheduled proposals, ***hence the importance of the STAT***. The STAT, for example, will incorporate the following: Will there be subawards or subcontracts? How many? To whom? Who are the institutional points of contact at those partner institutions responsible for the subaward budget, budget justification, institutional letters of commitment, current and pending support, CVs, etc., ***and who is listed in the STAT as the person responsible for tracking all this***?

Research services offices or OSP staff often take on the task of converting the final proposal file to pdf, if required, and uploading it to the sponsor's designated portal (e.g., Grants.gov, Fastlane), or a hard copy might go in overnight delivery to the sponsor. ***The STAT must account for this "endgame" schedule*** in a way that can **accommodate the unexpected**, or other difficulties, in bringing together all the component sections of the entire document.

Finally, if your campus has an office tasked with research development and grant writing, take advantage of their expertise and experience on prior center proposals, including insights they gained in the review process or in site visit reviews by a funding agency. ***Sometimes knowing what went wrong on a prior proposal can be more valuable knowledge than knowing what went right***.

More on Constructing the STAT

For large center proposals, many members of the production team will need to be ***assigned roles and responsibilities by name in the STAT***, and many questions will need to be asked and answered regarding the team's composition. For example, **the STAT will address:**

- Who is responsible for the first and subsequent drafts of the ***integrative sections*** of the project description section, e.g., executive summary, vision statement, rationale for the center, goals and objectives, research focus areas integration plan, benefits of the center, expected research synergies, etc.? [**This is not a trivial task** and lies at the heart of the competitive research proposal and STAT planning, and it is often nuanced given

that ***your research description is not necessarily the same as a description of the significance of your research.***]

- Are lead authors, perhaps coPIs, assigned for each of the research focus areas?
- Who will write the management plan?
- Who will write the five-year strategic plan?
- ***Does the research team need other support expertise***?
- Who is best able to produce professional-quality milestone charts, graphics, illustrations, tables, and other visuals that complement the text and strengthen the overall positive impact the proposal must make on project managers and reviewers?
- Who will be responsible for reading or quickly reviewing ***all the documents cited by the sponsor in the solicitation***, typically by URL, as having relevance to the program, e.g., agency strategic plans, national academy reports, agency reports and workshops, etc. [***This is a critical role,*** since making competitive arguments for the significance of your research without being fully informed of the agency's research vision, mission, and research investment agenda is ***often a fatal flaw in the proposal narrative***.]
- How will internal references be cited in the proposal?
- Research centers, particularly from NSF and the federal mission agencies, almost always require an ***education and outreach component***. Who will lead that section, and who will serve as contributing authors, e.g., for undergraduate research, postdoctoral mentoring, research experiences for teachers, etc.? Who are contributing authors from partner institutions? Who will be responsible for **assessment and evaluation**? Does the capacity for this exist in-house or will an external evaluator have to be included in the budget to write that section of the narrative?
- If the proposal requires ***institutional data***, e.g., STEM degrees granted in total and to women and minorities by academic department, who will take responsibility for gathering the data and putting it in the format specified in the solicitation? Who keeps the data? Are data kept by colleges and departments, or by an office of institutional research? Are the data accessible to queries that meet the sponsor requests? Who collects data from partner institutions and from whom?

Schedule Development Meetings

The entire proposal production team benefits when the proposal team holds a major development meeting once a week. Specifics of the agenda may vary, but the foundation of the meeting will consist of a review and discussion of progress made during the past week *as it is calibrated to the Schedule and Task Assignment Table*.

Keeper/Monitor of the Schedule and Task Assignment Table

A STAT is of little use if it is not used, monitored, and updated daily so that it can provide a current snapshot of the proposal production status. The responsibility for internal performance expectations related to assigned tasks and assigned schedules ultimately falls to the principal investigator, but it is wise to offload as much as possible of process and production tracking from the PI to an experienced assistant. ***It encourages efficiency and coordination to assign one person the task of tracking all STAT-specific activities***, due dates,

and status reports, along with informing the PI and the research team of the group's progress, particularly should any difficulties arise that could potentially alter the proposal production schedule.

STAT: Identify Lead PI at Each Partner Institution

In addition to scheduling and tasking interaction among research services or sponsored projects offices to coordinate preaward process activities, particularly the budget, the STAT should identify a lead person at each partner institution to ensure that partner contributions are completed on time and reviewed for quality control, particularly for the narrative sections in the project description.

STAT: Identify the Keeper of the Proposal Master File

It is of enormous value to identify one person responsible for (a) continuously updating the ***evolving proposal draft of the project description,*** (b) keeping the most current version of the proposal file organized and identifiable by version number in the file name, and (3) inserting the date/time of each update as the first line on page one, so that an orderly process of continuous revisions can be achieved. This person assists the PI and supports the coPIs to ensure that narrative contributions, graphs, tables, illustrations, and other documentation in the proposal undergoing continuous revisions and improvements by contributing team members get inserted into the master file. This is not a simple task, but it is important to identify a person that can offload this task from the PI or coPIs so that they spend their time and energy developing the research narrative critical to success.

This person needs to be highly skilled in manipulating large text files containing graphics (particularly graphic contributions in various formats), tables, and other visuals that may be embedded in the narrative. ***It is absolutely essential that this person be a skilled user of track-edit and all its features, including document comparisons.*** Many disruptive formatting "gremlins" can sneak into a master file when multiple team members contribute to the proposal using different platforms (e.g., Windows, Macs, or even Linux or LaTeX) or various versions of Microsoft Office. On large proposals, these cross-platform format perturbations can amplify the stress level significantly of the person responsible for keeping one master document and reflecting that status in the STAT.

STAT: Establish Document Contribution Protocols

It encourages coordination and efficiency when the PI, coPIs and the person responsible for keeping the most current master document establish a few simple protocols that every contributor to the proposal narrative will be asked to follow. ***One important protocol involves agreeing on a process whereby track-edit contributions to the master document use an agreed-upon mechanism for accepting or rejecting changes.*** For example, it may be the PI who reviews, accepts, and/or rejects track-edit contributions before they are merged with the master document. In other cases, it may be the coPI leading a research focus area that serves as the gate to changes made to the master document. The specific process is not as important as a general agreement on establishing some process to bring order to what can quickly become a very chaotic procedure if left to happenstance. There is nothing as dispiriting as realizing at some point that two "master" documents may have evolved because of

miscommunications or lack of a clearly understood ***protocol for reviewing and integrating narrative contributions into the master file***.

An important part of the document contribution protocol is that everyone must understand and follow the sponsor's formatting guidelines. The sponsor may specify margins and font size, but not font type. Define internal formatting standards early on in the process to make it easier on the person keeping the master file. ***Resist the urge to think a better proposal can be written were the font size reduced and all white space expunged from the document.***

STAT: Identify Institutional Support Required

Deans and vice presidents for research often seem less than charmed by requests for letters of institutional commitment, cost-sharing, or matching funds that are made on the morning of the day a proposal is due. These requirements need to be included in STAT and tracked, particularly to ensure that someone is responsible for drafting ***letters of commitment that represent actual commitments*** and not just institutional "best wishes."

Example Schedule and Task Assignment Table, STAT

for a Generic Research Center Proposal

Activity	Person(s) Responsible	Completion Dates
Proposal Final and Complete for Uploading	Development Team Final Review coPI Final Review **PI Final Review and Approval for Upload**	***~36 hours prior to uploading as insurance against the unexpected***
Cover Sheet		
Project or Executive Summary, 3 pages [*Note to Project Summary Author*: ***Your research description is not necessarily the same as a description of the significance of your research.***]	Principal Investigator	Draft 1: Draft 2: Draft 3: Draft 4: **Red Team Review**: Final:
Table of Contents	Production Staff (or auto-generates)	
Project Description		

Description of Center Research
• Vision Statement
• Rationale for Center
• Goals and Objectives
  ○ Research Focus Area 1
  ○ Research Focus Area 2
  ○ Research Focus Area 3
  ○ Research Focus Area 4
• Evaluation Criteria for Research Plan
• Research Strategic Plan
• Research Integration Plan
• Expected Research Synergies
	Principal Investigator
	Research Focus Area Leaders/coPIs
	Contributing Authors
		Draft 1:
		Draft 2:
		Draft 3:
		Draft 4:
		Red Team Review:
		Final:

• Research Milestone Chart by Year/5 Years • Research Dissemination Plan • Benefits of Funded Research Center		
Description of Management Plan • Organizational Diagram • Major Milestone Chart • Role of Key Members of Management Team • Description of External Advisory Committee • Strategic Planning Protocols • Steps for Ensuring Cross-Disciplinary Interactions • Research Assessment and Evaluation Plans • Sustainability Plan	Principal Investigator Research Focus Area Leaders/coPIs Contributing Authors	Draft 1: Draft 2: Draft 3: Draft 4: **Red Team Review**: Final:
Education and Outreach • Goals and Objectives • K-12 Engagement Plans • Community College Transition Partnerships • Undergraduate Research • Graduate Training • Course and Curriculum Development • Web-Based Education and Outreach • Workforce Development Plans • Recruitment of Underrepresented Groups • Tracking Student Progress • Evaluation and Assessment • Five-Year Degree Data for all Partners by Gender and Ethnicity • Five-Year Strategic Plan and Milestones	Principal Investigator Research Focus Area Leaders/coPIs Contributing Authors	Draft 1: Draft 2: Draft 3: Draft 4: **Red Team Review**: Final:
Plan for Mentoring Postdocs		Draft 1: Draft 2: **Red Team Review**: Final:
Diversity Objectives		Draft 1: Draft 2: **Red Team Review**: Final:
Knowledge Transfer Objectives • Publications • Technology Transfer • Commercialization • Plan for Intellectual Property • Industrial Collaborations		Draft 1: Draft 2: **Red Team Review**: Final:
Facilities and Equipment Description of Institutional Infrastructure		
Budget , Budget Justification, and Subawards		
Budget	Grants Office/OSP/RS	
Budget Justification	PI or coPI	
Budget and Budget Justification for Subaward 1		
Budget and Budget Justification for Subaward 2		
Other Documents and Appendices		

References Cited		
Biographical Sketches of Key Personnel		
Current and Pending Support		
Institutional Letters of Support and Commitment		
Table of Relevant Research Past Five Years		
Table of Relevant Education and Outreach		
Description of Responsible Conduct of Research and Intellectual Property Rights		
Appendices, Required and Allowed		

Ask Yourself the Right Questions

As the geologists say, "*If you don't ask the right questions, the rock won't answer*." This expression has its analog in the pursuit of research funding. If you don't ask the right questions about yourself, your potential funder, the funding solicitation, the process of identifying funding opportunities, and the process of planning, developing, writing and submitting a successful proposal, then the funding agency is unlikely to answer your request for funding in a positive way. In order to build a successful portfolio of research awards, you will have to satisfactorily answer many of the following questions.

The questions listed below are some of the critical touchstones that will transition you from a research idea to a funded research idea. You must answer some of these questions about yourself and your research readiness before submitting a successful proposal. Others are questions you must ask about the depth of your understanding of the funding agency, research solicitation, review and selection process, and the grant-writing process itself to determine whether you are prepared to write a competitive proposal.

1. **Know yourself (**as Ann Landers once said "***Know yourself. Do not accept your dog's admiration as conclusive evidence that you are wonderful***.")
    a. What are my research strengths?
        i. How do I most effectively characterize my research strengths, expertise, experience, background, and future directions?
            1. Can I do this succinctly, clearly, and simply?
            2. Can I explain my research and make a convincing case for the importance of my research to a scientifically literate (intelligent or "informed" reader) reviewer who is a nonexpert in my field?
        ii. What is the significance of my research expertise to my disciplinary field and can I explain this while citing the appropriate literature?
        iii. How will my research contribute to my disciplinary field or other disciplinary fields and advance them in some important way?
        iv. Is my research disciplinary, multidisciplinary, interdisciplinary, transdisciplinary?
            1. Do I understand how these terms are used by specific agencies, e.g., by NSF?
        v. Is my area of expertise addressed in the agency's strategic plan?
            1. How would my research advance the agency strategic plan?
        vi. Does my research bring value-added benefits to the agency and program?
        vii. Does my research advance the mission priorities of the agency?
            1. Do I clearly understand the difference between basic research agencies (e.g., NSF, NIH, DARPA) and mission-specific agencies (e.g., DOD, NOAA, DOE) and how different agencies characterize value-added benefits?
        viii. Have I prepared a convincing and brief (perhaps one page) white paper that serves as a very concise and clearly stated overview of my research goals, objectives, rationale, experience, and expertise that would be of interest to a potential funder? Also, does this white paper (abstract, project summary,

executive summary, “elevator speech,” etc.) make a compelling case for the value-added benefits my research would bring to the critical mission areas of the agency, or to the research field, or to other research fields?

b. What are my research weaknesses?
    i. Do I lack preliminary data; if so, how will I address that?
    ii. Do I lack publications on the research topic; if so, how will I address that?
        1. Do I lack the appropriate peer reviewed publications that will help convince reviewers of the importance of my research and my capacity to perform?
        2. Are my publications too weighted towards non-peer reviewed proceedings, book chapters, conference presentations, etc. that will leave reviewers unconvinced about the importance of my research and my capacity to perform?
    iii. Do I lack experience and expertise in the field; if so, how will I address that?
    iv. Do I need research collaborators; if so, how will I address that?
c. Do I have a strategic plan for my research?
    i. Where am I going and how do I plan to get there?
        1. Why is it important that I do this research?
    ii. How do I best characterize the significance of my current research/expertise
        1. To my field?
        2. To other fields?
        3. To the agency?
        4. To an agency mission?
    iii. Where will my research be in five years, or even ten or twenty years?
    iv. Does my research require my engagement in “team science” and research collaborations?
d. Can I define my disciplinary domain of interest (e.g., education, engineering, science, social science, humanities, education, health and biomedical sciences, etc.) with sufficient clarity to begin the process of identifying potential funders of my research?
e. Can I clearly characterize the nature of my research interests within my disciplinary domain, e.g., is my research predominantly basic or applied, or perhaps applications or contract based?
f. Have I identified funding agencies whose mission, strategic plan, and investment priorities are aligned with my research interests and expertise;
g. If required, do I know how to develop the research and/or educational partnerships and research collaborations with other researchers in other disciplines or at other institutions needed to be competitive at a specific agency or for a specific program area?
h. Have I gone through the process to further align my research interests with funding agency opportunities by:
    i. Reviewing past funding solicitations by the agency,
    ii. Reviewing abstracts of recently funded proposals by the agency in my disciplinary area

1. Reviewing abstracts (aka project summary or executive summary) of recently funded projects gives researchers yet another source of information about the interests of a funding agency by presenting review panels' and program officers' selections of successful proposals. Reading the abstracts of funded projects will give you a more nuanced understanding of the funding agency culture and expectations specific to a solicitation, or cluster of solicitations, within a disciplinary domain. Abstracts from the two most current past funding cycles are typically the most informative because annual grant solicitations often evolve over time. Most agencies post the abstracts of funded projects on their web sites.
2. Reviewing agency mission statements. Many avenues lead to gaining a more substantive and nuanced understanding of the mission and culture of the funding agency, including:
    a. Visiting the agency web site and reviewing the mission, strategic plans, and research and educational roadmaps of both the agency and the programmatic areas within the agency;
    b. Reviewing online postings of agency reports, presentations, and research and/or educational workshops given by agency program officers;
    c. Talking to colleagues that have been funded by the agency;
    d. Identifying researchers on your campus that have served as agency program officers (e.g., NSF rotators) and talking to them;
    e. Identifying researchers on your campus that have served as reviewers for specific agencies and programs and talking to them;
    f. Reading agency online abstracts of currently funded projects and asking (by email or phone) whether the PI is willing to talk to you about the agency;
    g. Reading current agency solicitations in your disciplinary area and identifying any reports, presentations, or technical workshops identified in the solicitation as motivating the agency's funding of particular research areas;
    h. Subscribing to agency RSS feeds and email alerts that keep you current on new solicitations, reports, presentations, technical workshops, and general agency news related to mission and research priorities.
3. Analyzing the funding agency will help you better understand several key elements common to every competitive proposal narrative:
    a. Who is the audience (e.g., agency program officers and reviewers) and how are they best characterized in terms of the expertise they bring to the review process?

b. What is the best way to address them?
c. What is a fundable idea, and how does it support the agency's research investment priorities, or mission-critical objectives?
d. How are claims of research uniqueness and innovation best supported in the proposal text and how well do they agree with the agency's research objectives, or mission focus?
e. How do you best communicate your passion, excitement, commitment, and capacity to perform the proposed research to review panels and program officers using the language of the funding agency?

iii. Reviewing the agency strategic investment plans, research roadmaps, and related documentation,
iv. Exploring the agency web site,
v. Reviewing agency workshops on funding, e.g., NSF regional grants conferences, or agency webinars specific to a particular solicitation or general webinars on writing proposals to that agency, e.g., DoED/IES,
vi. Reading the agency guidelines on submitting proposals to the agency,
vii. Reading agency guidelines on submitting unsolicited proposals to the agency, e.g., Department of Energy Guide to Submitting Unsolicited Proposals.

2. Know your funder

a. What kinds of research does the agency fund?
b. What is the agency mission(s)?
c. What is the agency culture?
d. What is the agency trying to accomplish with this specific program solicitation, or suite of related program solicitations?
e. How are proposals reviewed at the agency?
f. Who makes the funding decisions?
g. What is the role of the program officer in funding decisions?
h. Talk to the program officer(s), but keep these questions in mind:
    i. Do I have specific, well-thought-out questions I want answered?
    ii. Have I read and reread the solicitation?
    iii. Have I informed myself about the agency's mission and culture?
    iv. Have I informed myself about the mission and culture of the program area?
    v. Have I carefully read information posted to the agency web site?
    vi. Do I have an idea whose fittedness I want to discuss with the agency?
    vii. Do I understand I will not be asking about the likelihood of being funded?
    viii. Do I understand the call will not be a meandering fishing expedition?
    ix. Do I understand I will not be asking questions that are easily answerable by a close reading of the solicitation or documents referenced in the solicitation?
i. Never hesitate to contact a program officer for clarification—any ambiguities in your understanding of the agency mission priorities or in the funding solicitation need to be resolved; otherwise, it will be impossible to write a successful proposal.
    i. Timidity is NEVER rewarded in the competitive proposal process!

ii. Ambiguities are ALWAYS punished!

3. Identify a funding solicitation

a. Develop search protocols to fit your research interests
b. Know relevant agencies likely to fund your research
c. Learn the agency's grant cycles
d. Use agency email alerts and RSS feeds to keep you informed of upcoming funding opportunities and relevant reports, workshops, webinars, etc. that can help you write a more competitive proposal
e. Know the process for unsolicited proposals
    i. Proposals may be initiated in two general ways by the university researcher:
        1. in response to a published solicitation (solicited proposal, RFP, BAA, PA); or
        2. by the investigator (unsolicited proposals and white papers).
            a. ~50% of NSF and ~80% of NIH proposals are unsolicited—learn the process specific to agency
f. Review open BAAs (Broad Agency Announcements) for program funding opportunities and the process for submitting proposals, including such "multigate" review steps as quad charts, white papers, preliminary or preapplication proposals.
    i. BAAs are commonly used by mission agencies (e.g., DOD, DOE, NOAA). They remain open for some period of time, typically a year but often longer. The BAA lists the mission-priority research areas of interest to the agency along with all information needed to submit a proposal in response to the BAA.
g. Consider transagency research funding opportunities
    i. Transagency funding opportunities represent solicitations published jointly by two or more federal research agencies. For example, NSF has published joint solicitations with such agencies as USDA, DOE, DOD, among others, to address key interdisciplinary research areas common to the core mission of the partnered agencies. For example, NSF and USDA have partnered on the research topic related to water sustainability and climate.
h. Keep in mind that a funding solicitation is an invitation by a funding agency to submit a proposal focused on addressing ***research topic areas of interest to the agency***, i.e., your proposal must map tightly to agency mission and bring value-added benefits to that mission. **Bottom line**: it is your task to fit and be fully responsive to the research interests of the funding agency; it is not the task of the research agency to be responsive to your research interests. Moreover, keep in mind that:
    i. The solicitation is a non-negotiable listing of performance expectations reflecting the mission goals and research objectives of the funding agency.
    ii. The solicitation is not a menu or smorgasbord offering you a choice of addressing some research topics but not others, depending on your interest, or some review criteria, but not others.

iii. The solicitation contains or references all the key information you will need to develop and write a competitive proposal that is fully responsive to an agency's mission, for example, the agency's:
    1. submission process,
    2. research objectives,
    3. review criteria, and
    4. budget requirements.

iv. Review referenced documents in the funding solicitation, for example:
    1. Understand funding opportunities at all scales: RFP, Program, Division, Agency, Field, National, etc.
        a. The solicitation resides at the fine-grain scale, but it also resides in a larger context, or scale, of how the agency defines its mission at the larger scales, e.g., the agency strategic plan or research roadmap, as well as at the national level, e.g., perhaps a solicitation starts with a workshop or report from the National Academies on some "grand challenge" research topic and, therefore, your success in writing a proposal to a specific solicitation can be significantly influenced by how well you understand the agency's motives for in investing in the specific research topic.
    2. Reports, workshops, conferences, webinars, etc.
        a. This is a key point to keep in mind because successful grants are those that gain a marginal advantage over the competition. You are always competing at the margins or boundaries of excellence, and to do that well means that every opportunity you have to write a better proposal needs to be fully exploited. Viewing a webinar or reading a report that gives you a deeper and more nuanced understanding of the funding agency's reasons for supporting a program will provide critical information when crafting the arguments you will put forward to convince program officers and reviewers to fund your proposal.
    3. Agency mission, culture, investment priorities, strategic plan, etc.
        a. Agency web sites are now very robust and information rich in terms of helping you better understand the mission interest of the agency.

v. Understand the agency language used in solicitation, for example:
    1. Team science (aka partners, collaborators…)
        a. Complexity of the scientific problem
        b. Disciplines required to solve the problem
        c. Value-added benefits
        d. Integration and synergy
        e. Technology development
        f. Innovation ecosystems (e.g., NSF)

g. Commercialization partnerships
2. Value-added benefits
3. Interdisciplinarity
4. Transformational research
    a. NSF, for example, uses this term to describe a range of endeavors that promise extraordinary outcomes, such as revolutionizing entire disciplines, creating entirely new fields, or disrupting accepted theories and perspectives.
5. Synergy not silos
6. Societal Goals
7. Broader impacts

i. Solicited
j. Unsolicited (investigator initiated)
k. Identify your research and education interests and goals
l. Learn about the types of grants and agencies that fund research in your area
m. Understand interdisciplinarity and team grants
n. Learn how to find funding opportunities that fit your goals and interests
o. Learn how various agencies fund research and education projects, both solicited and unsolicited
p. Understand the agency's investment priorities/mission
q. Learn the Role of BAAs (Broad Agency Announcements) in Your Funding Strategies
    i. They describe the agency's research interest, either for an individual program requirement or for broadly defined areas of interest covering the full range of the agency's requirements;
    ii. Describe the application and submission process, particularly any requirements for approval waypoints, such as quad charts, white papers, preliminary proposals, and preapplications required to be issued an invitation to submit a full proposal;
    iii. Describe the criteria for selecting the proposals, their relative importance, and the method of evaluation;
    iv. Specify the period of time during which proposals submitted in response to the BAA will be accepted;
    v. Designate a Point of Contact (POC) specific to agency research topic areas. BAAs typically encourage potential applicants to contact the agency POC to discuss the relevance of their research to the agency mission priorities before preparing proposals
r. Develop a long-term strategy for funding your research

4. Map your research to agency opportunity

a. Make sure your research fits the research interests of the funding agency, either as defined in a specific solicitation or by fitting a list of agency research priority research topics, for example, as listed in an agency BAA.
b. Talk to a program officer about your research and how well it fits the interests of the agency.

c. Talk to colleagues who have been well-funded by the agency, served as reviewers for the agency, or have served as rotating program officers at the agency to gain an additional insight into how well your research and your "research readiness" maps to the mission of the funding agency.

5. Analyze the solicitation

a. Does my research expertise fit the goals and objectives of a specific solicitation?
   i. How well do I understand the agency goals and objectives in the solicitation?
   ii. Can I address all the research goals and objectives required by the solicitation?
      1. Do I need research collaborators for a competitive submission?
   iii. Am I understanding the solicitation for what it is--***not what I want it to be***?
   iv. Is there sufficient time to plan, develop, and write a competitive proposal?

b. Can I make a compelling case for the significance of my research to the solicitation?
   i. Why is my research significant?
      1. Why should an agency want to fund my research?
         a. Can I explain why my research is exciting and novel?
   ii. What are my research objectives?
      1. Is my research hypothesis-driven?
         a. If so, can I state the hypothesis clearly?
      2. How will my research lead to new knowledge?
         a. Will my research advance the field in some important way?
      3. Is my proposed research based on prior research support?
         a. What were the outcomes of my past funded research?
      4. Do I have preliminary data that bolster my case for funding?
         a. Do I have sufficient preliminary data to be competitive?
   iii. Do I have a realistic research plan?
      1. Can I make clear what I propose to do?
      2. Can I make clear why I propose to do it?
      3. Can I make clear why it is important to do it?
      4. Can I make clear that I have the expertise to do it?
      5. Can I demonstrate that my research plan is believable and not overly ambitious?
      6. Can I present a research plan based on a stepwise, logical approach?
      7. Can I instill in reviewers a confidence in my capacity to perform?
   iv. Is my research basic or applied?
      1. Do I know the difference between basic and applied research?
      2. Is the agency a basic research agency or a mission agency?
      3. Do I know the difference between a basic and a mission agency?
      4. Do I know how this distinction is made at the agency of interest?
         a. Does the agency fund both basic and applied research?
         b. Do I know which program offices at a specific agency fund basic research and which fund applied research?
   v. Am I considering the appropriate agency program for my research?

1. Is there more than one agency program for which my research is fitted?
2. Does the agency accept unsolicited proposals?
    a. Do I know the process for submitting an unsolicited proposal?
3. Have I had sufficient discussions with a program officer to ensure there are no unanswered questions I have about the agency that are key to my competitiveness, and that I have resolved any ambiguities in my understanding of the research funding solicitation, or agency priority areas if I am submitting an unsolicited proposal?

6. Develop a proposal production schedule

a. The end point of the proposal production schedule is the proposal due date and the beginning point is the date you decide you will submit a proposal—these two points bracket your production activities, including scheduling:
    i. Multiple draft iterations of the research narrative (project description)
        1. If there are multiple authors, then draft sections need to be assigned to team members for completion
    ii. Drafting the proposal budget, writing the budget justification, and preparing or managing the collection of related documents, commitments, and other proposal components not part of the research narrative, e.g., cost-sharing commitments, current and pending support, biographical sketches, data management plans, postdoc mentoring plans, letters of support, etc.
    iii. Task and performance assignments for all team members
        1. Good proposal team members do what they say they will do when they say they will do it and provide material of sufficient quality to enhance the competitiveness of the overall effort.
b. A poorly planned proposal has little likelihood of success. Walt Kelly's Pogo once famously observed, "***We have met the enemy and he is us***!" That observation perfectly fits a poorly planned proposal development effort.
c. A well-planned proposal development effort cannot turn ideas of modest importance into ideas of compelling significance, but it can give your ideas a chance to be realized through a well-crafted proposal rather than disguised by a poorly crafted one.

7. Use the solicitation as a draft proposal template

a. Copy and paste the solicitation's key sections, research objectives, and review criteria into a beginning draft narrative as an organizational template for the full proposal. This ensures that subsequent draft iterations of the research narrative will be continuously calibrated to the guidelines and fully responsive to all of the sponsor's requirements:
    i. fully responds to all requested information,
    ii. offers information in the order requested,
    iii. provides the required level of detail,
    iv. integrates review criteria into the narrative, and

v. makes a complete and compelling case for the significance of your research, i.e., why it has value-added impact on the agency's mission.

b. Do I understand how the agency will review my proposal?
   i. Do I understand the overarching review criteria used by the agency?
      1. Do I understand how basic research agencies review proposals?
      2. Do I understand how mission agencies review proposals?
         a. Do I understand the role of mission-critical priorities in the review process?
   ii. Do I understand the program or solicitation's specific review criteria?
   iii. Do I understand the role of the program officer in the review process?
      1. Are reviews binding on the program officer?
      2. Can the program officer consider some reviews advisory only?
   iv. Will my proposal be peer reviewed and by what format?
      1. Will there be a panel review?
      2. Will there be a mail review?
      3. Will some other process be used?
   v. Specific review criteria and review processes differ from agency to agency, as well as by program within an agency, or by type of solicitation. ***But the core, generic questions program officers and reviewers want answered can be simply stated***:
      1. What do you propose to do?
      2. Why is it important—what is its significance?
      3. Why are you able to do it?
      4. How will you do it?
      5. How does it contribute to and advance the research interests of the agency or the field?
   vi. Do I understand "***how to write for reviewers***" and program officers?
      1. Unless you are confident you know otherwise, when writing to reviewers, ***write for the intelligent reader and not the expert***. Remember you are most likely writing to a panel of reviewers, each member of which will be selected for a needed expertise. In all cases:
         a. You must craft a persuasive argument presenting the merit, significance, rigor, and relevance of your research that makes the reviewers want to fund it;
         b. You must convince reviewers you have the capacity to perform, and the institutional infrastructure to support your research;
         c. You must extend your argument to discuss the likely impact your research will have in advancing the field and creating new knowledge, both in your research area and possibly in other research fields as well; and
         d. When writing to federal mission agencies, you must demonstrate to the program managers and reviewers that your research advances the mission of the agency.

2. The author of a funded proposal has accomplished the following basic goals of writing for or with reviewers in mind:
    a. Ensured the reviewers were intrigued and excited about the proposed research;
    b. Understood its significance to the agency mission or field;
    c. Understood that existing research enhances the likely success of the proposed effort;
    d. Understood how the proposed research will be accomplished;
    e. Had confidence in the researcher's capacity to perform.
3. Writing for Reviewers—**Generic Narrative Tips**
    a. Sell your proposal to a good researcher but not an expert;
    b. Some review panels may not have an expert in your field, or panels may be blended for multidisciplinary initiatives, so write to all the reviewers on the panel;
    c. Recall that proposals are not journal articles; proposals must be user friendly and offer a narrative that is compelling and memorable to reviewers;
    d. Proposals are not mystery novels. Reveal the significance of your research early, not at the conclusion;
    e. Reviewers will assume that sloppy errors in language, usage, grammar, and logic will translate into sloppy errors in your research;
    f. Write a compelling project summary (or abstract) and narrative introduction:
        i. This is where you must capture the interest of reviewers and win them over by making them intrigued enough to want to read your entire proposal closely and with interest;
        ii. Define the significance of the core ideas early, clearly, and concisely;
        iii. Describe the connectedness of the core ideas to specific research activities and outcomes, and advance your ideas with sufficient detail to make your research memorable after the proposal is read.

8. Draft the project description

a. Use the solicitation as a template to draft the project narrative;
b. Make sure all members of the research team have read and understand the expectations of the solicitation;
c. Answer in narrative form all the questions asked in the solicitation in the order they are asked;
d. Plan to use graphics, visuals, and milestone charts to complement the narrative text
    i. Narrative text is linear. It is grounded on a logical sequence of explanation made coherent and persuasive by the author's writing skills. Graphics,

however, function as a "***visual language***" able to capture complex relationships in a simple and unifying way by synthesis, integration, and synergy, the holy grail of the successful narrative.

e. The generic underpinnings of a successful research grant include five key persuasive elements: ***the research vision, goals, objectives, rationale, and specific outcomes.*** These five key components are strengthened by preliminary data, results from prior research support, publications in the field, and patents, among other prior performance information that validate your capacity to perform. Depending on the solicitation, these elements may or may not appear in the order described here, but they typically provide the critical mass of the persuasive argument in successful proposals. They also provide clarity through a logically-tiered framework that allows reviewers to differentiate your research at multiple levels of specificity and detail, from the macrovision to microperformance details.

f. Recognize what a successful research narrative **is not**.
   i. A research plan cloaked in a fog of poorly written text.
   ii. A vague research vision lacking focus, or reading, as H.L. Mencken once observed, "*like an army of words marching across the page in search of an idea*."
   iii. A research narrative focusing heavily on general statements about past and planned research, but failing to give details and specifics that help readers understand the importance of the research, or its significance in advancing the field through questions, hypotheses, or solutions.

g. Recognize the elements of a successful research narrative**.**
   i. Starts with an important research idea stated clearly and simply so reviewers can quickly grasp the research questions or hypotheses.
   ii. Explains why your research is unique and supports this with sufficient specificity and detail to make your case.
   iii. Explains the importance, significance, or value-added benefits of your research to advancing the field, or advancing the research mission of the funding agency.
   iv. Provides reviewers with a clear statement of the significance of the project in the form of a precisely written project description supported by specificity and detail.
      1. Specificity grounds the research vision and goals in the key performance details unique to your research objectives, and thereby illuminates the importance of your research for reviewers.
      2. Specifics serve to both test and prove the value of your ideas, and when they are lacking, it tells a reviewer that your ideas may also be lacking, or have yet to become fully developed.
      3. Stating a goal without then offering compelling specifics that make clear the process you will use to transition a goal to reality, i.e., a research outcome, is the domain of politicians and bumper sticker slogans and not that of the successful research proposal.

v. Conversely, generalities often escape many authors' notice, yet appear as glaring flaws to readers and reviewers alike, especially those searching for the specificity needed to make an informed critical judgment on the project's merit. The experience of reading a narrative laced with generalities leaves the reader and reviewer alike with a foreboding and increasingly exasperating sense of uncertainty about specifically what the proposer actually plans to do.
vi. Moreover, ambiguity introduces significant uncertainty into the research narrative, although ambiguity in the narrative does offer one certainty—an unfunded proposal. ***This is because ambiguity in the project description imposes unwanted riddles on program officers and reviewers alike*** that may lead them to believe reading the research narrative is an experience somewhat akin to interviewing Schrödinger's Cat without opening the box to determine its state, either dead or alive. However, narrative ambiguity exists in only one state—confusion.

9. Ask colleagues to critique your drafts

a. Too often, the first – and final – substantive outside review of a proposal narrative occurs when the funding agency makes the funding decision. ***This is too late in the process to ensure success***!
b. Ask colleagues to review your proposal prior to submission and with sufficient time remaining for you to make narrative changes. Let them know upfront that you want the "***brutal, frank and honest***" review option and not the "***nice and sensitive to your feelings***" review option. Ask them to:
    i. Find weaknesses, deficiencies, and ambiguities in the proposal text;
    ii. Identify inconsistencies and omissions between the proposal narrative and the requirements of the solicitation and review criteria;
    iii. Play the devil's advocate when necessary;
    iv. Challenge the vision, assumptions, and other statements in the text that are not well supported or clearly stated, or are poorly argued;
    v. Make observations on the persuasiveness of the arguments you put forward describing the uniqueness of your research;
    vi. Offer suggestions that both correct identified deficiencies in your research narrative and better amplify identified strengths.

10. Converge on narrative perfection

a. The key to a successful proposal represents the outcome of a process of continuous iteration and improvement of the project narrative that, over a sufficient amount of time, ***converges on perfection***.

Part 4, Writing the Research Narrative

Writing the Vision, Goals, Objectives, Rationale, Outcomes
Writing the Successful Project Summary
The Role of the Evolving Proposal Narrative
Starter Templates to Guide Multiple Authors
Do You Have a Narrative Integration Plan?
The Challenge of Integrating Multiple Authors
Integrating PI Experiences from Various Agencies
The Background Researcher on Proposals

Writing the Vision, Goals, Objectives, Rationale, and Outcomes Statements

To craft a successful proposal requires that your research project description address the vision, goals, objectives, rationale, outcomes, and impact of your proposed research on the agency mission and the field. Depending on the specific solicitation, this requirement may be explicit or implicit, but either way, the care with which you address these factors will determine whether or not you persuade reviewers to recommend funding for your proposal. While the definition of these terms may differ somewhat by disciplinary domain or by funding agency, it is helpful in research grant writing to define these terms in ways that best reflect what might be considered the generic narrative structure of most research proposals. Some funding agencies are very prescriptive in defining a narrative structure, such as the U.S. Department of Education, whereas other agencies, such as the National Science Foundation, allow the author greater flexibility in choosing a narrative structure. Typically, however, Large Team Grants (LTGs) prescribe the defining the order, structure, and topics that must be addressed in the project description.

Of course, when a specific agency or solicitation prescribes a required format for a research narrative, then that format must be followed exactly as the sponsor presents it. ***However, in cases where the agency or the solicitation leaves the research narrative structure open or even undefined, something not uncommon at NSF then it is helpful to have in mind your own conceptual framework for best presenting your ideas to program officers and reviewers***. Finally, the generic elements of a competitive proposal discussed herein are scalable, from large center proposals to small research grants, as well as to white papers and concept papers that may initiate an invitation to submit a preliminary proposal that may, in turn, lead to an LTG opportunity.

Regardless where any particular agency or solicitation falls on this spectrum, ***the generic underpinnings of a successful research grant include a sequence of key persuasive elements: the research vision, goals, objectives, rationale, outcomes, and impact.*** Depending on the solicitation, these elements may or may not appear in the order described here, but they typically provide the critical mass of the persuasive argument in successful proposals. They also provide clarity through a logically tiered framework that allows reviewers to differentiate your research at multiple levels of specificity and detail, from the macrovision to microperformance details.

Unless defined otherwise in the solicitation, these ***terms may be self-defined for the purposes of a specific grant,*** since your goal is to define them in ways that assist the reviewers to more clearly understand the value of the proposed research in a logical, stepwise fashion. This understanding should include an overarching vision illuminated by increasingly detailed or finely grained narrative text that validates in detail your capacity to achieve the research vision. Of course, the goal here, as in all strategies to write a more competitive and hence fundable grant, is to make the research narrative more clear, accessible, and memorable to reviewers ***in a positive way***. Unfortunately, as experienced reviewers will tell you, there are also many ways to make your proposal ***memorable to reviewers in a negative way.***

These elements provide a series of sequential waypoints or critical touchstones that, in the aggregate, validate the merit of your research, much like the original touchstone was used as an assaying tool in ancient Greece to determine precious metals and compare unknown samples to those of known purity. Addressing these key elements in your project description

will enable reviewers to "assay" the value of your proposed research compared to that of your competitors. In essence, they form the critical building blocks of a compelling research narrative by ***giving reviewers the structure, order, detail, scale, and perspective needed to easily judge the value of your research***.

In all cases, come to your own working definition of these terms in a way that clearly will help the reviewers understand your research. Think of these terms as ***differentiating tools*** bringing clarity to your research narrative. Don't worry so much about how others define these terms; instead, adopt and adapt them to suit your own purposes. We address below some possible ways to think about these terms with the overall intent of using the key distinctions they provide to improve the quality and hence competitiveness of your project description.

A vision statement typically provides the global, unifying, thematic overview of the research to be accomplished over the proposed funding period and its significance and value-added benefits to the funding agency mission, or to the research field itself. For example, the vision statement might address some ***significant transformation that will occur over the grant period at a particular scale most relevant to your research focus***. This might range from large scale transformations made possible by center-level research funding, or a transformation on a small scale related to a very narrowly focused research question. Regardless, being able to describe your research in an integrated way ***within the defined research boundaries*** described in the specific agency solicitation is an important first step in the sequence of steps you must take to construct a clear and compelling project narrative.

A research vision will typically be better understood by ***defining one or more research goals to be achieved over the term of the award***. The research goals are more specific than the research vision and serve as the major organizing framework for achieving that vision. Goals are defined both in terms of representing one or more research milestones or major accomplishments and in demonstrating how the goals intersect over the performance period. For example, a research center proposal will present an overarching research vision to be achieved by specific research goals that, when integrated over the performance period of the grant, allow research synergy to be achieved in some way. Institutional transformation LTGs, e.g., NSF ADVANCE, IGERT, CREST, among others, all define a vision and then list programmatic goals that, when achieved, make the vision possible. Smaller grants may have only one or two goals. It is also important, given the emphasis on performance metrics and evaluation at federal agencies, ***that you define your goals in ways that render them easily evaluated, both by reviewers and, on larger proposals, by a sponsor's annual performance review***. Don't confuse goals with nebulous wishes. Goals need sufficient clarity and specificity to permit reviewers to evaluate them for their potential impact on the agency's mission, or for advancing the research field in some way, or for accomplishing the broader goals and objectives defined specific to the solicitation.

Once the research goals have been defined, clearly state the ***key research objectives***. Unfortunately, the definition of goals versus objectives can cause organizational confusion in the writing of a project narrative, most often when these terms are used interchangeably. This discussion of the distinction of goals versus objectives can sometimes turn into the equivalent of the arguments posed by medieval theologians asking how many angels can dance on the head of a pin. It is always best not to go down these rabbit holes and simply self-define the terms consistently and in ways that best suit your narrative needs. For research grant writing, if

the terms are not defined in the solicitation, the key is to produce a clear, compelling and easily understood project narrative for reviewers. In this instance, ***defining goals*** as the overarching, longer term outcomes, milestones, or accomplishments of the research and ***defining research objectives*** as the critical operational subsets ***used to achieve each goal*** works well as an organizational framework for the narrative and allows the reviewers to quickly grasp the significance of the research at various scales. For example, research objectives in aggregate define a key research goal; research goals in aggregate define a research vision. The intent here is to provide reviewers clarity. ***The foundation of clarity is defining an organizational framework for the research narrative that allows distinctions to be made easily and in a logical sequence.*** The increasingly finely grained sequence of vision, goals, and research objectives offers one such narrative pattern that can be used to make a proposal more easily ***accessible and memorable to reviewers***.

Moreover, reviewers must ***understand the rationale motivating your research***, such as, why your research idea is a good one; why your research is important and significant; why your research approach will be productive; why your research expertise makes you uniquely qualified to advance the proposed research; why your institutional research infrastructure (equipment, instrumentation, support, resources) will enable your research; and why your research plan is appropriate, effective, and efficient.

Finally, while your research goals address overarching milestones, accomplishments, or outcomes, reviewers will also appreciate a more finely grained explanation of the ***specific outcomes*** of your research in a way that encourages them to clearly understand the value of funding your research. In this regard, it is important to define specific research outcomes in a way that invites a rigorous evaluation of your research performance over the term of the grant or for annual performance reviews on larger grants. Given the emphasis on research metrics at federal agencies, defining and integrating key performance metrics into the research could positively influence your proposal's competitiveness. In some cases, particularly at the research center level or for institutional transformation grants, among others, an external evaluator may be required. It is, therefore, important that the narrative discussion of specific outcomes be stated in ways that make them ***clear and memorable*** to reviewers.

The foregoing steps are not meant to be cast in stone, but to offer a starting point for a framework for organizing the research narrative that will enhance your chances of success.

Writing the Project Summary

One key skill to master as you develop a more robust repertoire of research grant-writing expertise is the mastery of the one- or two-page description of your research objectives and their significance, herein called the ***project summary***. Depending on the agency and the specific solicitation, this brief statement may also be referred to, or serve as, a project abstract, executive summary, research vision statement, project rationale, or as the introduction to the full proposal. In some cases, the agency may dictate precisely the content, order, and format of the summary, while in other cases, an agency may leave its form and content fairly open ended and generic. Often the content, order, and format will be suited to a particular solicitation. Regardless, the common characteristic is brevity, typically a length of one to two pages. This constraint requires that the successful summary statement be clear, succinct, and compelling . Achieving those characteristics requires significant preliminary thought, discussion, and multiple drafts of what will become the final project summary text.

When writing the project summary, keep in mind Mark Twain's comment in his correspondence with a friend: "***If I had had more time I would have written you a shorter letter***." This captures what needs to be done in ***crafting***, as opposed to merely writing, the project summary. This brief narrative statement at the front end of the proposal offers you the best opportunity you will ever have to capture the interest of the reviewers early on as they decide whether or not to fund your project. ***It is here you must convince your reviewers to read the rest of your proposal***—thoughtfully, carefully, and attentively, and with interest and curiosity. If you lose the reviewers here, you have likely left them without reason or interest to read the next fifteen, or twenty-five, or more pages of your proposal.

It is not clear how many proposals Professor Albert Einstein actually wrote, but he certainly understood the ground rules for a persuasive project summary: "***If you can't explain it simply, you don't understand it well enough. Most of the fundamental ideas of science are essentially simple, and should be described as simply as they can be, but not simpler***." This is good advice to take to heart in learning the craft of writing the project summary describing your research and its significance with the simple clarity and precision needed to win over reviewers. You certainly don't want to write a project summary that puts reviewers in mind of H. L. Mencken's comment on an article he reviewed as "***an army of words marching across the page in search of an idea***."

For example, as illustrative of the above quotes, the ***brief project summary below*** was part of a ***successful*** application for ARPA-E funding. These researchers achieved a significant success considering that over 540 white papers were submitted, and of those invited to submit a full proposal, 37 were actually funded by ARPA-E for a total of $100 million in this round, ***57% going to universities***. This summary, and the two other ARPA-E examples, clearly and succinctly addresses the core key questions that must be answered in a project summary, and they are ***easily understood by the intelligent reader who is not an expert in the field***, a common quality of review panel members:

Transformational Nanostructured Permanent Magnets ($2,249,980)

- **What Will You Do** (develop cost competitive next-generation permanent magnets);

- **Why Is It Significant** (demonstrate for the first time a bulk exchange-spring nanocomposite permanent magnet; performance result will exceed the maximum theoretical energy product of the state-of-the-art Nd2Fe14B at 64 MGOe.);
- **What Is Its Impact** (These magnets will enable further market penetration of hybrid vehicles and wind turbine generators, while enhancing US competitiveness in rare-earth mineral based products);

"In this project, we **will develop cost competitive next-generation permanent magnets** with magnetic energy product of at least 80 MGOe and **80% less rare-earth mineral content**. To increase the magnet's energy product, **GE will develop** bulk proprietary nanostructured consolidated and fully dense microstructures and will **demonstrate for the first time** a bulk exchange-spring nanocomposite permanent magnet. This transformational permanent magnet **performance result will exceed the maximum** theoretical energy product of the state-of-the-art Nd2Fe14B at 64 MGOe. The **impact** of these new magnets is to increase the efficiency and power density of electric machines while reducing raw material cost. **These magnets will enable further market penetration of hybrid vehicles and wind turbine generators, while enhancing US competitiveness in rare-earth mineral based products."**

The above example uses 125 words to address the key questions that must be answered for the reviewers, and allows reviewers to quickly grasp the importance of the research. It does this simply and neatly and uses ***language that is accessible to the intelligent technical reader***, not just an expert in the technical area. Most importantly, it is written in a way that ***implants in the reviewers' mind the few but fundamental reasons why the research should be funded***. It also gives the reviewer reason to continue reading the full proposal because it prompts technical curiosity. A project summary crafted to offer reviewers a clear, succinct, and simple explanation for ***what you will do, why it is significant, and what its intended impact*** will be gives your narrative a chance to capture reviewers' interest.

Moreover, a successful project summary can provide the conceptual core, research vision, goals and objectives, and key connective details that will form the foundation of the competitive full proposal. Of course this gets to an issue of how the project summary is developed and written. Some authors create a project summary from a near final draft of the proposal by copying and pasting proposal text into an abbreviated form that responds to the solicitation's project summary criteria. It is certainly important that the crafting of the project summary continue as a series of iterations that converge on excellence until the due date forces the proposal to be relinquished for submission. However, a project summary that evolves with the writing of the proposal project description has many benefits.

The crafting of a project summary can contribute to developing the concept of the research narrative by forging early on the key connective details and structure of all the required proposal sections, which the full research narrative then expands upon. The proposal writing process itself is one of ***iterative exploration*** converging on a compelling and competitive narrative over time, i.e., before the due date. What seems like a "good idea" at the start of this iterative process can disintegrate under closer examination. Verbal epiphanies voiced at research development meetings are deceptive because they lack connectedness and the appropriate balance and synthesis of ideas with the detail needed for a successful narrative.

This ***conjoining of ideas with the performance details*** offers the central challenge to crafting a competitive proposal narrative. Developing continuous drafts of a project summary concurrent with the writing of the project narrative is one way to better achieve the most competitive arguments advanced to convince reviewers to fund your project. Two more examples taken from well-crafted project summaries are given below.

Thermal Energy Storage with Supercritical Fluids ($2,420,802)

- **What Will You Do** (develop a thermal energy storage system which will significantly reduce the cost and increase the volumetric and mass based energy density);
- **Why Is It Significant** (Supercritical storage enables high volumetric energy density);
- **What Is Its Impact** (For high temperature storage the volumetric energy density will potentially increase by over a factor of 2 when compared to two-tank molten salt systems, with a cost less than 70% of the molten salt system);

"Thermal Energy Storage with Supercritical Fluids Two-tank molten salt is **currently the preferred state-of-the art** thermal energy storage for solar thermal power plants. The team will develop a thermal energy storage system which **will significantly reduce the cost and increase the volumetric and mass based energy density**. This team will **develop and implement** a supercritical fluid based thermal energy storage system designed to operate both at moderate (100 – 200 oC) and high temperatures (300 – 550 oC) with a modular single-tank design. Supercritical storage **enables high volumetric energy density** due to the high density of the supercritical state and the ability to provide high temperature storage. The team will **identify and develop fluids with high specific storage capacity and design tanks to enable cost-effective small footprint storage of solar thermal power**. For high temperature storage the volumetric energy density will **potentially increase by over a factor of 2** when compared to two-tank molten salt systems, with a cost less than 70% of the molten salt system."

Optofluidic Solar Concentrators ($500,000)

- **What Will You Do** (Develop a solar concentrator using a novel optofluidic system);
- **Why Is It Significant** (Without any mechanical moving parts, this dynamic liquid prism allows the device to adaptively track both the daily and seasonal changes of the sun's orbit.);
- **What Is Its Impact** (reduces capital costs for concentrating photovoltaics (CPV) and increases operational efficiency… the elimination of bulky tracking hardware and quiet operation will allow extensive residential deployment of concentrated solar power);

"Currently tracking of solar radiation in concentrated photovoltaic systems is provided by mechanical means with multiple moving parts which **raises reliability concerns**. **These systems are also bulky**. Teledyne Scientific and Imaging (TS&I) and its team member, the University of Maryland, **propose to develop a solar concentrator using a novel optofluidic system**. The implementation of the proposed optofluidic system is based on electrowetting. The electrowetting effect controls the contact angle of a liquid on a hydrophobic surface through the application of an electric field. With two immiscible fluids in a transparent cell, they can

actively control the contact angle along the fluid-fluid-solid tri-junction line and hence the orientation of the fluid-fluid interface via electrowetting. The naturally-formed meniscus between the two liquids can function as an optical prism. **Without any mechanical moving parts**, this dynamic liquid prism allows the device to adaptively track both the daily and seasonal changes of the Sun's orbit, i.e., dual-axis tracking. **This innovative technology reduces capital costs** for concentrating photovoltaics (CPV) and increases operational efficiency by eliminating the power consumption of mechanical tracking. **Most importantly, the elimination of bulky tracking hardware and quiet operation** will allow extensive residential deployment of concentrated solar power."

Signs of a Poorly Written Project Summary

The above examples and discussions have focused on the well-crafted project summary. The sample project summaries used here were taken from successful proposals in highly competitive ARPA-E requests. Finding successful project summaries in your specific area of research is fairly easily done by searching on funding agency web sites for information on funded projects. ARPA-E posts successful project summaries, as do other agencies, such as NSF and NIH. These can be used to find models of success in your research domain; however, a well-crafted project summary is generic to any discipline, since the three core questions addressed here that must be answered are fundamental to any proposal to any agency on any topic.

Examples of poorly written project summaries for illustrative purposes are difficult to find, primarily because poorly written project summaries introduce what was likely a poorly written and hence unfunded proposal. Nevertheless, below are listed some ***cautionary signs*** of a poorly written project summary followed by an example of an anonymous and poorly written project summary.

Tell Tale Signs of a Poorly Written Project Summary

- Does not **clearly state** the relevance and impact of the research
- Fails to make a **compelling case** for the **value of the research**
- Disproportionately emphasizes technical minutia over the **significance and impact of the research, or its relevance to the agency mission**
- Compresses technical details to a density impenetrable to all but the author
- Fails to make a composite argument melding and connecting ideas to key technical objectives
- Threads together a series of disciplinary, "cutting-edge slogans," presenting them as the proposed research objectives—***slogans are not ideas***
- Appears poorly organized, poorly written, containing grammatical errors, spelling errors, ambiguity, and weak arguments
- Uses too much jargon
- ***Some authors' curious notion that ideas become more compelling and better understood as the font size is reduced and all white space is expunged from the project summary***

- An author's belief that only a few people are smart enough to fully grasp the ideas put forward in the project summary, and, unfortunately, none of them served on the review panel of the author's declined proposal.

Second Law Optimization Operations Research ($2,355,177)

"The proposed project will transform the boundaries of current operations research related to the optimization of construction schedules on multibillion dollar projects in novel ways by a unique and newly derived theoretical modeling framework allowing our research team to apply the Second Law of Thermodynamics to this transformative vision in novel ways. By the interpretation of the standard operations research critical path model for materials scheduling optimization as an isolated, entropy driven system forced to converge on equilibrium, we can understand operations optimization strategies not only in new and novel ways but as immutably as an empirically validated postulate that will advance the field of operations research in new and novel ways, particularly in terms of societal benefits derived from extraordinary cost savings gained from transformative operations efficiencies. Moreover, by the application of the Second Law to this important topic we will be able to achieve extraordinary calibration of the cesium standard atomic clock to the time sequence optimization models in this proposed 'new paradigm' method."

A reasonable response from a reviewer to the above project summary might be "**Huh?!**"

The Evolving Proposal Narrative

The fundamental requirement of the proposal narrative at the time of submittal is that it be a well-written document that responds fully, clearly, and persuasively to the research goals and objectives and review criteria defined by the sponsor in the funding solicitation. However, long before submitting the proposal narrative to a funding agency, you will find that it ***plays a key role in the conceptual development of the proposed research.***

The proposal narrative development process is akin to a slowly lifting fog, whereby a ***continuous process of draft text iterations*** gradually transforms initially diffuse ideas into a tightly crafted proposal narrative. Equally important, the evolving proposal narrative ***serves as an incubator of ideas***, particularly in the early stages of proposal development, and ***acts as the structural framework,*** imposing rigor, clarity, and simplicity on evolving ideas and concepts and establishing their connectedness to operational and performance details. The proposal narrative process typically begins with a significant amount of (pick your adjective) chaos, uncertainty, vagueness, ambiguity, false starts, and indecision, among many other indeterminacies, concerning how best to meet the funding agency research objectives.

In much the same way as mathematics or a computer program helps impose rigor, relational clarity, logical sequences, and simplicity on our understanding of the behavior of the physical world, language plays a similar role in the evolving proposal narrative. The key point to understand and anticipate is that ***competitive ideas evolve and converge over time; they do not appear fully and perfectly formed by a narrative genie***. Most often the ideas that evolve during the development and writing of a proposal originate in discussions among researchers at research development meetings. Sometimes these "brainstorming" discussions are predicated on and informed by each participant's thorough understanding of the research solicitation (RFP, BAA, FOA, etc.); ***unfortunately***, at other times, they are not. In any case, if it is determined that a solicitation matches the research interests of potential proposers and that a competitive proposal can be written in the time available, ***the path to the end product, a competitive proposal narrative, is often far from clear at the earliest stages of proposal development***.

Bringing clarity to the proposal development process typically starts with ideas, concepts, and directions expressed verbally among researchers related to meeting the research objectives of the solicitation. Depending on the type of proposal, initial discussions, or even "brainstorming" ideas ***initially expressed verbally*** can range from slightly to extremely illusory when attempting the first draft. The real challenge occurs when it comes time ***to translate ideas expressed verbally into the narrative language required to make a compelling case for the significance of the research***. Verbal "understandings" among participants can be both illusory and transitory, ***and multiple participants may carry away multiple understandings*** from research development meetings. In fact, in the initial stages of drafting the proposal narrative, there are often many uncertainties and unknowns about the final research plan that will emerge by the time the final proposal takes shape. This makes the proposal writing process itself one of ***iterative exploration*** converging on a compelling and competitive research narrative over time, i.e., before the due date. What seems like a "good idea" at the start of this iterative process can often disintegrate under closer examination. Verbal epiphanies voiced at development meetings are deceptive because they lack connectedness and the appropriate balance and synthesis of ideas with the detail needed for a successful

narrative. It is this ***conjoining of ideas with performance details*** that offers the central challenge to crafting a competitive proposal narrative.

However, this iterative process of translating ideas into the structure imposed by language in the research narrative serves many important functions—it helps tame the conceptual excesses and unwarranted effusiveness that may occur among some members of a research team at the early stages of proposal development; it helps define the clear boundaries, scale, and scope of the initiative; it sharpens the focus and tightens the descriptions of concepts and ideas; and it forces connectedness among ideas, and between the ideas and operational details that transition and transform ideas to clearly stated research or educational outcomes, or research deliverables.

In effect, the evolving proposal narrative helps transform ideas and anchor them in a ***common reality—the research narrative***—a reality that must be shared by research colleagues, program officers, and review panelists if the proposal is to meet with success. In this regard, a proposal narrative is not unlike a novel or a movie. It creates its own, self-contained reality. It contains all the information that the funding agency and review panel will know about your capabilities and your capacity to perform. With a few exceptions (e.g., site visits), an agency bases its decision to fund or not to fund ***entirely on the proposal narrative and the persuasive reality it creates***. The construction of this common reality through a process of writing and rewriting draft after draft of text helps test ideas in a "***language lab***" in a way not unlike experimentalists test ideas about the physical world.

Moreover, this process of defining a common reality and a common language through multiple draft iterations of the research narrative becomes particularly important in multidisciplinary efforts and collaborations. These situations require a common structure to meld multiple disciplinary research strands, or research focus areas, and to make ideas accessible to collaborators of potentially synergetic but differing disciplines. One common challenge in multidisciplinary research initiatives is the sponsor-required vision statement, or similar integrative and synthesizing statement. The key role of this statement is to unify the research effort and make a convincing case to the sponsor that critical and beneficial synergies inhere in several research strands integrated within one research project that would not be possible were the research strands funded separately as discrete projects to unconnected PIs. ***The crafting of a research vision statement or other unifying statement is as critical to a proposal's competiveness as it is challenging to write***.

However, a common underpinning of the successful research vision statement, executive summary, or research introduction in any proposal is grounded on the capacity of the principal investigators to ***understand that the narrative research description does not necessarily duplicate a narrative description of the significance of the research***. Describing the significance of your research lies at the heart of crafting a successful proposal narrative and this description may well emerge, like the narrative as a whole, through successive drafts.

Starter Templates to Guide Multiple Authors

Larger proposals, such as LTGs, that include multiple research partners pose a particular challenge to the coherence of a project narrative. Individual team members typically contribute individual narrative statements featuring their prior and future research, ***but with little or no recognition of how that research will integrate with other team members' contributions to the proposed project.*** These "stand-alone" statements fail to describe how each research strand complements every other strand, adding up to an integrated set of contributions to the project's vision, goals, and objectives. These individual narrative contributions often do not address the overarching questions that motivate the research, nor do they describe each of the multiple research strands in a context that clearly demonstrates their relationship to the motivating questions or hypotheses, or problems solved.

These typically one- to four-page ***descriptive only*** contributions to a proposal narrative too often resemble a series of isolated numbers comprising the combination to a safe, but lacking the sequence required to open it. In the case of a project narrative, the combination needed for funding must be a ***logically ordered sequence*** of questions, or hypotheses, or perhaps statements of need or problems solved, depending on the agency and type of research, that explain the novel and significant features of the research activities described in the narrative.

The evolution through multiple iterations of a competitive project description is somewhat like a slowly lifting morning fog that gradually burns away as the sun rises higher in the sky. However, as in series calculations that converge, there is benefit gained in finding ways to reduce the number of iterations needed to solve the problem, or, in the case of grants, to produce a competitive research narrative.

One way of reducing the number of draft iterations required to produce a successful research narrative is through the use of proposal and section narrative templates developed by the PI and those research development professionals assisting with proposal development and writing. These "***narrative starter templates***" can be used at any scale (e.g., proposal, section, subsection, paragraph) to help jump start the crafting of first and subsequent narrative drafts of the research and any other required proposal sections, e.g., plans for management, education, dissemination, diversity, and the like.

Initially, however, the solicitation guidelines (i.e., RFP, BAA, PA, etc.) play a key role in proposal organization by establishing the order, required level of detail, and focus of the research narrative in meeting the goals, objectives, desired outcomes, and review criteria established by the funding agency. This is done by a "copy and paste" of the solicitation's key sections, research objectives, and review criteria into a beginning narrative document. This allows the solicitation to serve as an ***organizational template*** for the full proposal. It ensures that subsequent draft iterations of the research narrative are **continuously calibrated to the guidelines and fully responsive to all of the sponsor's requirements**. This solicitation-based proposal template ensures that your narrative responses are complete, answering every question, explicit or implicit, in the guidelines. In this way, the first draft of the proposal will fully mirror the program solicitation requirements.

This solicitation-based preliminary proposal template will create the framework for the final research narrative, but in many cases concerning proposals requiring multiple narrative contributions from contributing researchers, the RFP-based narrative template may still be too

general and require greater detail to help coordinate the structure, scope and specific details required from contributing authors. With sufficient time, planning, coordination, editing, and rewriting, individual contributions to the narrative draft will eventually converge from discrete contributions to a fully integrated and coherent narrative that reads as a seamless document synthesized by one final author. However, the iterative process of editing and rewriting takes time. Any process that can be used by the PI and those assisting with the proposal to reduce the number of iterations it takes to converge on a successful research narrative is always beneficial.

The use of ***narrative starter templates*** that serve as a guide to individual contributing authors helps ensure that the narrative contributions are ordered and structured to reflect the order and structure of other contributions. ***Basically, narrative starter templates can be used to jump start a proposal's convergence on success by identifying a precise set of initial conditions for each text contribution regardless of scale, and communicating them to the contributing authors before they being drafting text***. The operative phrase here is "***before they begin drafting text***."

Creating a final, seamless, and integrated proposal narrative is much more easily done if the person responsible for editing and rewriting the final document is working with narrative contributions with a similar structure, format, order, and logic to the arguments made for funding . This is important in terms of the readability of the overall proposal, and it is a significant benefit to researchers who are assigned responsibility for specific parts of the proposal, or researchers from multiple disciplines whose text contributions ultimately need to be fully integrated in the final proposal to ensure the research narrative does not read like an ad hoc collection of disassociated parts.

The use of narrative starter templates is a good way to guide the proposal writing process and help multiple authors contribute to the research narrative in a more efficient and successful way. Moreover, contributors asked to write a few paragraphs to a few pages to an entire section of a proposal will often have various levels of expertise in research grant writing, or differing levels of familiarity with a specific agency or program area within an agency, or may be less than fully aware of the research culture and mission of a specific agency. They may not know that the agency prefers certain research, education, or management models, or they may be collaborators from other institutions or industry, or they may have been asked to write supporting statements for a proposal.

Regardless, a knowledgeably crafted narrative starter template ***developed <u>specifically for</u> the needs of individual contributors*** can make a significant contribution to the proposal writing process, particularly by ensuring time is not squandered attempting to salvage or begin anew on contributions made to the overall narrative that are not of sufficient quality to ensure a competitive proposal.

Narrative starter templates are easily developed and sufficiently brief (often three paragraphs on one page) to make them quickly available to researchers who appreciate any process that saves them time, helps them better understand what is being asked of them, and makes their narrative contribution more competitive. A unit of persuasive narrative, regardless of size, in this case the narrative starter template, ***will typically be comprised of three key elements:***

- an overview or overarching statement that is inclusive of a vision or goal,

- details and specificity that ground the overview statement on the operational objectives of the specific topic (e.g., research plan, management plan, education plan, diversity plan, dissemination plan, commercialization plan, etc.), and
- a description of the importance, significance, or value-added contributions of the research to a field or an agency mission or a problem.

In most cases, a well-crafted narrative starter template will be grounded on specific questions posed by the sponsor in the solicitation. For example, the NSF Major Research Instrumentation benefits from this process because there are multiple users, ***but not necessarily research collaborators***, of some specific equipment. However, ***all must each answer several key questions specific to their research***, including a description of the research activities to be enabled, research instrumentation and needs, and impact on research and training infrastructure.

By contrast, the NSF Research Coordination Network Program has as its core requirement that "all major organizational collaborations should be described and justified in terms of how each serves the needs or enhances the goals of the network." This is not a trivial requirement, nor one easily answered without a lot of thought, discussion, and integrative planning of draft text by investigators at multiple sites. What both examples have in common, however, is a proposal narrative that will include multiple contributors to various parts of the project description and the development of a narrative starter template can serve to expedite this process.

For example, consider a template drafted for a two-page section of an MRI proposal where the multiple users are required to describe how the instrument will impact the research and training infrastructure. A competitive response to this requirement will be grounded on the detail and specificity each instrument user is able to offer about why the research enabled by the instrument will further the capacity to conduct long term, leading edge research that will impact both education and training as well as contribute to the diversity of the scientific workforce.

The template for this specific section of the proposal will consist of three brief paragraphs: (P1) **overview**, (P2) **details**, and (P3) **significance**. In many cases, the template can be made more robust if an initial draft is written by the PI, perhaps together with a grant writer assigned to the project. This is important because the PI will likely have a deeper understanding of the institutional research context than other users, something important to the section, and the PI and grant writer may have a broader understanding of education, training, and diversity models that have proven effective in multiple settings. In the end, there are only a finite number of models that are then adapted to the institutional context.

In effect, the PI and a grant writer can create the first broad brush organizational outline of the specific section in a starter template. They will follow this with additional narrative responses grounded in the specific section by providing the detail and specificity of the instrument users' research integrated into this template format. For example, if the request was for a transmission electron microscope used in biological and materials research, the user would provide the specificity of how the instrument would be used to enhance student education and training by allowing them to study small details in the cell or different materials down to near atomic levels.

However, regardless of the proposal topic or agency, a starter template is one way of ensuring that multiple contributors to a research narrative take the characteristics of a persuasive, and hence more competitive narrative pattern, to a more finely-grained level of the proposal (i.e., paragraph, page, etc.) than might otherwise occur by just using the solicitation-based template that serves as the overarching outline for the entire proposal. At any scale, the sequence or pattern of competitive text is largely the same, as stated above: (1) **overview**, (2) **details**, and (3) **significance**.

Narrative Integration Plan

It is not uncommon to devote proposal development meetings to specific core sections of a proposal, such as plans for research themes, education and outreach, commercialization, innovation, societal benefits, diversity, and international partnerships, among others. However, plans to ensure narrative integration are less commonly addressed early on in the planning and development process. Unfortunately, integrating the proposal narrative is too often addressed late in the process ***when the lack of integration in a near final narrative becomes a deficiency identified during a red team or similar review process***.

While integrative elements and statements can always be patched into a near final narrative draft under pressure from a due date, this "band-aid" approach is far from the optimum path to a successful proposal, and ultimately may not convince program officers and reviewers that your proposal can achieve the desired synergy and value-added benefits expected, nor answer the core question: "***What are the benefits of funding one large multidisciplinary and multi-PI proposal over funding multiple smaller proposals to single PIs***?"

The ability to craft a well-integrated proposal narrative amounts to much more than a matter of style; it significantly impacts your research success over time. A well-planned and crafted integrative research narrative predisposes a proposal to success in a funding climate increasingly focused on transformative and interdisciplinary research ***occurring at disciplinary boundaries and intersections rich with the potential for technology development, innovation, and commercialization***. For example, under the NSF vision for research and education in the university environment, ***disciplinary and geographic boundaries have become porous as NSF has adopted a global research environment as its benchmark*** [Google Search: *OneNSF* and *Creative Research Awards for Transformative Interdisciplinary Ventures*].

As stated in NSF's [Google Search] *Profiles in Team Science* and the [Google Search] *NSF Science and Technology Centers Report* (2007; 2012), "***Increasingly, researchers are tackling questions that transcend disciplinary boundaries, and federal agencies are creating new models for funding team science.*** Solving "big" problems in science generally requires big teams, big budgets, and a long time frame. It usually involves the collaboration of many different scientists and engineers from a wide variety of disciplines in the context of a research center or institute, which often attempts to integrate research with education, technology transfer efforts, outreach activities, and diversity enhancement programs."

Given this evolving research funding environment***,*** creating an integration plan for your proposal is becoming a key requirement for success. ***An integration plan should be developed early on and should inform the development of all narrative drafts***, not only for the proposed research themes but also for other sections of the proposal. It is particularly important, for example, that an integration plan should inform the writing of the management plan and the development of, for example, a five-year milestone chart for your research. This plan is as important to senior faculty submitting center and center-level proposals as it is to junior faculty submitting early CAREER awards to NSF, DOE, and the defense agencies. On many initiatives, the synergy and value-added benefits of the research described in the project narrative can potentially move a proposal from very good to excellent in the minds of program officers and reviewers.

Creating an integration plan for the research narrative is an effective process for overcoming the common problem that arises when several individual team members

contribute research narrative sections to a proposal ***with little or no recognition of how that research will integrate with other team members' contributions to the proposed project.*** These stand-alone or siloed contributions to the overall research narrative too often fail to describe how each research strand complements every other strand, adding up to an integrated set of contributions to the project's vision, goals, and objectives, and thereby achieving the synergy and value-added benefits required for success. These individual narrative contributions often do not address the overarching questions that motivate the research, nor do they describe each of the multiple research strands in a context that clearly demonstrates their relationship to the motivating questions or hypotheses.

Moreover, it is often the case that proposals ***benefit enormously from the illuminating interplay between a well-crafted narrative text and accompanying graphics.*** The graphical representation of a research vision, or diagrams that show how the component goals and objectives of a large research project relate and interact together to form a coherent, synergized whole, can make the ***proposal narrative less challenging both to write and to read***. Such a graphic developed by the research team as part of a narrative integration plan can also make the writing of the proposal easier by ensuring that each member of the writing team understands the interdependencies of the research disciplines that collectively comprise the overall project.

Given the above, a narrative integration plan can be developed by bringing together those team members responsible for drafting contributions to the project description. Each member can help to define how each research domain intersects, enables, and complements each other to the point where the use of the term "synergy" to characterize the aggregate contributions of research strands in the proposal is no longer a slogan but a genuine operating principle.

For example, flexible and conformal photovoltaic technologies are an area of current research interest in overcoming the limitations of non-flexible, silicon-based PV panel technology. However, contributions to this research may come from several disciplines, e.g., materials science, mathematics and modeling, electrical engineering design, and manufacturing, among others. The goal of the narrative integration plan of such a proposal would be to clarify with team members the ways in which an assigned research section will contribute to the overall goal of overcoming challenges to the technology. What are the inputs needed by one research strand, e.g., design, that are outputs of another research strand, e.g., materials or modeling.

In the end, putting in place a narrative integration plan does not pose a large difficulty; rather, it's a step often forgotten until close to the due date when some keen reader of a draft iteration notices that the key sections of the proposal read more like articles in an edited collection rather than key sections woven seamlessly into the fabric of the proposal demonstrating how sections complement and amplify each other to achieve a common goal.

The Challenge of Integrating Multiple Authors

Larger proposals such as LTGs that include multiple research partners pose a particular challenge to the coherence of a project narrative. Individual team members typically contribute individual narrative statements featuring their prior and future research ***but with little or no recognition of how that research will integrate with other team members' contributions to the proposed project.*** These "stand-alone" statements fail to describe how each research strand complements every other strand, adding up to an integrated set of contributions to the project's vision, goals, and objectives. These individual narrative contributions often do not address the overarching questions that motivate the research, nor do they describe each of the multiple research strands in a context that clearly demonstrates their relationship to the motivating questions or hypotheses.

Too often, these typically one- to four-page ***descriptive only*** contributions to a proposal narrative resemble a series of isolated numbers comprising the combination to a safe, but lacking the sequence required to open it. In the case of a project narrative, the combination needed for funding must be a ***logically ordered sequence*** of questions, or hypotheses, or perhaps statements of need, depending on the agency and type of research, that explain the novel and significant features of the research activities described in the narrative.

Descriptions of research activities or capacities improperly sequenced and explained within the overarching context of a research vision, goals, and objectives ***turn the narrative into something of a mystery for readers and reviewers.*** You don't want reviewers noting to themselves and other review panel members after reading the research narrative "*it is not at all clear why all these descriptions about various research capacities are important and what exactly this research team intends to do*." However, this will be the result if the research narrative evolves, to use the current vernacular, as a collection of "***stove-piped" or "siloed" contributions by multiple authors.***

For example, a proposal addressing an issue related to sustainability may be comprised of research team members from geosciences; physical, biological, and agricultural sciences; engineering; computational sciences; and the social and behavioral sciences. Perhaps the research focus is on the sustainability of a coastal ecosystem impacted by climate change. In this case, it is easy to envision multiple research contributions by those with research expertise in climate, water, modeling, sensors, coastal biology, social and economic impacts of sustainability on affected stakeholders, and research expertise on one or more species in the coastal estuaries that serve as indicators of ecosystem health. Moreover, it is easy to see how researchers in one of the foregoing research areas important to the sustainability of coastal ecosystems may be tempted to write their narrative contributions as "***siloed text.***"

This will most likely occur when the vision is still evolving as the research contributors draft their narrative contributions, or when the overarching questions motivating the research have yet to be fully defined, or are in the process of being re-defined. ***The vagueness or incompleteness of the research vision can increase the likelihood that a first full draft of the proposal will read as a series of siloed statements unintegrated with one another***.

Moreover, it is often the case that the ***research team members attempt to do too many important tasks simultaneously but in isolation from each other.*** In these cases, finding time to draft text is often difficult enough, let alone adding the requirement of reading and considering others' contributions. This difficulty can be compounded by electronic

communications among team members that fluctuate between periods of silence punctuated by a cascade of electronic messages, often including drafts of graphics, figures, and multiple track-edited versions of an evolving project description that can quickly become a blizzard, or rainbow, of track-edit colors.

These issues all cry out for an orderly resolution grounded on a well-crafted proposal development schedule. This planning tool will help meld the vision and goals of the project and communicate them continuously via a defined production timeline to all of the contributing authors. This will better ensure that the text evolves in a way that not only describes the importance of each research-specific strand or research contribution but also describes how it interrelates with every other research strand included in the project description. It is not an easy task, but this integration holds the key to success. The team is well advised to find someone among its own members or from a campus research office who can ***assist the PI in bringing informed coordination to the proposal development process.***

Another pitfall of a multiply authored research narrative or project description lies in writing these ***statements as if the authors were contributing to an edited collection or a journal issue rather than to the single, integrated statement*** identified as the research vision. This occurs most often on multi- or trans-disciplinary proposals that evolve ad hoc rather than from a well-planned proposal production schedule, or when the decision to submit these complex proposals occurs only a month or several weeks before the due date. In this last case, the proposal schedule can lead to a "fire drill" in which potential new research partners are added concurrently with the writing of the first drafts of the research narrative.

These situations can produce several drafts of the project description at a rapid rate as multiple contributions are added to the narrative. The complete draft of the project description may give the illusion of completeness***, but on closer examination lacks an overarching organizing theme or research vision that synthesizes the component contributions resulting in a coherent and logically sequenced whole***. Correcting this document after it has evolved can be difficult; unfortunately, such a draft is likely to amount to ***nothing more than a siloed collection of research descriptions*** loosely associated and lacking a narrative thread that can persuade reviewers of its coherence. Once a complete narrative structure has emerged, contributors resist making major renovations to it. However, if the collaborators understand that the first full draft of a research project narrative is best viewed as a preliminary set of loosely associated descriptions, then the principal investigator can call for major revisions designed to produce a more integrated statement.

Indicators of a failed narrative, or a weak narrative, may reveal themselves sufficiently before the due date to allow the time and effort required to transform a weak narrative into a competitive narrative. Perhaps the best indicator of a weak complete first draft of the research project description begins with a nagging sense of unease after reading it. It doesn't seem to convey a clear sense of what specifically is being proposed, what questions are being asked, or hypotheses posed, nor does it explain why the research is unique, innovative or advances the field in some way. It may also fail to convey a sense of how the multiple research descriptions meld to an integrated whole. ***Another indicator of a failed or weak narrative is a difficulty in clearly explaining the significance of the project and its outcomes after closely reading the 15 or 20 pages or 40 or more pages describing it***.

It is a mistake to assume that your sense of uncertainty and vagueness following the reading of the proposal indicates a lack of technical expertise to critique the narrative, i.e., that the fault lies with the reader and not the writer. Two good reasons to dismiss that thought implicate both you and the proposal author(s): (1) federal research agencies, particularly the major ones that most often comprise the overall research portfolios of universities, advise writing the research narrative for the intelligent reader, not the expert reader. NSF, for example, advises writing to the reader of *Scientific American*, or the scientifically literate reader. (2) Moreover, research agencies that fund large, often transdisciplinary proposals, will have blended review panels comprised of members from various disciplinary backgrounds, including the social and behavioral sciences and, in some cases, the humanities. Research collaborators must describe their research in a way that convinces the entire review panel, not just those from specific disciplinary domains, to recommend the project for funding.

So if you are asked to critique a proposal, ***do not hesitate to note when you do not understand clearly what is being proposed***, or when the project's goals and objectives appear ambiguous. Recall Professor Albert Einstein's observation that put a heavy burden on scientific authors: "*If you can't explain it simply, you don't understand it well enough. Most of the fundamental ideas of science are essentially simple, and may, as a rule, be expressed in a language comprehensible to everyone*." The bottom line: ***When proposals lack clarity, the fault lies with the author and not a review panel***. In practice, it is better to be presented with a challenging critique and penetrating questions in response to a draft project description than to hear those challenging critiques and penetrating questions from a review panel and program officer. In this case, your ***second chance is likely to occur one year in the future when a re-submittal is possible.***

Of course the best solution to the above issues is to formulate a plan for the proposal's production that anticipates such core issues as partnership configurations, vision, and goals in a logical sequence that allows time for a draft narrative of the project description to evolve continuously . A poorly planned proposal has little likelihood of success. Walt Kelly's Pogo once famously observed, "*We have met the enemy and he is us*!" That observation perfectly fits a ***poorly planned and poorly coordinated*** proposal development effort. But preparation and continuous coordination and communications can save you from becoming your proposal's enemy by avoiding the issues discussed above. A well-planned and well-coordinated proposal development effort cannot turn ideas of modest importance into ideas of compelling significance, but it can give your ideas a chance to be realized. A well-crafted proposal will anticipate continuous revision to ensure that the project as a whole includes and exceeds the sum of its individual contributors.

Integrating PI Experiences from Various Agencies

In today's funding climate, many researchers will be transitioning from writing grants with a single or small number of investigators addressing narrowly defined disciplinary topics to writing larger, interdisciplinary or center-level grants under the umbrella of team science. As these new collaborations form, team members may discover that while some of them have gained funding experience at the agency to which the current effort will be submitted, others have not.

This is a natural outgrowth of a research climate in which solicitations increasingly address more challenging research questions of importance to a funding agency. For example, the [Google Search] National Academy of Engineering's 14 grand challenges for engineering in the twenty-first century and similar documents have prompted solicitations from various agencies addressing these complex research topics. Many research agencies identify their own research grand challenges and advance them through targeted solicitations, such as [Google Search] DOE's Office of Science five grand challenges related to matter and energy. These grants typically feature a scale and scope, as well as funding levels and funding periods, larger and more expansive than those with narrower disciplinary bounds.

In this time of transition from more to less bounded disciplinary exploration, the entire research team stands to benefit from a discussion of the nature of each member's experience with the funding agency's mission and culture. A close understanding of that mission and culture should underlie team members' decision of how best to define and describe the project's vision, goals, and objectives in the research narrative. While the PI and some other research team members may have varying degrees of funding success at the specific agency, it is not uncommon that other members of the team have little or none. This uneven spread of experience among team members can be anticipated as a natural outgrowth of solicitations more frequently requiring a transdisciplinary team configuration.

With this in mind, the team might consider beginning its work with an explanation of the agency's mission and culture presented by those team members who have gained the most experience with that agency. This presentation will convey the most benefit if it occurs before team members have begun drafting their respective sections of the research narrative. In preparing this overview of the agency's mission and culture, the presenters will want to stress the important ways in which the mission and culture of the agency in question differs from the mission and culture of other research agencies where some members of the research team have achieved most of their funding success.

Taking this step will give the team a strong advantage when you consider that a competitive proposal undergoes several key development stages, each of which depends upon each team member's complete understanding of the solicitation in the context of the funding agency's mission and culture. This understanding begins with a reading of the solicitation through the lens of the agency's unique purpose. Insufficient understanding of the agency's particular mission and culture can lead to an insufficient understanding of the solicitation itself, a common Achilles' Heel of unsuccessful proposals. Further, in cases where several members of a research team lack knowledge of the agency's mission and culture, development discussions frequently veer off track or fail to adequately target key aspects of the solicitation, or they fundamentally misinterpret the solicitation. This can make development discussions difficult and time consuming.

For example, suppose a research team has been configured to address some grand challenge area, perhaps sustainability and water, in an NSF solicitation. Perhaps the PI is well funded at NSF, and maybe a few other members of the team are as well, but several other members of the team have no experience with NSF but extensive experience in the topic at such mission agencies as DOE, USDA, and DOD. Perhaps the team also includes one or more members from such disciplines as the social and behavioral sciences, public policy, economics, or communications, among others.

Before beginning discussion of the scale, scope, and proportional contribution each discipline will make to the overall effort, and before discussing how those disciplines must be integrated to achieve a synergistic vision, the leaders must begin by defining a common language for the entire research team. The founding of a common language responsive to a specific solicitation will emerge from all team members' understanding of the mission, culture, and language of a specific funding agency. Without this common language based upon a common understanding, some members may misjudge and consequently poorly express their contribution to the line of research being proposed. In such cases, team members are likely to revert to language appropriate not to the current agency but to agencies with which those members have had previous experience. Setting out a common understanding and common language for that understanding as a first step in the team's collaboration may head off a member's tendency to draw upon familiar but currently inappropriate terms and concepts in drafting their contribution to the emerging narrative.

Given the amount of time that will be required to develop the research ideas and to write the proposal, it is important to minimize the unproductive time spent during that process by ensuring that all team members begin the collaboration with a thorough understanding of the sponsoring agency's mission and culture expressed in a shared language. The key points to include in presenting that mission and culture include such factors as noting the type of research funded by the agency (e.g., basic or applied), characteristics of the agency's merit review process, partnership configurations and characteristics that have proven to be most competitive at the agency, and the scope and scale of interdisciplinarity at the agency, among others. The key point is to understand these issues in the context of the particular agency that will fund the proposed project and not as an artifact of a team member's experience of these factors viewed through the lens of prior success at a different agency with a different mission and culture.

It is helpful at the start of developing and writing large LTG proposals to ***spend time differentiating the mission and culture of the sponsoring agency from those agencies at which various members have experienced success***. Arriving at a common understanding and language for describing the mission, culture, and investment priorities of any funding agency, as well as research program areas within an agency, positions a team to achieving competitiveness at that agency.

The success of a large inter- or transdisciplinary proposal can be undermined when team members assume that their success at one agency can be applied directly to another agency with a distinct mission and culture. Obviously, the preponderance of the research experiences gained by some team members at one agency on a topic such as sustainability and water will likely transfer in large part to another agency, say from DOE or USDA to NSF. But some smaller portion will not transfer, and since proposals are successful that approach

perfection, it is important not to confuse agency expectations by ensuring that every team member shares an understanding of and a language for appealing to the particular agency sponsoring the proposal under development. In this way, the team can enhance the competitiveness of a proposal by fitting the research narrative closely to the mission, culture, and solicitation requirements of the sponsoring agency.

The Background Researcher on Proposals

Many LTG solicitations reference documents, reports, technical workshops, conferences, and the like, either internal or external to the funding agency, that form the underpinnings for the agency initiating and funding the research program. This is particularly the case for large, research center solicitations sponsored by NIH, NSF, DOE, DOD, and NOAA, among others, that represent major agency investments over five, ten, or more years, in topic areas critical to the agency mission. Reviewing and understanding the often numerous documents referenced in a solicitation can be a time-consuming but important task. Such a review can give the researcher a competitive advantage in a well-written and well-argued research narrative. Researchers often overlook this opportunity to enhance their competitiveness by hesitating to invest the time it takes to review referenced documents and cite them in their own research narrative where such references can bolster the case for funding.

Of course, references cited in the solicitation by the funding agency play an altogether different role in the research narrative than do the references to cited articles authored by members of the research team. These can convince program officers and reviewers of the experience and capacity of the research team to perform. Clearly, references to cited articles authored by team members, particularly those demonstrating a history of collaboration, are the more valuable. But arguments woven into the research narrative demonstrating the research team's understanding of its research within the broader context of the funding agency's motives can provide an additional competitive advantage in the review process.

After all, all grants, but particularly center-level and center grants, are highly competitive and so every opportunity must be taken to gain every possible competitive advantage, both large and small. While a brilliant idea and the capacity to implement and manage the research forms the essential core of a successful proposal, a multitude of other competitive advantages must be seized to ensure success in a highly competitive environment. ***No competitive advantage is too small to ignore in planning, developing, and writing a competitive proposal***.

An informed understanding of all the referenced documents in the research solicitation is one such area that offers another way to write a more complete, and hence successful, project description. Given this, someone needs to assume this role, particularly in the case of solicitations in which the funding agency embeds significant background references. This task can be performed by someone on the research team or by an experienced research development staff member. Regardless, the person in this role must have the capacity to ***translate a review of the documents referenced in the solicitation in a way that extracts relevant knowledge that can then be woven into the project narrative*** to clearly demonstrates the team's nuanced understanding of the role their research can play in advancing the goals and objectives of the funding agency.

While many possible ways can be found to determine who might best play the role of researching the solicitation references for relevance to the research narrative, it is important that this role be fulfilled. The selected person should pursue this information early in the planning and development of the proposal so that the results can be seeded into the research narrative to make the project description stronger and better argued. Failing to perform this step represents a potential competitive advantage lost.

Part 5, Other Narrative Components

Writing a Successful Project Management Plan
Writing the Project Sustainability Statement
Evaluation Resources on the Internet
NSF Broader Impacts
The NRC, a Partner for Writing More Competitive Proposals
STEM Learning and Activity Models for Proposals
Social Science Components of NSF Proposals
Preparing Letters of Support and Collaboration
No Squishy Commitments or Weasel Clauses

Writing a Successful Project Management Plan

The management plan plays a critical role in an LTG's overall competitiveness. Moreover, in the LTG context, the management plan typically includes a multiyear research strategic plan and milestone chart that clearly lays out a path to meeting the research goals of the project. A management plan must convince program officers and reviewers that a funded project will be consistently and carefully managed and will meet the sponsor's research expectations. Before drafting a management plan, it is important first to understand what the sponsor expects of such a plan, which is often described in detail in the solicitation. It is also important to think about how your management structure will bring added value to a project by helping meet the proposed research goals, objectives, expected outcomes, and other performance metrics that validate a sponsor's investment in your research.

Moreover, effective management plans may vary widely by program type and by funding agency. However, in all cases, you must address the funding agency's fundamental expectation that the proposal demonstrates your capacity to perform. The management plan offers an opportunity to instill confidence in both agency program officers and reviewers that you will function as an effective and efficient steward of an agency's research investment. While the research plan (vision, goals, and objectives) of the proposal must address the significance of your ideas, the management section must make a compelling case that project resources will be well managed, thereby ensuring the full realization of your research ideas and, simultaneously, the satisfaction of the funder's expectations for the program.

Ultimately in LTGs, the management plan plays a very significant role in determining the proposal's success. An agency would no more invest in an LTG with a poor management plan that you would invest retirement savings with a poorly managed financial institution. When the management plan is well considered and well crafted, the full research narrative achieves a completeness that inspires in program officers and reviewers a confidence in your capacity to perform, and hence, a willingness to invest in your ideas.

PIs transitioning from smaller grants requiring less rigorous management plans to LTGs requiring detailed and comprehensive management plans will want to guard against the perception that this section of the proposal can be treated as an afterthought in relation to the proposal's other narrative sections. If the PI does not write the management plan, then the person assigned that task, perhaps another member of the research management team, or an experienced grant writer working with the PI, should draft the plan in continuous consultation with the PI. It must appear clear to program officers and reviewers that the management plan optimizes both your efficient use of agency resources and the potential inherent in your research ideas.

Weak management plans often lack contextual specificity. This results in a management narrative that appears disconnected from the research vision, goals, and operational objectives. Another sign of a weak management plan appears when the plan fails to reflect the proportional continuity of the proposal's budget, especially within the budget justification narrative. In the worst scenario, the research plan, management plan, and budget justification sections are essentially stove-piped or siloed statements, written as stand-alone sections that fail to explain how they connect to achieve research and operational synergy. A robust narrative synthesis of these key sections of the proposal must be provided to achieve success in LTG proposals.

Weak management plans occur when members of a proposal development and writing team treat them as nothing more than generic boilerplate text easily transplanted from old proposals to current ones with a few minor adjustments. Attempts to find "spare parts for proposals" salvaged from prior efforts that now populate the "grant-writing cloud" are ill advised.

A successful proposal grows from the seed of a compelling and exciting research vision. Every required proposal component that evolves from that vision must do so in an internally integrated manner that adds a logical synthesis, and hence strength, to the core research vision. Attempts to transplant a modified management plan from an existing project into a new proposal will most likely weaken both the management plan as well as the overall proposal. Writing a successful project narrative requires many thoughtful iterations of each proposal section that reveal to the reader the relational symmetry of one section to another. ***The well-written and convincing management plan must clearly evolve to reflect and serve the needs of your specific research vision and the performance metrics required for your success.***

So it is important to beware the notion that a management plan can be a largely borrowed or heavily modeled statement based upon other proposals, or a tattered template shared "in the grant-writing cloud." ***There are not enough immunosuppressant grant-writing techniques available to disguise such "borrowing" from the astute reviewer***, particularly given that the good program officer and reviewer will function as the immune system of a proposal under consideration. If they detect a transplanted management plan, they should reject it.

Those considering an LTG submission are well advised to become a judicious reviewer of best practices in writing the management plan for a specific proposal and a careful interviewer of the PI or members of successful management teams, particularly those funded by the agency and program for which you are preparing a submittal. For example, one short-term test of a well-designed management plan lies in determining how well it functions during the first six or twelve months of a new project, often considered the project start-up period. The start-up period of a large research or educational program can often require some level of adjustment in the face of operational realities not anticipated by the proposal. Or, as General Colin Powell observed once, "*everybody has a plan until they are shot at*."

It is helpful, particularly for new PIs or PIs transitioning to larger and more complex LTGs, to take advantage of ***best management practices*** that have evolved over time as part of long-standing center proposals under specific programs or at specific agencies. In many cases, these best practices represent a partnership over time between the directors of major research centers and the funding agency to find the most effective operational models for specific research domains. For example, if you are submitting a center-level proposal to NSF, it will be helpful to familiarize yourself with the [Google Search] **Engineering Research Centers Association**, especially the **ERC Best Management Practices Manual**, and the **STC program,** because many NSF programs beyond just the ERC and STC require a management plan to include program components related to such areas as education, diversity, and technology transfer, among others.

Large proposals from several federal agencies often require the management of knowledge transfer across various research, education, and societal domains. But reviewing best practices will be insufficient if the review is not conjoined to the PI's demonstrated track

record of successfully managing prior research projects of increasing size and complexity. In the case of very large grants from federal agencies, the successful PI will likely be a senior faculty member highly recognized for research, leadership, and management skills. If you are a more junior faculty member, begin developing a management track record on research grants that will position you over time to compete for LTGs.

Writing the Project Sustainability Statement

Often LTG solicitations will ask applicants to "*Describe how you will sustain program activities after the award period.*" Agencies typically require applicants to address this issue in the project description. It is not a trivial request, nor one to be taken lightly, ***nor one that can be addressed with fiscal smoke and mirrors***, although too often that bit of legerdemain is attempted. Answering this question superficially will only serve to annoy reviewers and program officers. It is also a difficult question whose simplest answer can rarely be given: "The president [or dean] commits to sustain the program after the grant period at the same level of funding provided under the grant by including the program in the base budget of the university [or college] for a period of at least N years."

Unfortunately, base budget allocations at most universities remain tight, often undergoing reductions by state legislatures, increasing the fierce competition for budget allocations within universities. As a consequence, coming up with a sustainability plan for a project after the grant period has ended requires some thinking. This puts you in a position similar to that of nuclear physicists after WWII when funding for the Manhattan project ended. Nobel Laureate I.I. Rabi famously told his Columbia physics lab colleagues, "Our budget has been cut and there is no more money for experimental equipment. ***So now we are going to have to start to think***."

Fortunately, researchers can often find some programmatic wiggle room when writing a sustainability statement, and most agencies and foundations do not expect a program to continue forever as a perfect clone of itself after the grant period expires. In fact, some research center solicitations do not require a sustainability plan on the grounds that the research conducted under a five-year award and an additional five-year renewal award should sufficiently address the research questions of interest to the funding agency.

In most cases, project descriptions requiring a sustainability section are specific to a solicitation and require a response unique to that program. The scale of a project will often determine the sponsor's expectations of a well-crafted sustainability plan. However, as in many areas related to strategies for writing competitive proposals, applicants can take a generic approach, as described below, to developing strategies, plans, and activities for a convincing sustainability plan.

Of course, the most important rule to follow in writing a sustainability section is to give it the detailed attention it deserves as one of many sections of a project description that, in aggregate, will give your proposal a competitive advantage. Don't waste your time wondering how much weight a sustainability statement will be given in the final award decision. In some cases it may be significant, and in other cases less so. Regardless, it is always best to assume that if a sponsor asks applicants to address a particular topic in the research narrative, then the wise author will respond fully to that topic, crafting a reply as close to perfect as is possible. If the funding agency were indifferent to how well you respond to a specific question, then it would not ask the question.

Moreover, avoid treating the sustainability statement as an afterthought to be addressed in the final days of completing the research narrative. ***Don't write it as boilerplate***. Thinking of any component of a project description as boilerplate is a recipe for failure. After all, proposals represent the quality of your ideas. If a solicitation requires a sustainability and commitment statement, then that statement should be grounded in your ideas of how best to

sustain the project's goals and objectives after the grant period. The development of the sustainability statement should align itself with the other core elements of the proposal. The core goals and key objectives of any particular project will need to be addressed in a sustainability and commitment statement, or what is sometimes called a project continuance plan.

As a first step in developing a sustainability statement, ascertain the sponsor's expectations. In some cases, the solicitation may be very specific in describing the precise activities that need to be sustained; in other cases, the sponsor may be more general, leaving it up to the applicant to complete a sustainability plan that fits the particular program's longer-term goals and objectives.

It may be appropriate in the planning, development, and writing of a proposal that requires a sustainability statement to ***develop a strategic plan for sustainability*** that identifies the program goals and objectives that need to be sustained. These goals and objectives then need to be mapped to institutional resources that will be available after the grant period to ensure continuation of key program activities. There are often a broad range of institutional resources and program linkages of potential use in continuing key program activities after the grant period, including:

- incorporation of some project activities into a base budget;
- commitment of staff time;
- continuation of space commitments made during the grant period, or new space commitments;
- access to equipment and instrumentation;
- institutional support in seeking other funding opportunities from federal agencies and foundations, industry, or university donors;
- adoption of project goals in strategic plans and mission statements;
- institutionalizing project goals, e.g., changes to community, culture, and climate developed under a diversity project, or adoption of new courses developed as part of a research program;
- developing institutional partnerships and collaborations that allow the integration of key project components into existing institutional infrastructures;
- identifying institutional "administrative champions" that support the project's goals and objectives and will work to sustain them.

Some guidance on developing sustainability plans can often be obtained in agency reports and other program documents. For example [Google Search]*, Results from the Best Practices for IGERT Sustainability*, a report by the Center for Innovation and Research in Graduate Education, University of Washington (2007), based on 20 interviews with 19 IGERT PIs, showed that programs were most successful in attaining sustainability if they managed to be integrated early on in wider campus initiatives and fostered close ties to disciplinary home departments. Similarly, the NSF Engineering Research Centers most successful in achieving sustainability after NSF funding included the following characteristics in their plans, according to the NSF commissioned report [Google Search] *Post-Graduation Status of National Science*

Foundation Engineering Research Centers, Report of a Survey of Graduated ERCs (January 2010), SciTech Communications LLC:

- Broad involvement of faculty, staff, industrial partners and university administration in transition planning;
- Institutional factors---degree of university commitment, extent to which the center is prized and whether or not the center's policies support cross-disciplinary research and education;
- Education program sufficiently valued by faculty and students that it will be maintained;
- Commitment and interest of core group of faculty;
- Active industrial support and continuation of industrial membership and industrial advisory board guidance;
- Effective implementation of a realistic transition strategy that builds on and enhances the center's strengths.

However, the most critical component of a successful sustainability plan is that the leadership and management of the project during the grant period be exemplary, and that the core goals and objectives of the project align themselves with the institutional mission, strategic plan, and vision. In this regard, keep in mind the old adage that "success has many sponsors, but failure is an orphan."

The biggest contributor to a successfully sustained program is that it be grounded on a successful program.

Evaluation Resources on the Internet

Program evaluation and assessment requirements defined in federal agency research and educational grant solicitations commonly responded to by universities ***are becoming increasingly rigorous, particularly on many LTGs.*** This is evident from [Google Search] the July 29, 2010 OMB Memorandum for the Heads of Executive Departments and Agencies on **Evaluating Programs for Efficacy and Cost-Efficiency.** This followed [Google Search] the earlier 2009 Memorandum **Increased Emphasis on Program Evaluations** on the same topic**.** The core message in each memo was the requirement that federal agencies show that their Fiscal Year 2012 funding priorities **are evidence based or otherwise subject to rigorous evaluation**.

The take away message here is that funding agencies will increasingly expect that appropriate evaluation metrics be applied to both research and educational grant programs to justify those investments. And the larger the investment, such as LTGs, the more rigorous are the evaluation requirements. Evaluation protocols for a broad range of large university grants, particularly educational grants, hybrid research and educational grants, and institutional transformational grants (e.g., NSF ADVANCE), have evolved dramatically over time from simple input/output models to very robust evaluation and assessment models that may examine, for instance, cognition related to how students learn STEM disciplines. For example, [Google Search] NSF's **Promoting Research and Innovation in Methodologies for Evaluation (PRIME)** seeks to support research on evaluation with special emphasis on exploring innovative **new approaches for determining the impacts and usefulness of evaluations of STEM education projects and programs.** A look at this solicitation will illustrate the evolution of expectations related to STEM evaluations. This is relevant to center grants, particularly at NSF, given the agency emphasis on integrating research and education at all levels and other broader impacts requirements that are part of large grants.

Writing a strong evaluation section specific to a program, e.g., K-12 or public outreach, diversity, undergraduate research, diversity, etc., included as a required educational component of large center or institutional proposals to federal agencies, or as the entirety of smaller proposals specific to an educational objective, is a demanding and increasingly rigorous task with a significant impact on the competitiveness of the overall proposal. Many large research grants, as well as smaller grants like the NSF CAREER, require an educational component. Other LTGs, including many from the U.S. Department of Education, focus entirely on educational programs requiring robust evaluation and assessment protocols.

On larger proposals, with more complex K-12 STEM outreach components, researchers may want to work with university-based evaluation centers, either on their own campus or at evaluation centers elsewhere. Most campuses have offices of institutional research and assessment, but few of those offices have the evaluation and assessment skill sets required for evaluating the educational components of center-level grants to federal agencies. Depending on the size of the grant and complexity of the education and outreach sections, various paths may be available to faculty and research development professionals required to include an evaluation section in a proposal. In some cases, the program management staff of previous grants awarded to a university may have developed evaluation and assessment skills relevant to new initiatives. In some cases these program staff may have completed training at [Google Search] Western Michigan University's Evaluation Center, the Evaluators' Institute, and/or American Evaluation Association-sponsored workshops, and thereby provide an invaluable "in-

house" expertise for developing the evaluation section of a proposal. In other cases, there may be doctoral students in education or the social and behavioral sciences on campus with evaluation and assessment expertise.

At NSF, for example, the Broader Impacts review criterion can often be addressed through some type of educational component. Also, many of the federal mission agencies (NOAA, DOD, DOE, USDA, NASA, etc.) may require educational components in research grants to address their long-term interests in the preparation of a future STEM workforce at all degree levels with training in mission-critical disciplines specific to an agency. Where the proposal development budget does not permit the hiring of internal or external evaluators to draft the evaluation section required for an educational component, the fundamental evaluation and assessment protocols, formative and summative, and evaluation and assessment logic models may have to be learned by those developing and writing the specific grant. In those cases, there are many rich and robust web resources available where the fundamentals of evaluation and assessment models specific to various educational program types can be learned by researchers and grant professionals.

The following are representative examples of those resources, including handbooks developed specific to evaluation by NSF for applicants to programs at that agency to a very comprehensive evaluation site maintained by [Google Search] University of Wisconsin-Cooperative Extension ***Program Development and Evaluation Unit***.

The 2002 User-Friendly Handbook for Project Evaluation [Google Search]
National Science Foundation
This Handbook provides principal investigators with basic guidelines for the evaluation of NSF educational programs. It targets people who need to learn more about what evaluation can do and how to do an evaluation, rather than investigators with evaluation experience who already have expertise in the field. The Handbook discusses quantitative and qualitative evaluation methods, suggesting ways in which both methods can be used as complements in an evaluation strategy.

User-Friendly Handbook for Mixed Method Evaluations [Google Search]
National Science Foundation
Experienced evaluators find that the best results are often achieved through the use of mixed method evaluations, combining quantitative and qualitative techniques. Whereas the handbook described above provides an overview of the collection and analysis of qualitative data, this handbook provides more information on qualitative techniques and discusses how qualitative data can be effectively combined with quantitative measures.

Online Evaluation Resource Library [Google Search]
The **Online Evaluation Resource Library**, funded by NSF, was developed to collect and make available evaluation plans, instruments, and reports for NSF projects that can be used as examples by Principal Investigators, project evaluators, and others outside the NSF community as they design proposals and projects.

Evaluation Resources, University of Wisconsin – Extension [Google Search]

Evaluation is a core function of **University of Wisconsin-Cooperative Extension** with support provided by the Program Development and Evaluation Unit (PDE). This site provides key resources for evaluation, most notably:

- The "Planning a Program Evaluation" **booklet** and **worksheet** (PDF files) [Google Search]
  The worksheet is also available as a **Word document** that can be saved and used to enter text.
- The "Enhancing Program Performance with Logic Models" **online course** [Google Search]
- **Now available, a PDF version of the course for offline use** [Google Search]
  This file (216 pages, 3.35MB) may be downloaded to view offline or print all or selected pages for reference.
- **Templates for creating a logic model** [Google Search]
- **Examples of logic models** [Google Search]
- **Logic model online, self-study module: "Enhancing Program Performance with Logic Models"** [Google Search]

W.K. Kellogg Foundation Evaluation Handbook [Google Search]
For those with evaluation experience, or for those inexperienced in evaluation but with the time and resources to learn more, this handbook provides enough basic information to allow project staff to conduct an evaluation without the assistance of an external evaluator.

W.K. Kellogg Foundation Logic Model Development Guide [Google Search]
Nonprofits today are being pressed to demonstrate the effectiveness of their program activities by initiating and completing outcome-oriented evaluations of projects. This guide was developed to provide practical assistance to nonprofits engaged in this process. In the pages of this guide, we hope to give the staff of nonprofits and community members alike sufficient orientation to the underlying principles of "**logic modeling**" to use this tool to enhance their program planning, implementation, and dissemination activities.

The Program Manager's Guide to Evaluation [Google Search]
Department of Health and Human Services, Administration on Children, Youth, and Families
This informative guide explains program evaluation – what it is, how to understand it, and how to do it. It answers questions about evaluation and explains how to use evaluation to improve programs and benefit staff and families.

CDC Evaluation Working Group [Google Search]
Centers for Disease Control and Prevention
This site is an excellent resource organized around the following topics for further information about evaluation or assistance in conducting an evaluation project. Explore the following links for further information about evaluation or assistance in conducting an evaluation project.

Planning an Effective Program Evaluation [Google Search]
American Physiological Society
This web site offers an interactive online short course that includes six lessons about evaluation basics, questions raised by program directors, and resources available both on- and offline.

Each lesson includes an interactive component designed for the user to develop an evaluation planning document.

The Evaluation Center, Western Michigan University [Google Search]
The Center's role is to provide national and international leadership for advancing the theory and practice of evaluation, as applied to education and human services.

American Evaluation Association Guiding Principles For Evaluators [Google Search]
Here you will find the *Guiding Principles for Evaluators* in their entirety. Brochures of the *abbreviated* version of the *Guiding Principles* are available, free of charge, in both hardcopy and PDF.

NSF Broader Impacts

Over the past decade or so, much has been written and discussed about the NSF review criterion **Broader Impacts**, including workshops, reports, and web sites specific to helping researchers develop appropriate BI activities. ***The BI criterion requires your close and thoughtful attention to make sure it is developed in relation to research context, capacities, and scale.*** As stated in the NSF **Grant Proposal Guide**, the BI criterion **must** be clearly addressed ***in the project summary in a separate statement*** that demonstrates the broader impacts resulting from the proposed activity. If the BI criterion, along with the intellectual merit criterion, is not addressed in this way in the project summary, your proposal will be ***returned without review by NSF***. Moreover, BI must also be addressed in an expanded way in the project narrative, and may also form a component of the biographical sketch (**d. Synergistic Activities**) in which you provide a list of up to five examples that demonstrate the broader impact of your professional and scholarly activities that ***focuses on the integration and transfer of knowledge as well as its creation***.

All this can cause some anxiety on the part of researchers who feel they do not understand the BI criterion clearly, or who feel unprepared by training and other factors to address this criterion effectively in the project narrative. The best antidote for this anxiety, particularly one offering mithridatic properties, is to ***first take the time to examine the BI criterion in detail***, along with reviewing more in-depth examples of the range of BI activities, to give you a deeper appreciation of the ***intent of the BI criterion*** and, hence, ***gain a more nuanced understanding of the how the BI criterion applies to you.*** The URLs provided below will be a good entry point to this process.

There are many advantages to becoming self-sufficient or "packing your own chute" when it comes to interpreting how the BI criterion applies to you in the ***context, scope, and scale*** of any particular, i.e., specific, proposal you put forward to NSF. Becoming ***personally knowledgeable about the BI criterion*** and how you can best map your research and capacities to appropriate BI activities can give you ***one more competitive advantage*** in the NSF merit review process.

Proposals are won at the margins of excellence. Everything you do right in the proposal narrative that brings you as near to a perfect proposal narrative as possible will give you the accumulation of marginal advantage needed to convince reviewers and program officers to fund your effort. BI is one of many areas of competitive advantage you can gain by ***taking the time to fully understand the criterion, since you are the only one that can truly judge how potential BI activities fit your research context in the appropriate scope and scale and within your capacities and BI interests.***

Take the time to learn about the BI criterion in detail to gain a ***nuanced understanding of its intent and purpose***. Truly understanding and appreciating the BI intent and purpose will then allow you to develop good ideas for BI activities in your proposal as required by the specific solicitation you are responding to at NSF. Do not try to "***farm out***" the BI activities of your proposal to someone lacking knowledge of your research that will just offer you an "***off the shelf***" or "***canned***" BI write-up ***disconnected from your research context***, or that fails to arise logically (organically) from your research scope and scale and your own BI interests and capacities. ***The BI activities you propose have to make sense within the overall context of your research activities, and they have to be believable to reviewers and program officers.***

For example, a copy and paste of BI text from a center-level proposal to a small proposal with a few PIs will be out of bounds both in scope and scale.

Moreover, proposing BI activities offered to you by someone on your campus with a collection of BI narrative text taken from multiple proposals over multiple years puts your proposal at risk. For example, perhaps by getting a **"*canned" BI narrative*** proposing to transfer your research into middle schools and impacting 500 students will likely be seen as unrealistic at best by reviewers if you have no experience working with schools in the past, or clearly do not understand the nuances of working with school districts, STEM teachers, and their students in relation to STEM standards. So it is important to learn about BI so you do not get blindsided by proposing activities that do not make sense for you or your research interests. Also, talk to research colleagues, particularly those who have managed BI activities on proposals of various sizes and scales, to ***get better ideas of how you can best fit NSF's BI expectations to the context of your research***.

The NRC, a Partner for Writing More Competitive Proposals

Writing a competitive proposal requires making compelling and competitive arguments for the significance and value of your research and/or educational initiatives. Moreover, in many cases, the arguments you make in your proposal narrative for the significance, value, and impact of your research on the mission of a specific funding agency through a specific agency solicitation can be further enhanced by demonstrating the significance, value, and impact of your research on the national research agenda in terms of the specific research topic areas, goals, and objectives defined in the solicitation to which you are responding. Demonstrating the importance of your research in that national context will give you one more competitive advantage in writing a successful proposal.

In this regard, [Google search] **National Research Council** reports are an invaluable asset and resource in the development and writing of successful proposals to federal agencies, ***particularly in terms of helping you define and place your research in a national context***. In fact, many NRC reports have resulted in new programs and new funding solicitations by federal agencies in both research and educational domains of interest to university faculty. NRC reports are sometimes referenced in specific solicitations and program guidelines as motivating the solicitation itself. Now, more than 4,000 [Google search] National Academies Press PDFs are available to **Download for Free**. It is an important resource to use in order to increase your proposal success rate.

About NRC

NRC functions under the auspices of the National Academy of Sciences (NAS), the National Academy of Engineering (NAE), and the Institute of Medicine (IOM). The NAS, NAE, IOM, and NRC are part of a private, nonprofit institution that provides science, technology, and health policy advice under a congressional charter signed by President Abraham Lincoln that was originally granted to the NAS in 1863. Under this charter, the NRC was established in 1916, the NAE in 1964, and the IOM in 1970. The four organizations are collectively referred to as the National Academies.

The mission of the NRC is to improve government decision making and public policy, increase public education and understanding, and ***promote the acquisition and dissemination of knowledge in matters involving science, engineering, technology, and health.*** The institution takes this charge seriously and works to inform policies and actions that have the power to improve the lives of people in the U.S. and around the world.

The NRC is committed to providing elected leaders, policy makers, and the public with expert advice based on sound scientific evidence. The NRC does not receive direct federal appropriations for its work. Individual projects are funded by federal agencies, foundations, other governmental and private sources, and the institution's endowment. The work is made possible by 6,000 of the world's top scientists, engineers, and other professionals who volunteer their time without compensation to serve on committees and participate in activities. The NRC is administered jointly by the NAS, NAE, and the IOM through the NRC Governing Board.

The core services involve collecting, analyzing, and sharing information and knowledge. The independence of the institution, combined with its unique ability to convene experts, allows it to respond to a host of requests.

The portfolio of activities includes:

- Consensus Studies: These comprehensive reports focus on major policy issues and provide recommendations for solving complex problems.
- Expert Meetings and Workshops: By convening symposia, workshops, meetings, and roundtables, the NRC connects professionals as well as the interested public and stimulates dialogue on diverse matters.
- Program and Research Management: At the request of state and federal agencies, the NRC manages and evaluates research programs, conducts program assessments, and reviews proposals.
- Fellowships: The NRC administers several postdoctoral fellowship programs.
- Free Scientific Information: Publishing more than 200 reports and related publications each year, the institution is one of the largest providers of free scientific and technical information in the world. Most of it is now on the NRC web site.

STEM Learning and Activity Models for Proposals

If you are submitting an LTG to NSF that requires a STEM component, or if you want to include such a component to address the broader impacts criterion, then familiarize yourself with STEM learning models. Understanding STEM components from the NSF perspective can help researchers see their applicability to many NSF research proposals agency-wide.

Acquiring this understanding can be particularly important for principal investigators on LTGs who need some basic understanding of the NSF models and protocols for STEM learning along the K-PhD continuum in both formal and informal settings. Research teams on larger NSF research proposals need not transform themselves into STEM learning researchers, but they do need to identify and involve the right STEM partners when required by the proposal, or when the research focus of the proposal "suggests" possible STEM learning activities in response to the broader impacts review criterion or to the overarching NSF theme of integrating research and education.

Many principal investigators have only a tentative understanding of how to structure a competitively written broader impacts or research and education integration section for their proposal that is ***logical, coherent, and effective within the context*** of their overall research goals and objectives. For example, principal investigators may not have a good working understanding of what NSF means by STEM learning in either formal or informal settings. In many ways, this issue parallels the review panel advice often given by funding agencies recommending that researchers write their narratives not to the expert in the field but to the scientifically literate reviewer. In this case, the principal investigators do not have to be experts on STEM learning and activities models, ***but it is very helpful if they are literate on the subject of STEM education models with respect to NSF "best practices."*** At the very least, principal investigators on larger research projects need to make informed decisions when identifying an educational partner that will offer them NSF-informed suggestions and help them draft narrative sections of the proposal addressing educational activities, when required. This must be done in a way that reflects both the research objectives of the proposal and the various ***NSF STEM models and protocols appropriate for the various levels, settings, scales, and contexts of STEM learning*** that map neatly to the proposed research.

Moreover, principal investigators can benefit significantly by taking advantage of institutional expertise on planning educational activities appropriate to their NSF proposal. Just as in real estate, whose mantra is "location, location, location," the key focus here needs to be "context, context, context," when explaining the relation between proposed educational activities and the proposed research. ***The most successful educational activities emerge organically from the context of the research and are not imposed upon it.*** Furthermore, particularly at NSF, the successful proposal will demonstrate that s***uch activities are consistent with research and best practices in curriculum, pedagogy, and evaluation***.

Supporting expertise for STEM education models will reside in various offices on each campus, including research offices at the university or college level, grant-writing offices, program managers of currently funded STEM education projects, faculty with smaller grants that include educational components, and experienced NSF evaluators, among others. However, ***principal investigators on NSF research proposals are advised to become well informed on NSF expectations and best practices for educational activities. This will allow***

them to judge the value of the advice they are offered and the quality of the contributions made to the education section of the proposal narrative.

PIs should avoid "***farming out***" the educational activities component of their proposal to someone without knowledge of their research. This usually results in an "***off the shelf***" or "***canned***" educational write-up ***disconnected from the research context and awkwardly positioned relative to*** the research scope and scale of the PI's interests and capacities. ***Educational activities have to make sense within the overall context of the research activities, and they have to be believable to reviewers and program officers.*** For example, a copy and paste of educational activities taken from a center-level proposal and transferred to a small proposal with a few PIs will appear disproportionate in scope and scale. The copy and paste function, particularly in the hands of the indiscriminate and uninformed, can unfortunately doom a proposal narrative to the dreaded and self-inflicted 3-D outcomes: ***dangerous, detrimental, and deleterious***.

In this regard, PI's need to keep in mind that p***roposals are won at the margins of excellence***. Everything you do well that brings you as near a perfect proposal narrative as possible will give you the accumulation of marginal advantage needed to convince reviewers and program officers to fund your effort. Ensuring a strong education component of a research narrative can become one of many areas of competitive advantage you can gain by ***taking the time to fully understand NSF's expectations and best practices for educational activities. You are the only judge of how well potential educational activities fit your research context at the appropriate scope and scale and within your capacities and educational interests.***

Various educational activities often suggested by NSF include involving K-12 students, undergraduates, graduate students, and the general public in the project. However, the activities chosen for this involvement must relate to the proposed research. NSF examples of specific activities often include but are not limited to the following: designing innovative courses or curricula; supporting teacher preparation and enhancement; conducting outreach and mentoring activities to enhance scientific literacy or involve students from groups that have been traditionally underrepresented in science; researching students' learning and conceptual development in the discipline; incorporating research activities into undergraduate courses; providing mentored international research experiences for U.S. students; linking education activities to industrial, international, or cross-disciplinary work; and implementing innovative methods for evaluation and assessment. NSF education activities may also include designing new or adapting and implementing effective educational materials and practices. ***Such activities should be consistent with research and best practices in curriculum, pedagogy, and evaluation***.

Social Science Components of NSF Proposals

As proposals become increasingly complex, often driven by large solicitations requiring umbrella structures to achieve research goals, a challenging task confronts the research leadership. While domain-specific research remains at the core of center and center-level NSF solicitations, the social sciences, like STEM learning activities, are becoming increasingly important to the overall success of proposals.

However, in most cases, the developmental origins of large research proposals lie with one or a few discipline-specific principal investigators who then build a research team that maps to the specific goals, objectives, and program-specific review criteria of the solicitation. Moreover, the research portfolios of universities are driven increasingly by research in specific disciplines, e.g., engineering, science, and technology, among others, which function as an incubator and generator of economic activity at the local, state, and national levels. In many cases, these large research efforts represent a distributed partnership of universities, government agencies, and the private sector in multiple configurations and at various scales designed to optimize competitiveness and success.

This can present a challenge for the PI and the leadership team, particularly the challenge of expanding the core leadership by identifying new members with a disciplinary expertise, such as the social scientist, who work outside the PI's research domain. This is important for many reasons, most notably in relation to the research narrative. The section of the narrative addressing the importance of social science to the domain-specific research core of the proposal must reflect the same overall excellence as the research core to ensure the proposal's success. In fact, ***competitive proposals must contain a single, integrated research narrative.*** Too often, proposal narratives appear as a ***series of loosely associated sub narratives*** addressing first the scientific goals, then several ancillary goals, trailing along like cabooses, describing how the proposal will also meet the societal, STEM, and related requirements of the solicitation.

Finally, in this regard, the time has long passed at NSF and other agencies that increasingly use NSF solicitation models, ***when the PI of a multifaceted research project can confidently claim that only the quality of the core research matters in the final review process***. This line of argument often mistakenly assumes that narrative components related to, for example, STEM learning activities, societal impacts, diversity, and plans for research and education integration will not be given substantial weight in the awards process. Dismissing or remaining indifferent to these integrative requirements brings to mind the Pogo comment: "***We have seen the enemy and he is us***!"

NSF recognizes these issues. The NSF-funded [Google search] ***Final Report for Centers, Universities, and the Scientific Innovation Ecology: A Workshop*** (BCS-0907827, July 2009), poses the following four questions, ***which often confront the leadership team on large NSF proposals***, certainly in the case of Science and Technology Centers and Engineering Research Centers, but increasingly across the spectrum of all NSF LTGs, whether directorate specific or crosscutting.

- *What is the role of federally funded, university-based centers and institutes in the organizational, social, and economic ecology of scientific innovation?*

- *What theoretical perspectives from the various social sciences can inform the development and evaluation of national science and technology policies at different levels of the system?*
- *How can social scientists contribute to the work of centers' and institutes' domain sciences?*
- *Might social-scientific knowledge in such fields as measurement, organizations, networking, communications, and cultures become a significant component in effective centers and institutes?*

This 21-page report offers a good starting point for any PI thinking of submitting a large or crosscutting research proposal. It comprehensively explains the context in which NSF views these issues and gives the researcher ***guidance for identifying potential collaborators from the social sciences***. It is important in team development and to the success of the proposal to ***avoid a disciplinary disconnect between those leading a large center-level proposal, perhaps in engineering and related disciplines, and those team members recruited to address social science issues***. Each team member, particularly the PI, needs to be scientifically literate, but not an expert, in the research topic areas that will be integrated to define the vision, goals, and objectives of the overarching research narrative.

It can be very helpful early in the proposal development process for each member of the research team responsible for drafting sections of the research narrative to explain to the other team members the research topic he will address and its importance to the overall effort, particularly in terms of value-added benefits. The more completely each research team member integrates, synthesizes, and connects her research to that of her colleagues, the more competitive the final proposal will be for funding. Moreover, in its final form, an integrated research narrative must be written in a common language and not in multiple, "siloed" languages limited to specific disciplines.

These issues are further addressed in the [Google search] **NSF Workshop**: ***Interdisciplinary Collaboration in Innovative Science and Engineering Fields.*** The main goals of this workshop were to: (1) ***discuss the potential for a shared vocabulary across the different fields that study interdisciplinarity and related issues***, (2) elaborate on specific similarities and differences in theory, data, and methods, (3) classify gaps and important future directions in the study of interdisciplinarity, and (4) identify specific infrastructure changes that would enable the study of multi- and interdisciplinary collaboration.

The NSF program, [Google search] **Science, Technology, and Society (STS)**, gives a deeper insight into these issues**.** STS considers proposals for scientific research at the interface of science (including engineering) or technology, and society. STS researchers use diverse methods, including those from the social sciences, history, and philosophy. Successful proposals will be transferable (i.e., generate results that provide insights into other scientific contexts). They will produce outcomes that address pertinent problems and issues at the interface of science, technology, and society, such as those having to do with practices and assumptions, ethics, values, governance, and policy. A review of the abstracts of recently funded programs made under this solicitation can be very helpful as well in understanding the relationship between science, engineering, and technology and the social sciences.

Other similar resource links are given below as starting points for exploring the role of the social sciences within larger research proposals to NSF and other federal agencies as defined in specific solicitations:

Science, Technology, and Sustainability: Building a Research Agenda, National Science Foundation Supported Workshop, September, 2008.

Over the last decade, the thesis that scientific and technological research can contribute to overcoming sustainability challenges has become conventional wisdom among policy, business, and research leaders. ***By contrast, relatively little attention has been given to the question of how a better understanding of the human and social dimensions of science and technology could also contribute to improving both the understanding of sustainability challenges and efforts to solve them***. Yet, such analyses would seem central to sustainability research. After all, human applications of science and technology pose arguably the single greatest source of threats to global sustainability, whether we are talking about the energy and transportation systems that underpin global industrial activities or the worldwide expansion of agriculture into forest and savannah ecosystems***. These applications arise out of complex social, political, and economic contexts – and they intertwine science, technology, and society in their implementation – making knowledge of both the human and social contexts and elements of science and technology essential to understanding and responding to sustainability challenges***. Thus, while science and technology are central to efforts to improve human health and well-being, the application of science and technology has not always contributed as anticipated in past efforts to improve the human condition. It is essential, therefore, that research on the relationships between science, technology, and society be integrated into the broader sustainability research agenda.

Science of Science and Innovation Policy (SciSIP)

The SciSIP program invites the participation of researchers from all of the social, behavioral, and economic sciences, as well as those working in domain-specific applications such as chemistry, biology, physics, or nanotechnology. The program welcomes proposals for individual or multi-investigator research projects, doctoral dissertation improvement awards, conferences, workshops, symposia, experimental research, data collection and dissemination, computer equipment and other instrumentation, and research experience for undergraduates. The program places a high priority on interdisciplinary research as well as international collaboration.

National Center for Science and Engineering Statistics (NCSES)

A Broader Mission. The responsibilities of NCSES have been broadened from those of the former Division of Science Resources Statistics. Data collections related to U.S. competitiveness and STEM education are part of these new responsibilities. NCSES is responsible for statistical data on the following:

- Research and development
- The science and engineering workforce
- U.S. competitiveness in science, engineering, technology, and R&D
- The condition and progress of STEM education in the United States

Building a Community of Practice II

Report on the Second AAAS-NSF SciSIP Workshop, October 2010

The second AAAS-NSF SciSIP workshop, *Building a Community of Practice II*, was held at AAAS headquarters in Washington, D.C., on October 19, 2010. This report describes the background of the workshop, outlines its format and content, and summarizes and comments on its major substantive themes. It complements AAAS's earlier report, *Toward a Community of Practice*, which includes preliminary findings of the first and second rounds of SciSIP research projects presented at the first AAAS-NSF SciSIP workshop, held on March 24-25, 2009, as well as summaries of the discussions and an interpretive analysis of the workshop.

Preparing Letters of Support and Collaboration

As projects become more collaborative and include partners from other sectors (e.g., national labs, school districts, research collaborators, industrial partners) it has become increasingly common to require that proposals include letters of support or collaboration. Here are some strategies for developing strong letters.

Determine whether you need a letter of support or a letter of collaboration. Letters of support express support for the value of the proposed project, but the writer is not involved in the project. Collaborators (either paid or unpaid) who will contribute to the success of the project in some way write letters of collaboration and the letter explicitly describes the collaborators' involvement. Some funders welcome letters of support, while others (such as NSF) are increasingly discouraging these letters, but do accept letters of collaboration.

When you contact the potential supporter or collaborator, offer to provide them with a first draft of the letter which they can then edit as they like. This serves two purposes: it removes some of the burden of composing the letter from the letter writer, usually making the process easier and faster for all involved; and it allows you to draft a strong letter as a starting point.

Letters may be addressed to the Program Officer or to the PI (sometimes the funder provides guidance on this). The more details included in the letter, the more convincing it will be to reviewers. In the draft letter you provide, start by naming the project by its title, summarizing the goals of the project, and providing an overview statement summarizing either the reason the writer supports the project, or how the writer will collaborate with the project (e.g., by providing data, hosting students for internships, allowing access to a specialized instrument, etc.).

In the next paragraph or two, the letter should describe the writer's background, interests, credentials, the mission of his institution, etc., thus providing some background to enable reviewers to understand why the writer is either qualified to support the project or to serve as a collaborator. Previous collaborations or connections with the PI could also be mentioned here. (You can often provide some general guidance and ask the letter writer to fill in details for this paragraph.)

In the following paragraph, describe in detail how the collaborator will contribute to the project or the expected outcomes of the project the writer finds valuable. Specific details will make the letter stronger. For example, for a collaborator who will host students for internships, how many students will be hosted for how long, and what type of research will they conduct? For a collaborator who will provide data for analysis, when will the data be provided and exactly what type of data will be provided? For a community stakeholder expressing support for the project, what outcomes of the project will be valuable, and how specifically will they support their mission? For a Department Head expressing support for a faculty member's research, how will the department support the project (e.g., by providing lab space, release time, supporting the listing of a new course, etc.)?

Letters typically close with an expression of enthusiasm for the project. Of course, the order in which you cover these points can be varied, based on what makes sense in your particular situation, and if you plan to include more than one letter with your proposal, be sure to vary the wording so that they aren't too similar.

It's a good idea to contact letter writers early so that you don't find yourself in the position of having to ask them to drop what they're doing to get a letter to you in time for the deadline. Also, if you are asking for a letter from an industrial collaborator (particularly if some resources are being committed in the letter), expect a relatively long process as corporate channels are negotiated in order to get approval.

Strong letters can impress reviewers and make your proposal more competitive, so it's definitely worth the effort to develop the best possible letters for your proposal.

No Squishy Commitments or Weasel Clauses

Many proposals require various commitments of resources such as space, facilities, administrative support, and related institutional commitments, including cost sharing and matching funds, specific to the funding agency and the particular solicitation. In some cases, these commitments are made in the form of letters of support included in the proposal as an appendix, or placed in a section following the project description dedicated to this purpose. The letters may detail commitments to the project made by various university administrators, such as a provost, vice president for research, dean, department head, etc., or the letters may detail commitments of partner institutions, e.g., other universities, research laboratories, instrumentation centers, etc., or perhaps school districts, science centers, museums, or other stakeholder groups impacted by the project in some significant way.

When the required commitments are very specifically described in the solicitation, e.g., matching funds as a defined percentage of the total funding requested, then the applicant cannot resort to ambiguity—either the required matching funds are described and available in an identified account, or they are not. When the sponsors of the solicitation detail and prescriptively define matching commitments, they leave no room for smoke and mirrors. However, in other cases, commitments may be defined in more general terms in a specific solicitation, or by a specific funding agency, particularly when the commitments required are unique to the programmatic configuration of each proposal submitted in response to a common solicitation. In this case, the solicitation may give general guidance on letters of support, including noting whether the letters are optional rather than required, and thereby leaving it up to the proposer to include commitments that she feels best strengthen the proposed project.

In these instances, when letters of support are unique to what is being proposed in the project description, the funding agency guidance on the content of the support letters will allow great latitude for the applicant. Proposal guidelines that offer flexibility rather than prescriptive rigidity on structure and content are always to be preferred. However, it can open the door for letters of support that might generally be described as "squishy," or otherwise vague, ambiguous, or nonspecific when the funding agency expects detail and specificity and, most of all, ***substantive commitments that clearly advance the proposed project in some important way***. Letters of support characterized in this way are often referred to as "smoke and mirrors." In other cases where the letter of support is preconditioned on multiple "contingencies" that must take place before the support is given, the letter might be said to be filled with "weasel clauses."

Squishy letters of commitment can be written for several reasons. In some cases, the principal investigators are so focused on writing the research narrative that they pass on the task of drafting or obtaining commitment letters to someone with only a general or vague understanding of the project. Or they may ask a colleague to write a commitment letter without sufficiently informing them about the project itself, or the requester's role in it. Unfortunately, in other cases, squishy letters of support occur because, in fact, the support given the project is actually squishy and not substantive, specific, or detailed. While the former may occur when those responsible for garnering letters of support do not fully understand the perhaps at times unstated requirement that ***letters of support be grounded on substance rather than superlatives***, squishy support letters can lead reviewers and program officers to the

conclusion that the applicant is trying to "pull the wool over their eyes," somewhat along the lines of the sixteenth-century trick of pulling woolen wigs down over a person's eyes. It is definitely not a good thing when reviewers and program officers think your letters of support are trying to pull the wool over their eyes. Once that seed is planted in their minds, it may lead them to question the actual substance of other elements of your proposal.

Letters of support written in flowery language with glowing superlatives of support but without a detailed knowledge of the project should not be included in your proposal—they will do more harm than good. Don't insult the program officers and reviewers with letters that give the illusion of support but amount essentially to empty promises, somewhat like a politician running for office on a platform of free beer and wide roads. You don't want reviewers reading your letters of support and asking themselves, like the elderly woman in the Wendy's ad, "***Where's the beef***?!"

For example, avoid "***where's the beef letters***" that sound like the one below, signed by various academic or research officers, or partner institutions:

"*I am honored and excited to offer the full and enthusiastic support of My Office to advance the critical goals and compelling objectives described in this groundbreaking proposal. I can assure Funding Agency that this proposed effort is fully and uniquely aligned with the strategic research objectives of this University. Moreover, the exciting and transformative research described in this proposal will clearly impact the field in novel ways and have profound and long-lasting implications for our national research enterprise. The research proposed herein is clearly seminal and will profoundly advance the field for decades if not generations to come, often in unimaginable ways. My commitment to supporting and sustaining this extraordinary research project is made with a profound sense of obligation to use the power and resources entrusted to me under my fiduciary responsibilities as High Ranking Administrator to ensure this project is successful in making an enormous impact at both national and global scales and thereby making an extraordinary contribution to the future of Human Kind*."

In conclusion, if in doubt, either when drafting a letter of support you would like someone to sign for inclusion in your proposal, or when providing someone with points to make in a letter of support, keep in mind that the ***fundamental objective of a letter of support is to align additional resources with your project in ways that clearly make it stronger, more robust, or better able to achieve the vision, goals, and objectives described in your research narrative***. Letters of support are not meant to be letters of "bon voyage" wishing you good fortune on your research journey, the functional equivalent of well wishers standing on the pier waving "good luck" as your ship departs to explore new research frontiers. Letters of support need to indicate that the person signing the letter will actually make the voyage of exploration with you and ***contribute in specific, defined, and substantive ways that will enhance your success***.

Part 6, Characteristics of the Successful Narrative

Writing a Compelling Project Narrative
The Role of Specificity in a Successful Proposal
Avoid the Generic Introduction
Narrative Silos Are Like Weeds
Why Generalities Suffocate the Narrative
Do Not Build Your Proposal Out of Spare Parts
Echo but Don't Parrot Agency Language
Interviewing Schrödinger's Cat: Eradicating Ambiguity
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No Tweaking, No Nudging, No Band Aids: Re-writing the Declined Proposal
The Role of Context in a Successful Proposal
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Proportionality and Sequence in the Narrative
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Logic Models: Scalable, Adaptable, and Versatile

Writing a Compelling Project Narrative

Perhaps the most ubiquitous grant-writing advice given researchers is to ***write a compelling research narrative that excites the reviewers and makes them want to fund your proposal***. It sounds like excellent advice, and it is. But so is the ubiquitous advice on how to lose weight—eat less and exercise more. Easier said than done in both cases. Of course, on reflection, the natural next question comes to mind: "***What characterizes a compelling project narrative***?" Furthermore: "What does it mean to excite the reviewers in a way that will make them want to fund your proposal?" The easy first answer, essentially an evasive and unsatisfying one, is, "You will recognize a compelling research narrative that excites the reviewers when you read it." This is somewhat like U.S. Supreme Court Justice Potter Stewart's observation about pornography (*Jacobellis v. Ohio*, 1964), something he said he could not intelligibly describe; nonetheless, he continued, " I know it when I see it." While the "I know it when I see it" standard has apparently worked reasonably well for the courts, it falls flat when it comes to giving insight to a principal investigator attempting to write a competitive research narrative.

However, it is possible to reverse engineer, or, as some may say, "deconstruct," this "compelling and exciting" project narrative advice by identifying its constituent parts, thereby ***better defining both what it is and what it is not***. Characterizing a research narrative that neither compels nor excites reviewers will help define one that does. In all cases, begin by keeping your audience in mind: reviewers and program officers (see *Writing for Reviewers—an Introduction* in the October 15, 2010 newsletter).

The characteristics of a research narrative that fails to compel or excite and that discourages positive reviews include:

- A research plan cloaked in a fog of poorly written text.
- A vague research vision lacking focus, or reading, as H.L. Menken once observed, "***like an army of words marching across the page in search of an idea***."
- A research narrative description focusing heavily on general statements about past and planned research, but failing to give details and specifics that help readers understand the importance of the research, or its significance in advancing the field through questions, hypotheses, or solutions.

The characteristics of a compelling research narrative that excites reviewers and makes them want to fund the research include:

- Beginning with an important research idea stated clearly and simply so reviewers can quickly grasp the research questions or hypotheses.
- Explaining why your research is unique and supporting this statement with sufficient specificity and detail to make your case.
- Explaining the importance, significance, or value-added benefits of your research to advancing the field or the agency's research mission.
- Providing reviewers with a clear statement of the significance of the project from a precisely written project description.
- Knowing where your research is taking you and writing the narrative to bring reviewers along with you—taking them on a convincing journey from your great idea to the important final destination: a recommendation for funding.

- Considering the general structure of persuasive writing that will engage reviewers effortlessly in the narrative's explanation of the research you will do; how you are able to accomplish it; why your questions, hypothesis, or outcomes will result in new knowledge to advance the field; and why you have the capacity, experience, and expertise to perform this work.

Think of a ***unit of persuasive (i.e., compelling) writing***, e.g., a paragraph, page, section, etc., as having ***three key, sequential components***, or parts***, each linked with well-crafted transitional sentences*** that, when concluded, leave the reviewer with a clear and integrated understanding of the given unit of narrative. These three parts typically consist of the following generic sequence, likely modified to fit your specific research context:

- **research overview,** followed by a transitional statement addressing
- **research specificity and detail,** followed by a transitional statement addressing
- **research importance, significance, value-added benefits, or relevance to agency research mission**.

Regardless of scale, these three narrative elements will make your narrative more compelling. ***They can be elaborated as follows***:

- ***An overarching, unifying description.*** This could be of your research vision and goals, or an overview of some important knowledge-based outcomes of your research (e.g., problem solved) critical to a specific field or multiple fields that will be advanced by your research, i.e., a description of the research you are doing and why are you doing it;
- ***A description that grounds the overarching research statement in the specificity*** and operational details unique to your field of expertise, e.g., your research objectives and how you will achieve them.
- ***A description of what makes your research significant,*** or how it adds value to a research field, or transforms it in some clearly defined ways.

This narrative pattern can be used at all scales, e.g., at small scales, such as a paragraph, or larger scales, such as a section, that, in aggregate, create a repeating pattern of persuasiveness for the entire proposal. Moreover, if you are not a contributing author to a proposal narrative but are asked to review and critique the narrative, these three components would form a checklist for your review. For instance, one common error in writing a compelling research narrative is to ***disproportionately focus on general descriptive detail of the research*** at the expense of the critical follow-on elaboration that provides reviewers with the specificity of detail that will segue to statements of research significance. Too often general descriptions start reviewers down a path that eventually withers away while failing to address the important questions that need to be answered. This might be called the "***dangling general narrative***," somewhat analogous to the grammarian's "dangling participle" that creates ambiguity and fails to clarify the nature and justification of the proposal's research point .

However, the ability to describe research significance and relevance to an agency mission, or field or problem must be mastered if you are to find funding success. Not to take away from Mariano Rivera of the New York Yankees or Kyra Sedgwick, ***but the "real closer" in successful research grant writing is the description of your project's significance***.

For example, regardless of scale, if you envision a compelling project narrative unit (e.g., paragraph, section, proposal) as comprised of three concentric rings, as in the graphic below,

then the narrative's outer boundary, in blue, is the overview, or overarching statement introducing the reviewers to your research topic. The white middle ring then narrows the focus by providing the specificity and detail needed for reviewers to gain a more finely-grained understanding of your research topic area and your research objectives. ***In this case, you might think of yourself as a guide for reviewers***: you first introduce them to and lead them through the blue ring with sufficient explanation that they understand the domain and boundaries of your proposed research. Next, you guide the reviewers into the white ring where you offer them the required specificity and detail about your research in a way that demonstrates its uniqueness and explains your research objectives. Finally, you lead the reviews into the center ring, or funding bull's eye, where you convince them of the importance of your research. ***This is where you provide the reviewers with descriptions of your project's significance that will convince them to fund your research***.

Once you have crafted these three components into a first draft, it is important to then craft further iterations of the text to ensure that all three elements mesh seamlessly into a compelling narrative that will persuade reviewers to fund you. Of course, none of this ensures your research narrative will be viewed as compelling and exciting by reviewers, but if your research is compelling and exciting, this process will ensure that your research ideas are not undermined by a poorly crafted narrative.

The Role of Specificity in a Successful Proposal

As one of the most critical components of a successful research narrative, specificity must be evident throughout project descriptions***. Specificity grounds the research vision and goals in the key performance details unique to your research objectives, and thereby illuminates the importance of your research for reviewers***. Judiciously selected specifics display the uniqueness of your research narrative and define the particularity of your research plan. When key research specifics are embedded in, or follow, overarching statements defining the research vision and project goals, they significantly enhance the clarity and persuasiveness of the research narrative. ***Well-chosen specifics serve as the glue that binds together the more general narrative statements introducing your research topic to the reviewers***. In effect, specifics help transition the narrative from a "black and white" to a "full color" portrait of your proposed research.

However, providing specificity should not be confused with inflating a research narrative with technical minutiae impenetrable to the typical reviewer. Specifics should be clear, precise, logically ordered and, like Goldilocks, supplied in just the right amount. ***They should be chosen to illuminate rather than disguise the importance of your research.*** Specificity should sharpen rather than blur the focus of the research narrative***, encouraging reviewers to recall the key factors that make your research feasible, unique, significant, and hence fundable***. As in all effective narrative techniques, balance and proportion are important; therefore, you might think in terms of "Goldilocks Specifics," somewhat like the "Goldilocks Planets" that are not so near a sun, nor so far away, that liquid water does not exist on the surface. In this case, the successful narrative gives neither too few nor too many specifics but just the right amount. Make your point, but don't belabor it, ***and remember that superlatives are not specifics, but merely adjectives on steroids***. Any attempt to substitute superlatives for specifics will be quickly noted by reviewers, and likely in an unfavorable way. ***Specifics function in the narrative text as mirrors that reflect your capacity to perform and make your narrative more convincing in a grounded way.***

For example, vision statements and project goals, such as the following from a Department of Energy funded proposal, define the proposed research landscape in broad brush strokes: "*The goals of the Greater Philadelphia Innovation Cluster (GPIC) for Energy Efficient Buildings are to improve energy efficiency and operability and reduce carbon emissions of new and existing buildings, and to stimulate private investment and quality job creation in the Greater Philadelphia region, the larger Mid Atlantic region, and beyond. GPIC will focus on full spectrum retrofit of existing average size commercial and multi-family residential buildings*."

Think of the vision and goals statements, such as above, as descriptions of some promised "units of change" (e.g., improved energy efficiency, improved energy operability, reduced carbon emissions, investments stimulated, and jobs created) that will occur over some "unit of time" that will result in some "unit of benefit." Essentially, vision and goals statements are promises of better things to come based on the proposed research. Without specifics, however, they are empty promises, or, as some might say, "***all hat and no cattle***."

The basic role of specifics in the research narrative is to make your research vision and goals ***believable, convincing, and memorable to reviewers***. Specifics will convince reviewers of your capacity to perform, of the reasonableness of your research plan and objectives, and of the promise that your research will advance the field or the strategic mission of a funding

agency in some important way. By contrast, entire proposals or sections of proposals defining a major project goal, e.g., energy efficiency, but lacking a detailed description of the research to be done, the justification for doing it, the manner of doing it, the people who will do it, and the benefits of doing it lack specificity. Generous reviewers of such uninspiring text might first question their own short-term memory and hold themselves at fault, but one important rule of grant writing is to always blame the writer and hold the reviewer blameless should the narrative fail to make a convincing case for funding. ***If reviewers must repeatedly look back in your narrative text to find and recall the essential specifics of your proposed research, then the fault lies in the writing and not the reviewers' memories***, regardless of Lewis Carroll's observation that "*It's a poor sort of memory that only works backwards*."

Why might narrative text lack specificity? It is easier and less time consuming to make general claims and promises than it is to select a logically connected series of specific details that illuminate your research objectives and answer the core questions listed above. ***Specifics serve to both test and prove the value of your ideas, and when they are lacking, it tells a reviewer that your ideas may also be lacking, or have yet to become fully developed.*** A proposal is judged in a kind of courtroom; the specifics of your proposal must answer reviewers' questions and overcome their skepticism to pave the way for a positive verdict.

In other cases, narrative text might lack specificity because one or more authors have mistakenly repeated various versions of the same goals and confused this repetition with an offering of specifics. Repeating goals in various ways does not address the core questions reviewers need answered. In this regard, keep in mind Richard Feynman's observation: "*You can know the name of a bird in all the languages of the world, but when you're finished, you'll know absolutely nothing whatever about the bird. So look at the bird and see what it's doing. I learned very early the difference between knowing the name of something and knowing something*." In the example used above, think of a goal as the name of something, in this case, "energy efficient buildings." ***Think of the specifics in your narrative as proof or validation that you know something about achieving your research goal***. In this case, it might be offering specifics about how building envelopes, smart buildings, sensors, materials, design practices, energy systems, construction practices, and the like, contribute to achieving your research goal. ***Stating a goal without then offering compelling specifics for transitioning a goal to reality, i.e., a research outcome, is the domain of politicians and bumper sticker slogans and not that of the successful research proposal***.

Moreover, continuing with the energy efficiency example, specifics need to be judiciously selected and characterized by the following :

- ***Relevance to the research goal***, e.g., if your energy efficient materials research focuses on only one of several areas, such as photovoltaics, thermoelectrics, solid-state lighting, among many others, your task is to offer specifics relevant only to your proposed research and not offer specifics relevant to the entire universe of energy efficient materials;
- ***Appropriateness of scale***, e.g., if the crystal structure of a material is not key to understanding the research, then don't belabor the Miller Index, or if only the time duration of an event is key to your research, then you needn't belabor the cesium oscillator or explain the history of NIST;

- ***Priority for accomplishing research goal***, e.g., offer first the key specifics that ***make your case most clearly and briefly and in a way most memorable to reviewers***, but don't offer an exhaustive list of specifics that overwhelm reviewers, thereby leaving it to reviewers to determine the most important details needed to convince them of your capacity to achieve your research goals.

Avoid the Generic Introduction and Background

A well-written proposal opens with a statement that tells reviewers and program officers what you are going to do, why you are going to do it, why it is important to do it, why you have the capacity to do it, and how, once completed, it will influence the field and agency's research mission. These questions all must be answered in a specific context and in a way that contrasts your proposed research to the current state of the field at various scales. For example, demonstrate how it will impact the agency program area, the agency-wide mission, and the national state of knowledge on the topic.

To illustrate further, applicants to DOE's *Energy Frontier Research Centers* program must describe how their research positions them "*at the scientific forefront of energy 'grand challenge' research areas*" and how the "*proposed research is aligned with the core research activities and priorities*" of DOE. Similar requirements are common, regardless of funding agency or the scale and scope of the research project. They can be particularly challenging in large team grants and center-level grants that require applicants to answer these "***stage setting***" background and context questions. Agencies use these statements to place the proposed research in a larger research context and thereby help reviewers and program officers to better understand how the research fits in a disciplinary field(s) and its value for advancing the field(s), or an agency's mission objectives.

This "***setting of the stage***" is typically done in an "*Introduction and Background*" or "*Introduction and Overview*" section of the Research Project Description, although different authors and agencies may denote the section in different ways. But basically it comprises the first section of the research narrative in which you introduce your research by answering the above questions, or similar questions posed in the funding solicitation.

It is a challenging task simply to distill the core significance of your research into a concise, clear, and easily understood description that will convince reviewers and program officers to fund your project over others. However, describing the impact of your research in the context of the field and/or agency mission--at a program level, agency level, and national level--is more challenging yet. This crucial context that illuminates the importance of your research for reviewers and program officers is challenging to write effectively, particularly with respect to achieving a suitable proportion of primary to secondary information and of excessive to minimal information .

As is the case in all sections of a well-written research narrative, ***you must define a hierarchical narrative structure reflecting the relative (weighted) importance and order of the information you choose to provide*** reviewers and program officers within the page and section limits of the proposal. Moreover, while the possible information you could present to reviewers is open-ended, agency constraints in the form of questions that must be answered will ***require significant information triage and culling*** to achieve an effective response within the proposal's page limits. This dilemma concerning "***what to say and what not to say***" poses a persistent challenge for anyone writing grants. However, it is particularly demanding when writing some variant of the generic "*Introduction and Background*" section of the research narrative.

For example, the background section must not be written as the history of the discipline starting with the ancient Greeks and culminating with your current proposed research. In this case, take to heart the poet William Blake's observation that "*You never know what is enough*

unless you know what is more than enough." If your narrative "starts back too far," it will need some serious culling, or you should consider a career authoring books on the history of science.

While this example is extreme, it nonetheless points to a flaw, although on a much smaller scale, common to many background sections used to introduce reviewers to your "setting the stage" statement. Remember, the background section sets the context, or sets the stage, for your research idea. ***Your research idea is the lead character on this stage*** and all other information serves as the illuminating backdrop to your proposed research.

Moreover, many center-level grants are fairly open-ended within multiple disciplinary domains, giving the applicant freedom to select the core research topic areas, e.g., the NSF Engineering Research Centers or Science and Technology Centers, while other grants are more focused on addressing a specific research objective of the agency, often a mission agency. In this latter case, all proposals submitted will fall within a more narrow and common research area. In this case, writing the background section presents the additional challenge of avoiding a statement numbingly similar to those written by other applicants and thereby either annoying or boring the reviewers. In effect, the more narrow the research objectives of the funding solicitation, the more likely that the background sections of all the proposals will overlap, presenting another challenge to writing a persuasive statement.

In other cases, background information may be included in the narrative in a misguided attempt to convince reviewers of the importance of addressing the specific objectives detailed in the solicitation. Reviewers have already agreed on that point. After all, that is why the agency is funding the research. ***Don't squander valuable space belaboring the obvious***. For example, if you are writing a proposal to an agency funding a program on climate change and water sustainability, you do not have to write a background section to convince reviewers and program officers that climate change is a fact and that it impacts water sustainability before addressing the specific research you propose to do and its importance. Similarly, if you are writing a major institutional proposal in response to a solicitation to form multiuniversity alliances that transition traditionally underrepresented groups to the STEM doctorate and the professoriate, you needn't write a background section convincing reviewers that diversity is important. They know that. That is why the program is being funded.

Of course, background sections are poorly written because generic background information is easy to write. This, in turn, gives the illusion of making narrative progress, when in fact you are struggling to generate narrative text that describes the importance of your research. No one who has written grants will deny that some panic can set in when staring at the initial blank page of a new project narrative. Nor can any author be blamed for beginning a project narrative writing text that clearly will be deleted in future drafts but at least gets the narrative started. That said, once the project narrative starts to come to life, it is time to go back and cut and shape the background section to ensure that it does only what it needs to do and not more: to demonstrate the importance of the proposed research to advancing a field described carefully enough to give reviewers a sense of how it compares to current practice and to judge the value-added benefits it brings to the field or agency mission.

Finally, a poorly structured background section will put reviewers to sleep. Do not introduce reviewers to your research by boring them with irrelevant, excessive, or generally known information. ***Opening a proposal with irrelevant and redundant information does not bode well for the attention reviewers will bring to the rest of your project narrative***.

Narrative Silos Are Like Weeds

Narrative silos are like weeds that need to be pulled or they will dominate the proposal and diminish its competitiveness. While mathematical integration can be important to the science or engineering proposed, narrative integration plays a central role in the well-written research proposal. Unfortunately, researchers tend to know less about how to integrate language than they do mathematics, although both are symbolic systems that allow us to understand and convey complex information with more clarity and depth. However, the successful research narrative must use language to integrate its ideas and methods, particularly as research funding agencies increasingly promote a more multidisciplinary, and often transdisciplinary, approach to addressing complex problems. ***In this climate, language must serve as the vehicle for crossing and mixing disciplines without mixing up the reviewers.***

Therefore, it is helpful when writing a research narrative to clarify the important ways research contributed from various fields intersects at disciplinary boundaries, and to explain the significance of those boundaries simply and clearly to reviewers and program officers alike. Narrative integration is grounded on connections, syntheses, intersections, interstices, and the melding of what is common to various disciplines and the differentiation of what is not. Illuminating connections for the reviewers can determine the proposal's success; without connections, as E.M. Forester observes in *Howards End*, "we are meaningless fragments, half monks, half beasts, ***unconnected arches that have never joined***." If a successful proposal bridges ideas spanning from a research solicitation to a funded research project, then the arches, or multidisciplinary research themes, must not be left unconnected, or siloed, as current vernacular would describe it.

If there were ever a place where teaming is critical, it is in the planning, outlining, developing, and writing of an integrated, and hence competitive, research narrative. Integrated research narratives, by definition, amount to much more than the narratives of single-PI proposals, although both types require narrative integration. The difference between the two lies mainly in the increased difficulty to be overcome in achieving integration as proposals increase in interdisciplinary scale and scope, a core characteristic of LTGs.

In practice, moreover, ***understanding the required integrative nature of any research narrative needs to start at the beginning of the writing process and not near the end of it,*** when the logic and argumentative structure have been fairly well set and consequently have ***become increasingly resistant to major revision***. It is always possible within days of the proposal due date to "seed" or "splice" integrating statements into a siloed research narrative in a desperate attempt to overcome obvious disconnects. These might exist between or among the core research themes, or between disconnected themes and any possible required narrative statements related to education or societal impacts. However, last minute attempts to overcome narrative deficiencies related to siloed text, no matter how skillfully done, may still appear to reviewers as last-minute remodeling or renovation of the research narrative.

In the case of multidisciplinary or transdisciplinary proposals, such as LTGs, where your competitiveness lies in the capacity to make strong and clear arguments for the value-added benefits and resultant synergy of the proposed disciplinary configurations, members of the writing team should clearly define the scale, scope, and significance of those benefits ***prior to the start of the writing process, or concurrent with it, but certainly not later than that***. While the writing process itself will likely illuminate more benefits to interdisciplinarity, those

assigned to write major research sections of an LTG should all understand at the start why the research is being proposed under one "umbrella" proposal rather than as multiple single-PI proposals submitted by the various section authors.

It can be helpful, in fact, to ***devote an early proposal development meeting entirely to identifying the research integration themes and disciplinary research integrators*** that will be woven into the research narrative itself. This raises the likelihood that, as section authors get writing assignments, they begin drafting text with the relational framework of the multidisciplinary proposal clearly in mind from the start. ***This coordinated communication resembles the hunting strategies or "rules" used by wolves, or perhaps quorum-sensing bacteria, in communicating a coordinated and focused action***.

Identify and communicate among the proposal writing team the key integrative characteristics of the effort, specifically the value-added benefits and clear synergy prior to each section author beginning a first draft, or one principal author melding input from several coPIs into a first draft. This will better ensure a seamless research narrative that evolves within a relational framework and logical structure that simply and clearly demonstrates the value of the proposed team science. Developing a consensus among writing team members of the key integrative arguments to be made in the research proposal narrative offers one more way to ensure a successful proposal by preventing narrative silos from developing like weeds that dominate the proposal and diminish its competitiveness.

Why Generalities Suffocate the Narrative

Generalities in the research narrative suffocate the project description in much the same way that exposure to cyanide ions inhibits our ability to take up and use oxygen in the bloodstream. At lower doses, the symptoms of exposure to generalities and cyanide ions are similar—general weakness, confusion, headaches, listlessness, and the inability to focus. At higher doses, the toxicity caused by either generalities or cyanide ions creates more serious difficulties that quickly become life threatening. Fortunately, cyanide antidote kits are available for humans, but immediate treatment is required.

By comparison, the "generalities antidote kit" for proposals involves a multistep process tailored to the severity of the problem. The kit for the narrative requires that generalities be displaced by massive doses of clarity, specificity, and detail administered repeatedly until the due date, if there is to be any hope of salvaging an otherwise hopeless project description. As the English mathematician Alfred North Whitehead observed: "We think in generalities, but we live in detail." The poet William Blake held a harsher view of generalities: "To generalize is to be an idiot. To particularize is the lone distinction of merit."

Unfortunately, generalities seem to escape many authors' notice, yet appear as glaring flaws to readers and reviewers alike, especially those searching for the specificity needed to make an informed critical judgment on the project's merit. The experience of reading a narrative laced with generalities leaves the reader and reviewer alike with a foreboding and increasingly exasperating sense of uncertainty about ***specifically what the proposer actually plans to do***. The overly generalized narrative often claims to offer great research benefits should the project be funded, but it nonetheless ***leaves the reader puzzled about how the claim will actually be accomplished***. This "*trust me*" narrative model has long been discredited by reviewers. In effect, generalities are to the research narrative what scrip is to legal tender—nothing more than a token or an IOU ***representing an implied promise to accomplish something important if funded, but leaving the actual performance details vague until the money arrives.***

While the gold standard is no longer used as a monetary system, it is, by analogy, used by reviewers who expect claims of value to be backed up by specifics and detail in the narrative. If not provided with narrative detail, reviewers will suspect you are trying to sell them the Brooklyn Bridge, or ocean front property in Oklahoma. As Chicago architect Ludwig Mies van der Rohe observed, "the devil is in the details." If so, to write a competitive proposal, be prepared to meet the devil. Otherwise, when reading your proposal, reviewers will feel like they are channeling Wendy's 1984 "***Where's the beef!?***" advertisement now immortalized on YouTube.

Generalities are often ubiquitous in the research narrative of poorly conceptualized proposals, and are especially prevalent and damaging in those core sections of the proposal that address background, statement of the research problem, and specific research aims/solutions, among other sections. There is a subtle distinction to be observed here: a poorly conceptualized proposal can be written correctly, in the narrow sense of being free of mistakes of grammar and usage, but nevertheless may fail to present a persuasive and convincing argument for funding. Moreover, generalities in the research narrative are not as easily fixed as are some of the more common problems associated with a proposal that can benefit from a good editor. An editor can help revise an existing narrative for greater clarity

and organizational structure, but cannot provide the competitive conceptual content needed to persuade reviewers to fund the project. This explains why generalities present a very serious and often fatal threat to the competitiveness of a project narrative: ***they arise from a basic conceptual problem rather than from an editorial problem fixable by rewording existing text for clarity and succinctness.***

The root cause of generalities in the research narrative is most often a failure to fully develop and mature the research ideas in the proposal itself. As the due date looms, it becomes critical to decide whether or not this failure can be corrected in time. It is not a problem fixable by a deep edit because the core ideas are not fully developed and are absent in the proposal itself. ***Editing cannot fix something that has not been expressed in the narrative to begin with.*** Attempting to do so would represent nothing more than what is commonly known as a "***mortician's edit***"—minor cosmetic improvements to a lost cause similar to rearranging the deck chairs on the sinking Titanic. Problems associated with an overly generalized project description have to be corrected by the proposal's authors. It is not a trivial task and requires that the ***principal authors perform a deep conceptual edit and rewrite*** of the project narrative whereby the missing specificity and detail are added and the ideas more fully matured. Sometimes this is possible before a deadline arrives; often it is not.

Fundamentally, generalities rob the narrative of the valuable space needed to make a convincing case for funding. ***Generalities are the ultimate freeloader in a project narrative.*** They bring nothing of value to the narrative, but rather suffocate it by substituting the dispensable for the essential; by substituting the unfocused for the focused; the amorphous for the specific; a directional fog for directional clarity; boilerplate for contextual detail; silos for synergy, synthesis, and integration; and by too often substituting slogans, buzz words, and jargon for ideas. Generalities devalue the currency of good ideas well stated.

These problems may be correctable if they are not pervasive and if they are diagnosed in time; however, the only real antidote requires an acknowledgement that the narrative lacks a clear and fully developed conceptual framework and is so heavily burdened by generalities pretending to be significant ideas that major and substantive rather than cosmetic doses of clarity, specificity, and detail are needed to transition the narrative from certain failure to potential success. This is neither an easy nor a trivial task to accomplish.

Detection of offending generalities in the narrative is an important first step in saving an otherwise likely doomed narrative. For example, many proposal solicitations directly or implicitly require a discussion of the problem being addressed in the research narrative. ***Describing the problem succinctly, judiciously, and proportionally is key.*** For example, if you are writing a CAREER proposal in physics, do not assume that you must explain the key role played by the study of the hydrogen atom in all of twentieth-century physics as background to your proposed research. Or, if you are proposing research related to global warming, do not spend time discussing the concepts of a spherical earth starting with Pythagoras. Reviewers will assume the earth is a globe. While these examples are amplified for effect, they represent one common failing of the too generalized project description.

Perhaps the generalities in a project narrative most difficult to correct appear when the narrative passively poses but fails to explain research questions, program goals, or project activities. For example, a narrative may fail to explain why the particular questions, goals, or activities described have been selected, what might be their significance or value-added

benefits to the field of study, how they will be accomplished; and what possible outcomes and impacts they may have on the field. Generalities in the core research narrative too often signal a project that has not been fully conceptualized at the level needed to be competitive. One telltale sign of this failure appears in a research narrative, at both the section and paragraph level, that does not first describe a specific goal or goals, and then describe with more detail and specificity such key ingredients as the objectives, rationale, approach, impact and significance of the proposed activity.

While both writing and organizational preferences will vary by author, persuasive writing at any scale (proposal, section, paragraph, sentence) will be characterized by clearly describing for readers and reviewers: (1) what you will do, (2) why you will do it, (3) how you will do it, (4) why it is significant, and (5) the value-added benefits or impact of doing it. These five generic questions will often be complemented by other core questions specific to a solicitation. However, too often in the poorly elaborated research narrative, the author disproportionately addresses the background of the research question being posed, overly elaborates on the current literature in the field, and woefully fails to address the foregoing five core questions in ways that clearly illuminate the value and significance of the proposed research.

Moreover, on large proposals such as LTGs, particularly center and center-level proposals to NSF, key program elements must be established in addition to the research core, such as components addressing educational activities, diversity, innovation, dissemination, societal impacts, management, and evaluation and assessment, specific to the particular program and solicitation. An overly generalized narrative addressing these components can be just as detrimental to success as overly generalized research descriptions.

In these cases, overly generalized text may indicate that the required components are outside the experience and expertise of the core researchers developing the proposal, suggesting that the researcher may be thinking, "Evaluation and assessment? How hard can it be? I can make this stuff up. After all, it's just an input/output problem." Components requiring expertise from the social and behavioral sciences or education will almost certainly require input from faculty in those disciplines with a research and publication track record relevant to the specific component. Moreover, if a proposal requires a research-enabled social science or research-based educational component, ***keep in mind that social and behavioral sciences and education faculty are not disciplinarily fungible***. Asking a social scientist or education researcher to join a proposal who does not have a research track record and relevant publications will not solve the problem of overly generalized narrative components.

Here, too, the absence of specificity and detail are the telltale signs of research ideas insufficiently developed to give a proposal a competitive chance at success.

Do Not Build Your Proposal out of Spare Parts

Learning how to develop and write successful proposals begins with gaining an understanding of some of the key generic strategies that enhance the competitiveness of proposals regardless of discipline or agency, or scale and scope. These core generic strategies form the necessary foundation for presenting your research idea in the best possible way to program officers and review panelists. The counterpart to understanding successful strategies amounts to understanding unsuccessful strategies, or unsuccessful practices that diminish the competitiveness of your proposal by obscuring your research idea in a patchwork research narrative .

In fact, a list of common mistakes, or common misconceptions, made in the development and writing of proposals of all sizes can be of enormous value in helping investigators continuously improve the success rate of their proposals in a difficult funding climate. This information may come from a senior faculty member with a history of both funded and unfunded proposals, or it can come from research development and grant-writing professionals who have benefitted from working with highly successful researchers on successful proposals of all sizes, especially LTGs in which many component parts comprise the center narrative.

The most successful faculty researchers tend to be those whose success in funding begins with smaller grants of a few PIs and grows over time to research centers or other LTGs. These researchers can develop a capacity to frame the development and writing of the proposal by thinking strategically about every part of the proposal narrative, from the overarching vision statement to the smallest details that illuminate the research team's capacity to perform.

Faculty transitioning to LTGs can learn from successful researchers that successful proposals represent new and exciting ideas originating from the PI and the PI's research team, or as NSF and NIH might characterize the research, it must be "***transformative***" research. ***This requires that the research narrative be as close to perfect as possible***—perfect in its vision, perfect in the operational details that advance the vision, perfect in its synthesis and integration of all component parts with the overall goals and objectives, and perfect in every section and subsection required to respond fully to the solicitation.

Therefore, it is important ***not to be tempted to use spare parts from older proposals*** (successful or unsuccessful), or information archived in database files, or narrative text created as so-called boilerplate by known or unknown authors. While writing a successful proposal narrative that advances new ideas in a compelling way is hard work, it cannot be made easier by the use of off-the-shelf text or boilerplate text written by others. On the contrary, ***it can be significantly harmed by that practice.*** Moreover, your career can be significantly harmed by the practice as well. NSF's Office of the Inspector General, for example, conducts audit investigations related specifically to identifying plagiarism in proposals submitted to that agency. You want to avoid NSF's "*perp walk*" audit for plagiarism because the consequences are severe.

In specific terms, ***the use of boilerplate imposes a distorting structure on the proposal narrative*** that should evolve logically, consistently, proportionally, and integratively from a core research idea. This consistency should apply to the ideas advanced by the principal author as well as the language patterns and structure used by the author to describe those ideas.

Unfortunately, no anti-rejection drugs exist to ameliorate the harm done by attempting to transplant boilerplate text into a proposal in hopes of making it more successful. In the successfully crafted proposal narrative, ideas and language interweave to create a coherent and seamless synthesis. Boilerplate or recycled text will destroy the needed symmetry at all scales.

What else is not a successful proposal? Edited collections of many short articles, or sections, written by an army of authors, some known and, in the case of boilerplate, some unknown, lacking a coordinated evolution of the research ideas, will not meet with success. Unfortunately, however, once a proposal narrative has been built in a way that reveals gaps between sections, parts, or topics, renovating that inchoate narrative will require significant time and energy. If a researcher also introduces boilerplate into the proposal narrative, either verbatim or modified, she will push the narrative structure further in the direction of a crazy quilt of ideas rather than a seamless integration of text and ideas. In many ways, the use of boilerplate text is akin to distributing a few counterfeit bills among the legal currency you use for cash purchases. At its worst, boilerplate text may come near to flirting with unintentional plagiarism, depending on the source of the text, and it is certainly not something federal research agencies would expect in a proposal that represents itself as a persuasive argument for the significance and merit of the proposed new research.

Having understood the disadvantages of boilerplate text, it's worth taking a moment to ensure that we all understand what this term means. Most successful PI's don't use this term (or the text itself), but inexperienced and eager researchers may use it. While various professions may use the term to refer to various types of text, ***in most cases it refers to inferior, off-the-shelf writing, often of unknown and dubious origin, that operates as a static, plug-in set of phrases, sentences, paragraphs, or conceptual outlines. By definition, boilerplate fails to change or to reflect the evolving set of ideas associated with the successful proposal.***

Boilerplate is frozen in time, whereas the successful research proposal originates with a good idea that evolves during the development and writing of the proposal narrative to make an original and compelling case for funding. Moreover, ***even the most excellent writing has a very short shelf life***, perhaps a matter of months. In fact, most often by the startup period of a grant, perhaps six to twelve months after the submission of the proposal, the successful narrative is typically dated and showing signs of age. If you are maturing research and educational ideas, then the ideas you have six months from now should be more robust and better explicated than the ones you have now. ***Do not encumber your good ideas with spare parts developed by someone else with absolutely no knowledge of why your ideas are significant and how best to configure those ideas within an integrated proposal narrative.***

When the term "boilerplate" in used by those who develop and write proposals typically within private sector consulting firms (engineering, architectural, scientific, etc.), then it typically refers to a description of past performances on similar projects in a capabilities section of the proposal. This recycled language is used to bolster the case that a contract awarded to the applicant would once again result in successful deliverables of one kind or another. However, when the term begins to migrate from contract work into proposals describing exploratory and transformational research to federal agencies, ***it has crossed a boundary from an appropriate use of the term to an inappropriate one***.

While faculty should avoid boilerplate, they can become knowledgeable about successful models for some of the common sections required in a proposal, particularly in LTGs, such as those related to institutional infrastructures, access to equipment, instrumentation and facilities, plans for undergraduate research or postdoc mentoring, management plans, diversity plans, data management plans, and the like. Descriptions of these resources may be adapted judiciously to inform possible topic points but not as transplanted text that disturbs the context of the proposal narrative. Boilerplate is like the mini spare tires that come with new cars: it is not intended for use on your extended research journey.

Bottom line: if you are proposing new research ideas, express the significance of those new ideas, and all topic components of them, in newly-crafted writing for every word of the proposal narrative. Success in proposal writing will not be achieved using after-market parts—***successful proposals are not renovations of the past but a creation for the future and the compelling arguments you make for the place and significance of your research ideas in that future***.

Echo but Don't Parrot Agency Language

Researchers benefit from becoming fluent in the language used by federal agencies and foundations to describe their overall research and educational investment priorities. Researchers also benefit from understanding the agency language, or dialect, used at the specific program level. This fluency can easily be gained ***in your disciplinary area of interest*** by reading solicitations, reviewing agency reports and program roadmaps, linking to agency webinars, reviewing reports of agency sponsored workshops on emerging research areas, and talking to program officers, among others.

For example, such terms as "sustainability, innovation, research ecosystems, transformative research partnerships," and countless others may be used by one or more federal research agencies, but the meaning of these terms will often have an agency-specific "flavor." Moreover, in many cases, research units within a large agency such as NSF, DOE, NIH, use a language unique to that unit. For example, if you plan to submit an ERC to NSF you will want to understand the "language" of the three plane diagram. The differences in language and definitions of research terms can be subtle and nuanced across agencies or clearly distinct, but it is important to be aware of them. It is also worth noting that the language and definitions of terms used by agencies evolves over time. For example, the umbrella term "broader impacts" at NSF has evolved and expanded significantly over the past decade and continues to do so.

Following these changes in meaning becomes particularly important as proposal solicitations become more multifaceted and transdisciplinary. While fluency in agency dialect is especially critical when working on center and center-level proposals, it has become necessary at all scales of the research enterprise. For example, many smaller research and education solicitations are often linked to an agency's entire research portfolio that addresses overarching research themes through large integrative center structures as well as through smaller, more narrowly focused programs. Specially defined terms may occur at either or both the narrow or the broad end of an agency's research spectrum.

Understanding agency language becomes critical at transitional points in a researcher's career. Principal investigators transitioning from highly focused, single-PI research grants to larger multi- or transdisciplinary research proposals need to be able to use agency language to describe and define their new, overarching research agenda, ***particularly the integration of multifaceted components from intellectually distinct research and/or educational domains***. In the area of research and educational grants, PIs who have included small-scale educational components in past grants but who wish to steer their efforts towards center-level grants will need to gain a level of fluency in the language of educational programs of various types as they navigate that change.

The researcher gains fluency in funding agency language to ensure that she will write the proposal narrative using the same concepts and the same understanding by which the funder describes the research and/or educational objectives it considers worth funding. Moreover, a common language becomes especially critical on multidisciplinary efforts to ensure that the leaders of the discipline-specific research strands that form an integrated whole can write an internally consistent research narrative that speaks to the entire research team, and thus communicates a common understanding to the reviewers and agency program officers.

Without a common language, it becomes all too easy to write a disassociated research narrative or a stove-piped collection of sections.

Let's take as an example of special language the use of the term "sustainability research." Its meaning will differ by funding agency, as well as by programmatic areas within agencies. If you direct your proposal to NSF, however, the language and terms you use to discuss the sustainability topic in the research narrative must reflect NSF's view of sustainability, generally captured by the following: "A number of general concepts underlie the science of sustainability, including complexity, emergent behavior, multiscale processes, and adaptability and resiliency in coupled, human-environment systems**."** In this example, your fluency in the use of agency language and terms would involve an understanding, likely by further investigative reading of NSF materials, of the full scope and scale of NSF's use of these terms and their interrelatedness. Once you have completed this investigation, you will become better able to map your research expertise to the agency's research objectives by ensuring that you use language in the project description that reflects or echoes the agency's (review panelists, program officers) use of the same language.

While it is important to achieve fluency in funding agency language, it is equally important to avoid parroting that language. A faint echo of agency language ***in the appropriate context*** will ensure that agency review panels and program officers recognize that the applicant shares with them a common understanding of central concepts and assumptions. Unfortunately, some programs and solicitations within agencies occasionally use descriptive language insufficiently grounded in examples or specificity and hence read more like a series of superlatives, or a train of slogans. But since superlatives, or slogans, are not ideas, their use should be avoided at all costs in grant writing, as well as program solicitations. To paraphrase Shakespeare's Macbeth, superlatives are "full of sound and fury, signifying nothing."

Vague, superlative-laced language can occasionally appear in new program solicitations that seek to weave together new disciplinary partnerships or explore new areas of research. Unfortunately, agency program officers may occasionally craft poorly written solicitations, or substitute superlatives and slogans for insightful specificity, or fail to know exactly what they seek as fundable research in a specific program area. ***In many cases, grant writing, like life, can be awash in ambiguities, and this uncertainty can creep into the language and terms used by both writers of proposals and writers of solicitations***. Guard against this ambiguity in your proposals. You can prevent this by becoming sufficiently fluent in the language and terms used by funding agencies to describe a specific research domain. Achieving fluency should not prove to be particularly onerous or time consuming, ***but it will pay great dividends by increasing the clarity of your research narrative, thereby making it accessible to reviewers and program officers.***

Interviewing Schrödinger's Cat: Eradicating Ambiguity

Ambiguity introduces significant uncertainty into the research narrative, although ambiguity in the narrative does offer one certainty—***an unfunded proposal***. This is because ***ambiguity in the project description imposes unwanted riddles*** on program officers and reviewers alike that may lead them to believe reading the research narrative is an experience somewhat akin to interviewing *Schrödinger's Cat* without opening the box to determine its state, either dead or alive. However, narrative ambiguity exists in only one state—***confusion***.

Ambiguity originates from many sources, including ambiguous solicitations and researchers' ambiguous readings and (mis)understandings of a well-crafted solicitation, the latter being the most common source. Ambiguity may also originate at the interface between the agency's research vision, goals, and objectives and your research expertise and research interests. Ambiguity may arise when your research expertise does not map well to the agency mission priorities, or when you engage in some wishful thinking and try to force fit your research expertise and interests to an agency solicitation, or when you ignore the agency research interests and put yours forward in hopes the program officers and reviewers won't notice the mismatch.

As the physicist Richard Feynman once commented, "*The first principle [in science] is that you must not fool yourself - and you are the easiest person to fool*." This is also sage advice to follow when you are tempted to view a solicitation as a mirror of your own interests rather than as a reflector of the agency's interests.

Unfortunately, ambiguity in the proposal process is like Whac-A-Mole, raising its ugly head throughout the proposal landscape. Ambiguity has the potential to lurk in every crook and cranny of a proposal, and eternal vigilance is needed to root it out, ensuring that it doesn't metastasize throughout the project description. ***Regrettably, ambiguity is a scalable scourge***. It can infect an abstract, a project summary, a section of a proposal, or the entire proposal. Larger proposals, partnership proposals, and proposals with multiple PIs representing multiple disciplines can often become a spawning ground for ambiguity. It is entirely appropriate in ***writing and editing a proposal narrative*** to adopt a rallying cry as strongly felt as the "*Live Free or Die*" motto seen on New Hampshire license plates. Perhaps "***Eradicate Ambiguity***!" would suffice for the research development and grant-writing personalized license plate.

Other favorite hiding places of ambiguity include proposal planning and development meetings, proposal outlines and templates, draft narrative sections, emails among participants, visuals and graphics to amplify the text, as well as wherever communications among proposal team members take place, regardless of team size. In fact, ambiguities are the grant-writing equivalent of termites in wood, silently and relentlessly destroying the structural fabric and logic of the proposal narrative.

If this problem is not identified and corrected prior to submission, program officers and reviewers, who in this case can be seen as inspectors called in to examine your proposal, will determine that, unbeknownst to you but obvious to them, your proposal is "full of holes," created by linguistic termites identified as various species of the genus "*ambiguous*" and thereby to observe that your proposal needs an "ambiguity exterminator" to correct the problem if a resubmission is being considered.

Of course, the two archenemies of ambiguity are simplicity and clarity, keeping in mind Professor Albert Einstein's observation: "*If you can't explain it simply, you don't understand it*

well enough. Most of the fundamental ideas of science are essentially simple, and may, as a rule, ***be expressed in a language comprehensible to everyone*****.**" Unfortunately, some authors consider ambiguity as evidence of their own brilliance, making it difficult to suggest that clarity is needed where the author sees only dazzling prose (See *Observations on Critiquing a Proposal*, March 15, 2012). Very rarely does the ambiguity in a research narrative approach the heady sort described by the late physicist John Wheeler-- "*If you are not completely confused by quantum mechanics, you do not understand it." A more apt guideline will suggest that if reviewers are even slightly confused by your proposal, they will not fund it. Reviewer confusion is the progeny of ambiguity in the research narrative.* Moreover, ambiguity is a problem that defies narrative integration and synthesis, two key characteristics of successful proposals.

Given the above, the best way to expunge ambiguity from a project narrative is to first clearly understand the expectations of the research sponsor as defined in the solicitation, and then draft an organizational template and outline of the project description to guide your writing of draft iterations. Use the template as both a guide and a prophylactic, or linguistic vaccine, to prevent ambiguity from occurring rather than trying to treat it after it has infected a completed proposal.

In many cases, ambiguity can arise in proposal development meetings, or afterwards, as in the children's "telephone game" in which one person whispers a message to another, passing stepwise around a circle of people until the last player announces what typically has become a wildly changed sentence or phrase. Team meetings, particularly those in which so-called brainstorming is encouraged, are fertile ground for ambiguity. In part this is because verbal communication lacks the permanence and logical structure of written language, and so has a half-life measured in days or even hours.

In the end, the cure for ambiguity lies in writing multiple drafts of a narrative, taking care that each iteration of the proposal improves its clarity and eliminates ambiguity. ***Expunging ambiguity from the proposal is as important to the proposal team members as it is to the final reviewers***. On multidisciplinary efforts, it is next to impossible to write an integrated project narrative that achieves the needed research synergy and value-added benefits when the contributions of research team members are bedeviled by ambiguity rather than clarity at the disciplinary boundaries.

Graphics as a Narrative Integrator

Just as the Feynman diagrams brought clarity to understanding the interactions of subatomic particles, on a less grand scale, diagrams, graphics, figures, tables, pictorial representations, and other visuals play a role, albeit too often overlooked, as an integrator of the research narrative. This holds true particularly in the case of complex project descriptions whose narratives describe interaction among multiple research strands. Good writing forms the underpinning of any successful proposal, which explains why grant-writing workshops, faculty grant mentors, and proposal development professionals all emphasize the importance of writing well.

The same advice is not always given, unfortunately, for the use of visuals as a complement to and integrator of the narrative text. The graphical representation of a research vision, or diagrams that show how the component goals and objectives of a large research project relate and interact together to form a coherent, synergized whole, can make the ***proposal narrative less challenging both to write and to read***. In fact, graphical representations of the main ideas of a proposal discussed and developed concurrently with the drafting of narrative text, can help the members of the research team write their contributions to the overall narrative with more clarity and focus than might otherwise be possible. The end goal, of course, is to achieve a project description that integrates narrative graphics and narrative text so closely as to make both easily accessible to review panels and program officers, especially in those cases where complex interactions among various research strands must be accessible and memorable. ***Good ideas deserve and benefit enormously from the illuminating interplay between well-crafted narrative text and accompanying graphics.***

Graphics can play a critical role in proposals of any size, but become increasingly important in large research proposals describing how the integration of multiple research themes achieves a synergy impossible without the value-added benefits that occur at the intersections and interfaces among research subtopics. The melding of graphical skills and writing skills can energize a research narrative. Moreover, the graphics provide a visual reference point for reviewers as they read the typically 15 to 40 pages of text required by the specific solicitation. Graphics can quickly illuminate the key points of intersection among the research topic descriptions and clarify the interrelatedness of topics in ways that can be quickly understood. Even in well-written proposals, it can be a challenge for readers and reviewers to ***capture and hold*** an understanding of 3, 4, or even 5 research strands that will be integrated into a coherent research vision.

Narrative text is linear. It is grounded on a logical sequence of explanation made coherent and persuasive by the author's writing skills. Graphics, however, function as a "***visual language"*** able to capture complex relationships in a simple and unifying way; hence the importance of the Feynman diagrams to physics for nearly 65 years, or, more recently, the use of computer-generated visualizations as a way of understanding huge datasets, ranging from the atmospheric sciences to petroleum engineering, among myriad other examples. With this in mind, high-quality graphics can make a significant contribution to the overall success of a proposal by offering a robust counterpart to the narrative text that serves to communicate the core research idea to reviewers and program officers in an alternative and memorable form.

It is particularly important when working on large proposals to identify early any graphics expertise that may reside within the research team or any research office that may

help with the proposal. Do not wait until a full draft of the proposal narrative starts to cry out for graphical support. Graphics, like the narrative text, need to be developed in tandem with the evolution of the vision, goals, and objectives of the research plan, and the text and graphics need to be logically intertwined to gain the potential synergy inherent within them. Moreover, just as you wouldn't write a proposal using spare parts from other proposals, don't borrow graphics from other proposals, or, worse yet, look around in a clip-art library for your visual materials.

Always keep in mind that the role of graphics is to deepen the understanding of the research ideas being proposed in the narrative text and to illuminate the interrelations among them in a simple and clear way. Graphics should function as a proposal integrator. Given the significant benefits of well-planned and well-crafted graphics to the success of the proposal, it is important that members of the research team give the integration of graphical information into the narrative text the consideration it is due as a potentially valuable contribution to a proposal's success.

Too Much Data?

Winston Churchill was once asked during the Cold War why he refused to fund additional nuclear weapons to increase the British stockpile. He replied that their only purpose "would be to make the rubble bounce." Similarly, the successful proposal relies on knowing the difference between sufficient and excessive information to ensure the wise use of allocated space and an appropriately balanced project narrative. For example, knowing how much background information--technical detail, preliminary data, etc.--will satisfy your readers is a key factor in writing a well-balanced proposal narrative. Finding this level is not always an easy task.

This is particularly the case when writing an institutional proposal of the type discussed in the companion article in this newsletter (*Value of Institutional Transformation Proposals*). These types of proposals, in particular, can lend themselves to data excess with the result that the proposal ends up looking more like an Excel document than a Word document. Sometimes the project narrative can be distorted by a blizzard of data used to substitute for a clear sense of precisely those data needed to best support a specific argument. But blizzards will not convince reviewers to fund the proposal.

Finding the right amount of data is somewhat like the trial and error test used by pasta chefs that gave rise to the expression "throw it against the wall and see if it sticks.". The tactic of throwing excessive data at a proposal narrative assumes that, if you throw all the data you have at reviewers, then surely something will stick, convincing them to recommend your proposal for funding. This is not a good bet. If the author of a proposal does not clearly know why some data are important to include and other data are not, then it is wishful thinking to assume the reviewers will take on this responsibility.

Excessive data in a proposal often appear when the solicitation leaves it up to the proposal author to select those data needed to make a case for funding rather than specifying which data do and do not need to be included. Of course, when solicitations are highly prescriptive about the data an agency wants to see in the proposal, then the task is fairly straightforward, at least it is if some office at your university actually gathers and keeps the required data in a usable format. In the case of institutional transformation proposals, the solicitation may require some specific core data, but leave the inclusion of most other data up to the principal investigators. Of course this forces you to think very carefully about which data you actually need to make your case. They may be fairly extensive, but they may not, depending on the proposed programmatic activities.

For example, it is often the case in institutional transformation proposals, as well as in research center grants that may include institutional transformation components, that the data used to support your arguments are self selected (as opposed to agency prescribed) based on the programmatic activities you propose and such supporting factors as your success in past efforts that demonstrate your capacity to perform. However, keep in mind that institutional and programmatic performance data or research data are used to support arguments you make in the project narrative specific to what you will do, why you will do it, why it is significant, its value-added contribution to the field, and why your past performance and expertise will contribute to the proposed project. Supporting data need to be tightly aligned and focused on your research goals and objectives to make the case to program officers and reviewers that your proposal merits funding. Just as you would not make arguments in your project narrative

that do not clearly advance your case for funding, it is equally important that you exclude data irrelevant to the goals and objectives you describe. Unfortunately, researchers are often tempted to add more rather than less data.

It is important to be mindful of reviewers' reluctance to sift through extensive data to determine the merit of your proposed project. That is not their job. It is the job of the author, however, to explain the significance of any data used in a narrative in the most economical way possible. A blizzard of data is likely to give reviewers a "brain freeze," along with heartburn. Proposals are about ideas, and data need to be judiciously selected to support the merit of the ideas described in the narrative. ***But data in and of themselves are not ideas***. Rather, your narrative needs to explain and illuminate the significant patterns in the data you present rather than push that task onto reviewers. In a sense, project data can be thought of as three-dimensional coordinates that more precisely characterize your position than would be possible otherwise.

In this way, project data complement the narrative text and visuals. But be judicious in the use of data. Consider when data are best woven into the narrative arguments and when they are best presented in tables or other representational formats, such as bar charts. Too much data presented in the narrative text can quickly make it dense and impenetrable. The point of using data is to numerically illuminate and support your arguments, not to send reviewers in search of an Enigma machine to decode your narrative.

In your final review of a proposal before submittal, examine the narrative for verboseness and any lack of proportional balance in its allocation of space. This also applies to data.

No Tweaking, No Nudging, No Band Aids: Re-writing the Declined Proposal

When researchers consider whether or not to resubmit a declined proposal, they often mistakenly assume that "tweaking" the original narrative in response to reviewers' comments will make it competitive. However, in most cases, declined proposals are not next in line for funding if only sufficient money could be found to fund one more worthy project. While Band Aid solutions to declined proposals may take significantly less time for all involved in the resubmission, they amount to the least competitive resubmission strategy possible. Tweaking in response to rejection underestimates not only the amount of work required to salvage a declined proposal but also the degree of improvement over the original that will be required to achieve competitiveness.

For example, if the funding rate for any particular program, say at NSF, is 10%, then a declined proposal has been ranked among the 90% that were not funded. So, for every 100 proposals submitted to a program that funds 10% of applicants, your declined proposal puts you among the 90% of unfunded applicants. In this example, you have absolutely no way of knowing precisely where your proposal is ranked among those not funded. Was your declined proposal 11th or 100th in line for funding? Where exactly did your declined proposal fall along the number line from 11 to 100?

You might glean some information from the reviews that will give you confidence in making some ***very general assumptions*** about your proposal's competitiveness, particularly at agencies that provide an overall numerical score as compared to agencies using a ranking system with terms such as "excellent", "very good", "good", "fair", and "poor", or some variant of these. Regardless, when a proposal is declined, the ambiguity and "noise" in the review system make it all but impossible to determine how close you actually came to being funded. It's therefore prudent to assume that the further your declined proposal sits from "next in line for funding," the less appropriate it is to apply such minor fixes as tweaking, nudging, and Band Aids in hopes of achieving a competitive metamorphosis. Magically turning a frog into a prince works in Brothers Grimm fairy tales and Disney movies, but not so well in research narratives.

Moreover, your competitors for the next program due date likely will include a significant number of the 90% of those whose proposals were also declined in the last competition. It's therefore prudent to keep in mind the old adage that success is 10% inspiration and 90% perspiration, or, as Thomas Edison said, "many of life's failures are people who did not realize how close they were to success when they gave up."

In proposal writing, not giving up most often means refusing the easy road of tweaks, nudges, and Band Aids in an attempt to save time and effort. Those who transform a declined proposal to a successful proposal in the next competition will likely be those who put in the hard work, or perspiration, of transforming the declined proposal into an essentially new proposal. After all, the goal is a metamorphosis of the declined proposal into a funded proposal, or transitioning a somewhat nondescript chrysalis sac into a beautiful butterfly. ***The most likely outcome of using tweaks, nudges, and Band Aids on a declined proposal is nothing more than turning a previously declined proposal into a newly declined proposal.***

If a compelling idea is disguised in a declined proposal, ***set it free by unshackling it from the original project narrative*** so that it might better flourish in a new project narrative that both addresses the reviewers' comments and reflects the growth of your research idea since the last submission. If a research idea has remained static over the year between annual due

dates, then the new submission will lose its competitive edge. Successful proposals advance new ideas in the context of a disciplinary field that is also rapidly advancing. Tweaks, nudges, and Band Aids characterize static research rather than compelling research.

Moreover, the structure, logic, rationale, and arguments advanced in a declined proposal should be assumed insufficient for a new effort. After all, they were rejected by the reviewers in their original version. Unfortunately, proposals have the shelf life of refrigerated fish, degrading rapidly after the date of submission and soon becoming obsolete. A declined proposal requires a deep rethinking of the research ideas and how to best present them. ***That means starting anew.***

The Role of Context in a Successful Proposal

A fundable idea will be compelling in its significance to the field and/or will bring important value-added benefits to the funding agency's mission. Funding agencies don't fund small ideas offering small advances to the field, or modest value-added benefits to the agency's mission-critical objectives. Agencies want to fund [pick your superlative: *exciting, game changing, big, novel, transformative, innovative*…] ideas.

You will therefore want to write the project narrative keeping in mind reviewers' interest in how your ideas could impact the field, and/or how they will bring value-added benefits to the agency's objectives. The reviewers will base their assessment of your proposal on your ability to demonstrate its significance relative to those comprising the current state of the field, or the agency's mission context.

In this regard, keep in mind that significance and value-added benefits must be demonstrated within the context of an agency's mission and of the current state of knowledge in your discipline. They will not be demonstrated by bestowing glowing adjectives upon your own ideas, or by making unsupported claims about the novelty of those ideas in the current state of the field. If glowing adjectives appear at all, they should be found in the reviews, not in the proposal. Reviewers may bestow superlatives upon your proposal, but they must never be self-bestowed. The detail and specificity of the disciplinary and agency contexts within which you position your ideas will illuminate the importance of your proposed research far better than any undemonstrated claims you may make about its merits

Moreover, it is common for authors of research narratives to over-write the general background narrative and under-write the research context narrative. While understandable, this tendency can seriously weaken a proposal. ***It is often easier to write a general introductory background to the research field than it is to describe the importance of the proposed research in the context of the current state of the field.*** The context that needs to be described in your research narrative and the place of your research in that context should reveal how your ideas lie at the cutting edge of the field. After all, research agencies fund projects that advance the field in some significant way.

Consequently, to increase the chances that reviewers will attach glowing adjectives to your research ideas, they must understand the place of your ideas in the context of the field's current state. This places several requirements on the author of a research narrative: first and foremost, the researcher must demonstrate a clear knowledge of the field's current state, or the current state of the agency's mission-critical objectives, and must be able to describe that current context clearly, succinctly, and convincingly to reviewers. It also requires that the author of a research narrative present a vision that advances the field in some important way, and to make that case to reviewers in a clear, succinct, and convincing narrative.

In turn, this requires the author of the research narrative to make several judgments: most importantly, the researcher must calibrate the description of the research context to the expertise resident on the review panel, both to individual reviewers and to the group as a whole. This calibration holds the key to success. If the description underestimates reviewers' backgrounds, it squanders valuable space in a page-limited project. However, if the description of the research context appears technically inaccessible to some or all of the reviewers, it will also diminish the proposal's competitiveness. The proposal's author must first make a reasonable assessment of the general level of research expertise on the review panel and then

must describe for that panel both the current state of the research field and the place of the proposed research in that context in clear and simply stated language.

Three items should appear in a clear statement of how the proposed research will advance the field: (1) a description of the principal investigator's fully integrated research vision; (2) a judicious number of citations woven precisely into that description; and (3) a clearly written statement illuminating the disciplinary context within which the research will be performed, revealing to reviewers how your research ideas will contribute to the field and therefore merit funding.

From Silos to Synergy: The Yellow Brick Road of Grant Writing

Much has been written and presented on the topics of team science and the science of team science (**Google, for example**: *NIH Collaboration and Team Science: A Field Guide, NIAID Opportunities and Guidelines to Facilitate Scientific Collaborations, NSF Profiles in Team Science, The Science of Team Science: Origins and Themes, and Burroughs Welcome Fund Thriving In An Era Of Team Science,* among hundreds of other contributions to the literature of this field). This commentary typically converges on common denominators and generic best practices relevant to these two topics. However, the toughest nut left uncracked is the very practical one of ***how does successful team science impact, or translate to, the writing of a successful LTG proposal***? Successful in this context means a funded LTG, or at least a highly competitive proposal hugging the funding line sufficiently closely to warrant confidence in a successful resubmittal.

Defining the key characteristics of the successful research team--shared vision, compelling ideas, leadership, trust, communication, interpersonal dynamics, etc.--obliquely addresses issues that will be critical if the research team is to develop and write a successful proposal. However, success will depend upon a very specific and detailed understanding of how the research narrative of an LTG proposal differs from the research narrative of the individual PI proposal, or a proposal that aligns but does not need to integrate a few PIs.

Keep in mind, too, that many members of an LTG proposal come to it by way of funding success as an individual PI or as a member of a funded proposal with a few PIs, but likely not with experience at the scale and scope of a large interdisciplinary or transdisciplinary proposal. By their very nature, LTG proposals involve high award dollars; complex, interrelated research topics; and a challenging research development and grant-writing process. Regardless, the best advice to beginning the team science proposal was given to Dorothy in the Wizard of Oz: "Follow the Yellow Brick Road."

The Yellow Brick Road of grant writing, however, is not a path from Munchkin Country to the Emerald City of the Wizard of Oz but rather ***a path leading from silos to synergy***, the latter being the Emerald City of the successful LTG. Moreover, the path from silos to synergy is likely the most challenging road traveled by the author of a funded proposal. As a core goal of the successful project description, narrative synergy is central to a successful proposal, particularly as solicitations address research objectives that require multi- or transdisciplinary teams aligned in often novel configurations.

Moreover, the degree to which a proposal narrative is siloed often is a function of how wide an interdisciplinary net needs to be cast in order to be competitive for a specific LTG solicitation. For example, some research requires only an individual principal investigator working in a very narrowly defined topic area to be competitive, while other research solicitations may require aligned but not integrated research activities by a few principal investigators, whereas still other proposals of a transdisciplinary nature require a deep synthesis of the research contributions of team members.

The ideal foundation of narrative synergy is an integrated research team characterized by a substantive understanding among team members of the role each member's research plays in the overall effort. However, something less than that ideal is the more common occurrence in developing and writing research narratives whose success depends heavily upon the skillful description of the value-added benefits resulting from disciplinary synergy.

Unfortunately, most proposal drafts begin with multiple silos contributed by multiple authors, and from that starting point, the somewhat arduous path from silos to synergy begins.

Synergy begins with a connectedness deepened by integration. Some synergy is brought to the proposal development process by the selection of the research team itself in order to fully respond to the solicitation; however, this initial synergy significantly deepens and broadens from the interaction of the team members in planning and writing the research project description, particularly as the scale, scope, and synthesis of the project vision, goals, and objectives become more fully defined, illuminated, and honed with each draft iteration.

The process of writing multiple draft iterations of the research narrative amounts to a discovery process in itself. It advances and deepens the understanding of each research team member about how to best optimize the configuration of research capacities across disciplines to convincingly demonstrate the value-added benefits of the proposed project to the funding agency. ***The path from silos to synergy is essentially the same path from an unfunded to a funded proposal, or from failure to success in grant writing***.

In its most extreme manifestation, the siloed proposal is easily diagnosed. It essentially reads like a collection of journal articles written by independent authors with no connection to each other beyond the most generic of similar threads around a general topic. In some severe cases, the siloed proposal reads like disconnected journal articles published in different disciplinary journals. Siloed narratives are the geopolitical equivalent of Balkanization, whereby narrative sections inhabit the same proposal neighborhood, but with sufficient privacy fencing to ensure that the narrative sections are essentially estranged rather than interdependent.

Assessing the extent to which a narrative draft is siloed is a key step in moving a proposal along the pathway from uncompetitive or unsuccessful to competitive and successful. Look for several of the tell-tale signs of the siloed proposal, some of which will likely exist in the initial draft and will need to be addressed in each subsequent draft to converge on an integrated research narrative. These signs include:

- The lack of a clearly stated vision statement defining the goals and objectives of the proposed project and serving as the central reference point, or anchor, for each narrative component of the project description. Essentially, synergy requires a conceptual foundation that serves as the center of gravity and ***illuminates the relational framework for the key research topics***. These topics need to be defined as individual research areas and then melded by explaining their key disciplinary intersections, or research integrators, that, in turn, give rise to synergy.
    - Heuristically, this process is somewhat like the use of the Armillary sphere that originated with the ancient Greek astronomers, or the celestial globes used by the Chinese, to help visualize the relational motion of the planets and relational path of the stars, later formalized mathematically by Kepler's planetary laws. While an integrated proposal does not meet this grand scale, ***it is key to understand synergy as the relational framework among component parts rather than just a discrete explanation of each part***. It is the difference between having all the parts needed to build a mechanical clock and the insight into how all the parts fit and work together, the former representing a proposal that is not integrated and the latter a proposal that is integrated and achieves synergy, or, in the case of the clock, accurately tells time.

- Lack of a clear and logical narrative path that binds the research goals and objectives and the underpinning hypotheses together in a way that synthesizes the research elements and clarifies how they contribute to integration.
- The absence of a clearly described interdependency of various sections of the proposal, either among the research strands or between the research section and other required sections of the proposal.
- The lack of narrative synthesis across sections, for example, explaining how one research strand enables another, or demonstrating how the research topics are dependent rather than independent activities.
- The absence of a logically ordered research plan, linked to a milestone chart, that describes the order of the research and clarifies the key points of intersection of the research components that, in turn, give rise to an integrated narrative.
- A draft of the proposal that contains "spare narrative parts" or sections of the research narrative that do not appear necessary for the success of the project or contribute to a better understanding of the integrative aspects of the proposed research.
- The lack of integrative visuals that serve as complementary graphical integrators to the narrative.
- The lack of clarity and the introduction of ambiguity in the research narrative, assuming that what is clear to the authors will be clear to the readers.

The key takeaway, however, is that LTG proposals that can be classified generally as "team science proposals" require a very clear and nuanced understanding of how they differ and to what extent they differ in the development and writing of the research narrative from more traditional grants to ensure the path from silos to synergy is successfully navigated and you arrive at your funding destination successfully--the grant-writing equivalent of the Emerald City.

Integrating PI Experiences from Various Agencies

In today's funding climate, many researchers will be transitioning from writing grants with a single or small number of investigators addressing narrowly defined disciplinary topics to writing larger, interdisciplinary or center-level grants under the umbrella of team science, or LTGs. As these new collaborations form, team members may discover that, while some of them have gained funding experience at the agency to which the current effort will be submitted, others have not.

This is a natural outgrowth of a research climate in which solicitations increasingly address more challenging research questions of importance to a funding agency. For example, the National Academy of Engineering's 14 grand challenges for engineering in the twenty-first century and similar documents have prompted solicitations from various agencies addressing these complex research topics. Many research agencies identify their own research grand challenges and advance them through targeted solicitations, such as DOE's Office of Science 5 grand challenges related to matter and energy. These grants typically feature a scale and scope, as well as funding levels and funding periods larger and more expansive than those with narrower disciplinary bounds.

In this time of transition from more to less bounded disciplinary exploration, the entire research team stands to benefit from a ***discussion of the nature of each member's experience with the funding agency's mission and culture***. A close understanding of that mission and culture should underlie team members' decision of how best to define and describe the project's vision, goals, and objectives in the research narrative. While the PI and some other research team members may have varying degrees of funding success at the specific agency, it is not uncommon that other members of the team have little or none. This uneven spread of experience among team members can be anticipated as a natural outgrowth of solicitations more frequently requiring a transdisciplinary team configuration such as LTGs.

With this in mind, the proposal team might consider beginning its work with an explanation of the agency's mission and culture presented by those team members who have gained the most experience with that agency. ***This presentation will convey the most benefit if it occurs before team members have begun drafting their respective sections of the research narrative.*** In preparing this overview of the agency's mission and culture, the presenters will want to stress the important ways in which the mission and culture of the agency in question differ from the mission and culture of other research agencies where some members of the research team have achieved most of their funding success.

Taking this step will give the team a strong advantage when you consider that a competitive proposal undergoes several key development stages, each of which depends upon each team member's complete understanding of the solicitation in the context of the funding agency's mission and culture. This understanding begins with a reading of the solicitation through the lens of the agency's unique purpose. Insufficient understanding of the agency's particular mission and culture can lead to an insufficient understanding of the solicitation itself, a common Achilles' Heel of unsuccessful proposals. ***Further, in cases where several members of a research team lack knowledge of the agency's mission and culture, development discussions frequently veer off track or fail to adequately target key aspects of the solicitation, or they fundamentally misinterpret the solicitation***. This can make development discussions difficult and time consuming.

For example, suppose a research team has been configured to address some grand challenge area, perhaps sustainability, in an NSF solicitation. Perhaps the PI is well funded at NSF, and maybe a few other members of the team are as well, but several other members of the team have no experience with NSF but rather extensive experience in the topic at such mission agencies as DOE, USDA, and DOD. Perhaps the team also includes one or more members from such disciplines as the social and behavioral sciences, public policy, economics, or communications, among others.

Before beginning discussion of the scale, scope, and proportional contribution each discipline will make to the overall effort, and before discussing how those disciplines must be integrated to achieve a synergistic vision, the leaders must begin by defining a common language for the entire research team. The finding of a common language responsive to a specific solicitation will emerge from all team members' understanding of the mission, culture, and language of a specific funding agency. Without this common language based upon a common understanding, some members may misjudge and consequently poorly express their contribution to the line of research being proposed. In such cases, team members are likely to revert to language appropriate not to the current agency but to agencies with which those members have had previous experience. Setting out a common understanding and common language for that understanding as a first step in the team's collaboration may head off a member's tendency to draw upon familiar but currently inappropriate terms and concepts in drafting their contribution to the emerging narrative.

Given the amount of time that will be required to develop the research ideas and to write the LTG proposal, it is important to minimize the unproductive time spent during that process by ensuring that all team members begin the collaboration with a thorough understanding of the sponsoring agency's mission and culture expressed in a shared language. The key points to include in presenting that mission and culture include such factors as noting the type of research funded by the agency (e.g., basic or applied), characteristics of the agency's merit review process, partnership configurations and characteristics that have proven to be most competitive at the agency, and the scope and scale of interdisciplinarity at the agency, among others. The key point is to understand these issues in the context of the particular agency that will fund the proposed project and not as an artifact of a team member's experience of these factors viewed through the lens of prior success at a different agency with a different mission and culture.

It is helpful at the start of developing and writing large team science and/or interdisciplinary proposals to spend time differentiating the mission and culture of the sponsoring agency from those agencies at which various members have experienced success. Arriving at a common understanding and language for describing the mission, culture, and investment priorities of any funding agency, as well as research program areas within an agency, positions a team to achieve competitiveness at that agency.

The success of an LTG can be undermined when team members assume that their success at one agency can be applied directly to another agency with a distinct mission and culture. Obviously, the preponderance of the research experiences gained by some team members at one agency on a topic such as sustainability will likely transfer in large part to another agency, say from DOE or USDA to NSF. But some smaller portion will not transfer, and since proposals are successful that approach perfection, it is important not to confuse agency

expectations by ensuring that every team member shares an understanding of and a language for appealing to the particular agency sponsoring the proposal under development. In this way, the team can enhance the competitiveness of a proposal by fitting the research narrative closely to the mission, culture, and solicitation requirements of the sponsoring agency.

Saturated Superlatives Clog the Arteries of Proposals

There is sufficient anecdotal evidence from reviewers that saturated superlatives in the research narrative, like saturated fats in the arteries, pose a risk factor for your proposal, ***especially when they are used in a transparent attempt to amplify and intensify and thereby disguise the mundane***. As nongrammarians, we can think of superlatives as adjectives on steroids. While a robust cascade of superlatives about his boxing prowess was often used by boxing great Muhammad Ali to unnerve his opponents, it is language best left to theatricals, Valley Girls, and big wave surfers, but not the project narrative.

Of course, amplified adjectives and superlatives appear not only in proposals that would benefit from a good editor but are seeing their way into solicitations. Even program officers seem motivated to use and invent ever more grand and creative language to describe the scope, scale, and complexity of new research directions. It is as if a linguistic arms race has begun to find adjectives and superlatives of ever increasing megatonnage to sufficiently describe the research sublime. A nonproliferation treaty on the excessive and injudicious use of superlatives in both the research narrative and in some research solicitations seems warranted.

For example, back in the 1990s, solicitations commonly referred to cross-disciplinary and multidisciplinary research. Subsequently, when solicitations commonly began using the term interdisciplinary, the National Academies in 2004 felt compelled to define the term: "*Interdisciplinary research is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice.*" [Committee on Facilitating Interdisciplinary Research, Committee on Science, Engineering, and Public Policy (2004). Facilitating interdisciplinary research. National Academies. Washington: National Academy Press, p. 2.]

More recently, transdisciplinary research and transformative research have become common terms in many research solicitations. For example, in a 2007 report, "*Enhancing Support of Transformative Research at the National Science Foundation,*" the National Science Board presented its findings and recommendations for NSF to enhance its ability to identify and fund transformative research. Based on this report, NSF adopted the following working definition: "*Transformative research involves ideas, discoveries, or tools that radically change our understanding of an important existing scientific or engineering concept or educational practice or leads to the creation of a new paradigm or field of science, engineering, or education. Such research challenges current understanding or provides pathways to new frontiers.*"

So when researchers respond to research solicitations sprinkled with such terms as "transcendent research paradigms" and "holistic synergy", among many other allusive and elusive terms, it is not surprising that some attempt is made to describe their research in a way that reflects the language of the funding agency. This is a reasonable tactic, after all, although to many it may seem like being caught up the linguistic equivalent of monetary inflation. A little bit is good, but too much devalues the currency. This is the case with the use of amplified adjectives and superlatives in the research narrative. A few are permissible when used

judiciously, but the author must guard against inflationary linguistics and the sprinkling of adjectives and superlatives on the research narrative like sprinkles on a cupcake.

Clarity and the lack of ambiguity are two of the most important characteristics of the successful proposal. Clarity is grounded on simplicity, detail, and specificity. Superlatives, on the other hand, are inherently ambiguous, substituting an amplified emotional appeal for specificity and detail. Therefore, it may well be that your research is transformative, but a cascade of superlatives characterizing your research should originate from the reviewers rather than from you.

Proportionality and Sequence in the Narrative

Proportionality and sequence contribute significantly to the overall quality and readability of the project description, and hence to the competitiveness of your proposal. Proportionality in the project narrative is the linguistic analog of the geometric aesthetic expressed in the Golden Ratio or Golden Rectangle that has charmed artists and architects since ancient times. Proportionality brings balance to the project narrative in a way that ***establishes the relative importance of the component sections at various scales*** (e.g., sentence, paragraph, section, etc.), that, in aggregate, comprise the project description. Sequence provides the underlying order or logic to the narrative structure, ensuring that it unfolds in a way that meets readers' expectations for an orderly presentation of ideas and a convincing, stepwise rationale for funding the proposed project.

Moreover, it is important to recall that proportionality is a limited property of the project description, i.e., it is bounded by the page limit allowed for the project description, as well as sometimes limited by internal page allocations for proposal sections set by the solicitation. ***Therefore, poorly proportioned and sequenced narrative text amounts to a highly inefficient use of space.*** Think of the page limit as a **page budget**, much as you would a monetary budget that determines the available money you have to allocate to various personal expenditures on a monthly basis. Therefore, within this limit, you must allocate your **page budget** in a way that ***best reflects a hierarchical ordering of the importance of what you most need to communicate to program officers and reviewers about the significance of your proposed research. You are attempting to put forward a compelling case for funding***.

Keep in mind, too, that funding agencies are not Keynesians when it comes to page limits—***there is a zero tolerance for page inflation***, not only for page limits but for any attempts to circumvent the intent of page limits by using smaller font sizes than those allowed, perhaps by the excessive placement of narrative text into tables, footnotes, figures, and graphics where smaller fonts are allowed. Of course, the quality of your ideas does not increase as a function of decreasing font size or highly compressed narrative text, ***but the irritability of reviewers certainly does***.

Therefore, while proportionality and sequence establish the argumentative symmetry or balance of the project description, many perturbations can degrade the needed symmetry. For example, one of the more common perturbations to the balance and symmetry of the research narrative is an excessively long background section used to introduce the reader to the research topic. Narrative generalities meant to set the stage for the importance of the proposed research topic can have the unintended effect of losing the reviewers' interest, and, more importantly, squandering the space allocations of your page budget.

In other cases, excessive background particularities can imbalance the project narrative with a blizzard of minutiae meant to demonstrate your grasp of the research. This, too, can have the unintended effect of losing the reviewers' interest, and, more importantly, squandering the space allocations of your page budget. Too much general detail and too much minute detail commonly plague many first drafts of the research narrative, and, unfortunately all too often, carry over into the final submitted draft as well. Much like the NASA search for a "Goldilocks Planet" that balances perfectly within a star's inhabitable zone and whose gravity approximates that of the earth, successful grant writing involves a perpetual search for the "Goldilocks Narrative," one that is perfectly balanced, or "just right."

Fortunately, it is fairly easy to plan the project narrative to ensure that both proportionality and sequence will optimize the narrative's balance. Simply using the solicitation as a narrative template will take you a long way towards understanding the relative importance the funding agency assigns to the topics you must address in the project description. Using the solicitation as an organizing template will also set the basic framework for the sequence in which the narrative addresses topics. Of course, some solicitations may define the structure, scope, and scale of the project narrative and the key questions and topics the agency wants addressed; others, however, may give the proposer latitude in organizing the proposal narrative to most effectively communicate the case for funding the proposed project.

Ultimately, however, optimizing proportionality and sequence in the project narrative follows from a series of good decisions made by the author(s) while drafting the project narrative. These good decisions are based on a keen sense of what is and what is not important to communicate to the reviewers (e.g., if buffers are not important to the research, don't belabor the buffers). Moreover, the most pertinent information must be assigned an order of relative importance to achieving the end goal--a funded project. Astute authors assign value to information as they write, thereby determining what to emphasize the most and the least, as well as where specific information falls on a value scale from the most important to the least important.

Moreover, the relative value of information can be either enhanced or degraded by the logical sequence in which it is presented to the reviewers in the project narrative. A well-written proposal amounts to a persuasive argument made to program officers and reviewers convincing them to fund your project. Persuasive arguments have an internal logic dictating the sequence in which information is presented. In this regard, a proposal is not unlike a novel or a movie. It creates its own, self-contained reality. The proposal contains all that the funding agency and review panel should need to know about your capabilities, including your capacity to perform.

Except for very large grants, an agency bases its decision to fund or not fund entirely on your proposal and the persuasive reality it creates. Proportionality and sequence are two key attributes of the reality you create that enables program officers and reviewers to better understand, appreciate, and support your research. ***These attributes lie at the core of the competitive proposal.*** They represent the essential framework upon which you craft and structure the logical, internal connectedness and balance of your proposal to ensure that you submit a Goldilocks Proposal—one that is ***just right***.

Getting the Writing Right

Principle #1: Effective writing emerges over time

How often have you re-read drafts of your proposals, reports, or even scholarly papers after letting them set for a few days and been perplexed (or dismayed) by the sentences you encounter? The crucial element here is "set for a few days," as re-reading your prose within hours of completing it is likely to convince you that it sounds just fine. It takes time away from a draft to make it truly visible and audible to yourself, and when you do see and hear it one or more days after you've written it, you will know whether it conveys the sense you intend or whether it's likely to confuse, distract, and generally annoy the reader. And so we encounter the first principle of getting the writing right: *good writing emerges gradually through a process of successive drafts separated by at least 24 hours.* Don't forget to build this time into your proposal planning.

But the truth is that, no matter how many drafts you create, your writing will benefit from another set of eyes, preferably the eyes of a colleague who knows the field, the state of the field's funding, and who has successfully secured funding from the same or a similar funding source. But before asking that colleague to read your draft, do them and yourself the service of telling them how you would like them to read and respond to your document. They won't be able to read your mind on this point—if you don't give them guidance, expect a cursory and superficial review. As you consider how to approach asking for a review, let's clear away a false assumption. It's customary to think about writing as if it were divided into two parts: content and style. But, contrary to that belief, the content of a proposal will be conveyed as fully through the author's writing choices, or style, as it will by the concepts they've selected as worthy of funding. Style and content inform one another. So, for example, it would not be helpful to ask a colleague, "Please review this proposal for its content. I'll worry about the style later." If the style is poor—riddled with errors, long-winded, scattered in focus, unevenly developed, and siloed into isolated sections—even the most fascinating concept will be sabotaged by gaps in the argument, ambiguities in language, organizational distractions, and the appearance of sloppiness. You can, of course, ask a colleague for a review of isolated sections of a proposal, but you will want someone to look at the entire document in its near-finished state to gain the full advantage a review can give you.

Principle #2: Every Proposal Needs a Colleague's Full and Frank Review

So how might you ask for a review? A second principle of getting the writing right is to ask for a *frank review* of the nearly completed proposal that pays attention to the proposal's ideas and to the writing itself. Time for this review will also need to be set aside in the proposal planning process. Give the reviewer sufficient lead time to complete a detailed reading and response. You might note that you are submitting this after careful thought and would appreciate attention to the document's effectiveness with respect to the ideas advanced and to how well the writing conveys those ideas. For example, you might ask the reviewer whether the proposal adequately answers all of the questions posed by the funder using clear and consistent prose. Does field-specific jargon get in the way at any point? Are the terms used appropriate and consistent throughout the document? Let your reviewer know that you welcome close attention to the writing itself. Without such an assurance, some reviewers might

steer clear of commenting on the proposal's language either to save any possible embarrassment or to minimize the time needed to complete the review.

Principle #3: Select a level of review

Yes, commenting on the style-content of a proposal can take more or less time, depending upon the thoroughness of the review. The third principle of getting the writing right is deliberately to select the level of review you give or solicit from others. If you are asked to review a colleague's proposal, or if you are seeking a professional editor to check your current draft, keep in mind a level of editing you would like to perform yourself or to have performed by a professional. **The first or most elementary level** would include checking the document for correct spelling, punctuation, and grammar. Second-language speakers are likely to benefit from an editing at this level, if not also from the other two levels described below. Spell checking programs accompanying text programs like "Word" can be used to find most spelling errors. But remember they do not identify whether "their" or "there" should appear in a sentence. The author/editor has to make that decision. This technology has made spelling errors close to inexcusable, so be sure to use a spell checker and also to read through a document for any words that may have been spelled correctly but used incorrectly.

The second level of editing includes suggested rewriting to improve the logical coherence of sentences, paragraphs, and sections; to ensure that transitions help the reader from one paragraph and section to the next; and to cut out excess words where necessary. At this level, look hard at the author's use of verbs. Does some form of the verb "to be" appear in nearly every sentence? If so, suggest more active verbs to give the writing a clearer sense of agency, energy, and focus.

The third level of editing includes reviewing the solicitation and other background as needed to prepare for a deep rewriting of the document. This rewriting will ensure that the proposal actually addresses the terms used in the solicitation, and that it does so using clear, precise, and accessible language. It will also ensure that paragraphs within the proposal feel connected to one another and to the proposal's primary claim. This level of rewriting will need the author's cooperation and consent; otherwise, she may feel offended or criticized by the sheer amount of change suggested.

In summary, the three principles for getting the writing of a proposal right for both authors and reviewers include: (1) allowing time in the proposal planning process to produce multiple drafts of the document following a series of reviews; (2) requesting/offering a frank review of the document; and (3) specifying the review level expected or offered given the constraints of time. In all cases, writers and editors will be aiming for linguistic precision and compression. To quote Dr. Seuss, "***The writer who breeds more words than he needs, is making a chore for the reader who reads***." You don't want to burden your reviewer at a granting agency; instead, ***make it easy for them to say yes to your proposal***.

Quantifying the Project Narrative

If you want to earn a reviewer's question mark next to your proposal, fill your narrative with adjectives, adverbs, and superlatives in place of quantified descriptions. The excessive use of adverb/verb combinations, such as claiming a proposed project "***will dramatically increase***" [take your pick: wind turbine efficiency, battery storage capacity, women entering doctoral STEM fields, technology innovation, success of students in algebra II, etc.], or claiming your project will "***significantly reduce***" [take your pick: footprint storage of solar thermal power systems, impact of oil drilling on sensitive coastal ecosystems, student attrition in Calculus I, risk of Type II diabetes, obesity, and cardiovascular disease, etc.], is a common but correctable reason why some proposals fail to capture reviewers' interest.

As Mark Twain observed: "*Clothes make the man. Naked people have little or no influence on society*." The same might be said of adverb/verb combinations not clothed in quantitative modifiers. In this case, as Mark Twain likely knew, these "*numerically naked" adverb/verb combinations will have little or no influence on reviewers*. Numbers matter. Numbers are the basis of comparative claims that inform program officers and reviewers alike and allow them to better judge the relative worthiness of your proposal.

Using the above example again, but with the verb properly clothed rather than numerically naked, would result in the following: claiming a proposed project "***will increase***" [take your pick: wind turbine efficiency **by 18%**, battery storage capacity **by 40%,** women entering doctoral STEM fields **by 30%**, technology innovation **by 18 months**, success of students in algebra II **to 100%,** etc.] or perhaps your project "***will reduce***" [take your pick: **by 52%** the footprint storage of solar thermal power systems, **to near zero** the impact of oil drilling on sensitive coastal ecosystems, **by 75%** student attrition in Calculus I, **by 24%** risk of Type II diabetes, obesity, and cardiovascular disease, etc.]. The absence of the adverbs "dramatically" and "significantly" is not noticed in the second example because they are not needed.

The old adage about a picture being worth a thousand words applies to the judicious use of quantitative information or data in the project narrative. You don't want to overwhelm reviewers with a cascade of quantitative information, ***but neither do you want to leave them frustrated by its absence***. The successful proposal relies on knowing the difference between sufficient and excessive quantitative information to ensure the wise use of allocated space and an appropriately balanced project narrative. For example, knowing how much background information-- technical detail, preliminary data, etc.--will satisfy your readers is a key factor in writing a well-balanced proposal narrative. Finding this level is not always an easy task, but it is an important part of writing a well-crafted project narrative.

In this regard, too much quantification can be as problematic as too little. So it is important to be mindful of reviewers' reluctance to sift through extensive quantitative data to determine the merit of your proposed project. That is not their job. It is the job of the author, however, to explain the significance of any data used in a narrative in the most economical way possible. A blizzard of quantitative data is likely to give reviewers a "brain freeze," along with heartburn. Proposals are about ideas, and data need to be judiciously selected to support the merit of the ideas described in the narrative. ***But data in and of themselves are not ideas***. You don't want, to paraphrase H. L. Mencken, an army of quantitative data marching across the page in search of an idea. Rather, your narrative needs to explain and illuminate the significant patterns in the data you present rather than pass that task onto reviewers.

Moreover, the amount of quantitative information or data required in a proposal varies greatly and is often a function of the specific solicitation and the author's ability to find the Goldilocks' Solution of not too much and not too little—but just right. In some cases, the data required in a proposal are specified in great detail by the sponsor, so much so that finding it in the appropriate format becomes a major challenge. This is often the case in various kinds of institutional transformation proposals, e.g., an NSF AGEP or ADVANCE, where extensive student data or institutional data may be required. In other cases, the research itself dictates the data that need to be incorporated into the project description. However, in most cases, the use of quantitative information is left entirely to the proposal's author. In the absence of agency guidelines describing a standard for sufficient quantitative information, the overreliance on adjectives, adverbs, and superlatives can become problematic and work against the proposal's merits.

This often becomes the case when descriptions of the goals, objectives, and anticipated outcomes of the proposed research are described in glowing but general terms (e.g., *novel, groundbreaking, frontiers of new knowledge*, etc.) insufficiently supported by quantitative information that allows program officers and reviewers to judge the impact of the proposed research, particularly in terms of its relative importance to the field. In many cases, a "unit of change" will be associated with your proposed research that translates your goals and objectives to outcomes. That "unit of change" begs for quantification rather than gushing adverbs and superlatives. As "Dragnet's" Sergeant Joe Friday always explained when interviewing witnesses to a crime, "All we want are the facts."

That is an important point to keep in mind. You do not want the program officer and the reviewers of your proposal to ruminate on the difference it would have made had you provided judiciously selected quantitative information to validate the impact and value-added benefits of your proposed project. Moreover, quantitative information plays a key role in evaluating the success of your research over time. It provides a way of answering the question, "How can the success of this project be measured?"

In thinking about the benefits of quantitative information in your research narrative, recall the Heilmeier Catechism. George Heilmeier directed DARPA in the 1970s. He had a set of questions he expected every proposal to answer:

1. What is the problem; why is it hard?
2. How is it solved today?
3. What is the new technical idea; why can we succeed now?
4. What is the impact if successful?
5. How will the program be organized?
6. How will intermediate results be generated?
7. How will you measure progress?
8. What will it cost?

It is likely that the answers to each of these questions would benefit from well-selected, succinct, and illuminating quantitative information. Such information will better enable reviewers to more accurately judge the merit of your proposed research and ***hence be more likely to fund it.***

Logic Models: Scalable, Adaptable, and Versatile

Logic models are a useful and versatile tool for developing a more successful proposal. While the use of logic models in proposals is most often associated with specific funding agencies or specific program areas, particularly in the social and behavioral sciences, education, extension, and evaluation and assessment, they can also be of great value in all research proposals as a development tool to better organize the project narrative, including LTGs. In particular, they can help clarify the logical and relational sequence of the ***common proposal core components of vision, goals, objectives, rationale, outputs, and outcomes***.

While these six core components, or a close variant, are generic to most proposals, it is not a trivial task to explain how they relate to each other logically and sequentially in the research narrative. In fact, a common flaw in poorly rated proposals stems from a research narrative that does not offer a clear, well-organized, logical, and convincing argument for the significance of the proposed research as it impacts the agency mission priorities and the field. This becomes more challenging as PIs transition from small proposals to larger team proposals with multiple research objectives. In some cases, team members may not have a common definition of how to differentiate between goals and objectives, or how to distinguish between output and outcomes, or how to describe the integration of the proposal's various research strands and their resultant synergy, particularly as these relate to quantifiable outcomes that impact the agency mission or the field. Adapting logic model templates and protocols to this process can help bring organizational clarity to project discussions. Importantly, melding logic model protocols with a proposal narrative template outlining the project requirements and review criteria in the solicitation as the basis for writing the first full narrative draft will help you write a better proposal.

While logic model protocols differ somewhat by agency and discipline, a generic logic model is basically a conceptual tool for program planning, organization, and evaluation. Logic models offer a graphical template comprised of several core program categories that help map the sequence, relationship, and rationale of programmatic activities and expected outcomes. For example, a logic model diagram for a project will:

- Clarify the linkages between investments and activities, outputs, and expected outcomes of the policy, program, or initiative;
- Communicate externally about the rationale, activities, and expected results of the policy, program, or initiative;
- Test whether the policy, program, or initiative "makes sense" from a logical perspective; and
- Provide the fundamental framework on which the performance measurement and evaluation strategies will be based (i.e., determines what constitutes success).

Importantly, a logic model need not appear as a graphic in a proposal, nor is it necessary to use the common terms associated with various versions of logic models (situation, inputs, activities, outputs, and outcomes related to knowledge, actions, or conditions) in the project narrative. With or without the graphic and terms, the process can play a highly useful role in developing a more organized and clearly written research narrative. For example, USDA/NIFA (National Institute of Food and Agriculture), have published the *Generic Logic Model for NIFA Reporting* as an illustrative guide for reporting on NIFA-funded research, education, and

extension activities**.** While specific to NIFA, the generic process is easily adaptable to most research projects. The key objective for the NIFA logic model is that proposers use it to submit a proposal that ***integrates research, education, and extension better than these would be integrated without the model.***

This goal is not unique to NIFA, but common across most federal agencies. It is particularly relevant to submitting proposals to NSF where a core agency mission is to integrate research, education, and training. In many cases, NSF recommends the use of logic models to evaluate and assess the educational components of large research grants, such as the NSF CREST proposal.

Moreover, some variant of logic models is helpful in developing the graphics that complement the research narrative on large team proposals requiring the integration of multiple partners, institutions, and research strands. In particular, large center-level grants will require milestone charts or graphics that represent the vision, goals, objectives, and outcomes of the project, such as NSF's ubiquitous 3-Plane Diagram meant to capture the synergistic core of Engineering Research Centers.

Adapting logic models as an adjunct to this process can be beneficial since logic models represent one more way to bring organizational clarity to a research narrative in a manner that is easily grasped and remembered by program officers and reviewers. Equally important, logic model protocols can help the proposal development team better communicate with each other during the writing of the proposal so that everyone on the team is better aligned with the core research vision, goals, objectives, rationale, outputs, and outcomes. ***Reviewers will always punish confusion, ambiguity, lack of clarity, and the absence of logically sequenced arguments in the project description***. Adapting the scalable and versatile logic model process as another tool in your research and proposal development toolkit is one more way to increase your chances of achieving a successful proposal submission.

Part 7, Preparing for Reviews and Red Teaming for Success

Writing for Reviewers
Observations on Critiquing a Proposal
Red Teaming Proposals for Funding Success

Writing for Reviewers

Specific review criteria and review processes differ from agency to agency, as well as by program within an agency, or by type of solicitation. **But the core, generic questions program officers and reviewers want answered can be simply stated**:

- What do you propose to do?
- Why is it important—what is its significance?
- Why are you able to do it?
- How will you do it?
- How does it contribute to and advance the research interests of the agency and/or the field?

These simple questions may be expressed in various ways by different agencies and programs, and more specific details will often be requested in the solicitation or program announcement (e.g., NSF has both overarching review criteria and program-specific review criteria). But ultimately, most review criteria can be distilled to some equivalent version of these simple questions. Your challenge when writing for reviewers is to answer these questions in a clear, convincing, and compelling way that reviewers can **easily understand**.

Solicitations may often contain a fairly long listing of review criteria specific to the program, but if you keep these core criteria in mind while writing your project narrative, you will better infuse your narrative with the key arguments, details, internal connections, and explanations reviewers will look to in making their evaluation of your proposed research.

Two types of reviewers will evaluate your proposal: those who are expert, or at least knowledgeable, in your research domain, and the those who are not. The program officer will play a key role in this process as well, but that role will be **agency specific** (e.g., at NSF, reviewer inputs are advisory to the program officer, whereas at NIH, the percentile score is key to your success). Unless you are confident you know otherwise, when writing to reviewers, **write for the intelligent reader and not the expert**. Remember you are most likely writing to a **panel** of reviewers, **each member** of which will be selected for a needed expertise. Smaller research proposals will likely have a more narrowly banded range of reviewer expertise than LTGs. Therefore, it is important when writing LTGs that they be written to address a mix of reviewers, something particularly common at NSF. However, in all cases:

- You must craft a persuasive argument presenting the merit, significance, rigor, and relevance of your research that **makes the reviewers want to fund it**;
- You must convince reviewers you have the capacity to perform, and the institutional infrastructure to support, your research;
- You must extend your argument to discuss the likely impact your research will have in advancing the field and creating new knowledge, both in your research area and possibly in other research fields as well; and
- When writing to federal mission agencies, you must demonstrate to the program managers and reviewers that your research advances the agency's mission.

The author of a funded proposal has accomplished the basic goals of writing for reviewers he or she

- Ensures that the reviewers will be intrigued and excited about the proposed research;
- Understands its significance;
- Understands that existing research enhances the likely success of the proposed effort;
- Understands how the proposed research will be accomplished; and
- Communicates confidence in the researcher's capacity to perform.

The proposal review is the most important factor influencing the likelihood your proposal will be funded. More than one person typically will review your proposal--these may be personnel at the agency or foundation, peer reviewers from academia, other people from outside the funding agency, or a combination. Reviewers will evaluate the proposal based on review criteria, both explicit (stated in the solicitation or other agency documents) and implicit (commonly held but unstated expectations held by the reviewers). Understanding how the reviewers will evaluate your proposal is critical to learning how to write a winning proposal. This, by the way, is not a simple task. It is a learned skill and a very valuable one once mastered.

Writing for Reviewers—Narrative Tips

- Sell your proposal to a good researcher but not an expert;
- Keep Albert Einstein's observations in mind:
  - ***If you can't explain something simply, you likely don't understand it well;***
  - ***Most of the fundamental ideas of science are essentially simple, and may, as a rule, be expressed in language comprehensible to everyone*.**
- Write to **all the reviewers** on the panel, as some review panels may not have an expert in your field, or panels may be blended for multidisciplinary initiatives;
- Recognize that reviewers reward compelling, exciting research, not just correct research;
- Write a proposal that reads easily and that offers a **compelling and memorable** narrative;
- Reveal the significance of your research early in the proposal, not at the conclusion;
- Avoid sloppy errors in language, usage, grammar, and logic that reviewers will assume could translate into sloppy errors in research;
- Write a compelling project summary and narrative introduction:
  - This is where you must capture the interest of reviewers and win them over by making them intrigued enough to want to read your entire proposal closely and with interest;
  - Define the significance of the core ideas quickly, clearly, and concisely;
  - Describe the connectedness of the core ideas to specific research activities and outcomes, and advance your ideas with sufficient detail to make your research **memorable after the proposal is read**;

Writing for Reviewers: Why Grammar is Important

Comments by George A. Hazelrigg, National Science Foundation

- Proposals are not graded on grammar. ***But if the grammar is not perfect, the result is ambiguities left to the reviewer to resolve***;
- Ambiguities make the proposal difficult to read and often **impossible to understand**, and often result in low ratings;
- Be sure your grammar is perfect.

Formatting for Reviewers

- You will not win over reviewers by reducing the font size, spacing, margins, and white space of the narrative text, or by cluttering it with space-saving jargon and acronyms, in the belief that the page limit does not allow your ideas to be sufficiently developed;
- Do not make your proposal difficult for reviewers to read. It is your obligation to make your proposal easy to read and accessible to them; it is not the obligation of reviewers to work hard, squint, and re-read sections of the proposal in an attempt to understand the significance of your research.

Agency Review Criteria

Each funding agency develops review criteria and a review process that best serve the agency's mission or a research strategic plan. The agency will usually post its review criteria and review process on its web site and include them within program solicitations. Two of the major funders of university research, NSF and NIH, have developed elaborate and comprehensive information on their web sites about the review criteria and process. Other agencies, particularly the defense agencies (e.g., DARPA, and the U.S Army, Navy, and Air Force research offices) will often list application review information within a Broad Agency Announcement (BAA).

Agencies typically develop two general kinds of review criteria. The first type of criteria are overarching across the agency and apply to every grant application; for example, intellectual merit and broader impacts at NSF; significance, approach, innovation, investigators, environment, and overall impact at NIH; or, at defense research laboratories, scientific and technical merit and the contributions of the research to the agency mission. Depending on the agency, not all overarching review criteria are weighted equally; for example, some agencies may list them in descending order of relative importance.

The second type of review criteria apply specifically to the particular program and may be very detailed in terms of expected project objectives and outcomes. The overarching review criteria of any agency typically are clearly stated and well explicated over time. For example, the "broader impacts" criterion, one of two overarching review criteria at NSF, has been much written about and discussed with detailed examples on the NSF web site, as well as at various NSF workshops. Over time, this criterion has become increasingly clear.

Solicitation-specific review criteria, however, especially on new programs, may not have been as fully vetted for possible ambiguities, in which case it becomes important to discuss the criteria with a program officer. If you are uncertain about the meaning of one or more review criteria, it is important to clarify the agency's intent with an agency program officer, or perhaps a colleague who has been well funded by the agency. It is important to identify both major types of review criteria, understand exactly how the agency defines them, and determine the relative weight (if applicable) the agency assigns to each criterion.

The Review Process

The review process itself can vary significantly from one agency to the next and from one program to the next. Reviewers may be other researchers and academics (a "peer review"); the reviewer may consist only of the program officer or a group of personnel from the funding agency (an "internal review"); or they may be a combination. Furthermore, reviews may be written independently and mailed in, or reviews may be conducted by a panel of reviewers who convene at the funding agency (often called a "panel review"). Reviewers may be experts in your field, they may be experts in related fields, or they may have little or no knowledge of your field. They may be a standing committee or they may change. Obviously, a writer who knows the backgrounds of the people who will review his or her proposal and crafts the proposal with those reviewers in mind will have a substantial advantage over a writer who blindly writes a proposal without knowing the audience he or she is trying to convince.

The most comprehensive information on the agency review process will come from visiting the agency web site and talking with agency program officers as well as with colleagues who have served as (a) reviewers for the agency, (b) rotating program officers at the agency, or (c) who have been well funded by the agency. Below are descriptions of procedures used by some of the major research funding agencies.

Agency review criteria and the review process can change or evolve over time, e.g., the major changes in the review process, particularly related to broader impacts, ***made by NSF in January of 2013***. Visit the agency web site to stay current on how your proposal will be reviewed.

Observations on Critiquing a Proposal

Faculty and staff in university research offices often receive requests to critique and comment on a proposal. Depending on your experience and success in writing proposals, or your skills as an editor, or your disciplinary expertise, or perhaps just your insights as an intelligent and logical reader, you can choose from a range of responses to enhance the competitiveness of a research narrative. Completing this task carefully can make the difference between success and failure by ensuring that ***a substantive critique of a proposal occurs before the funding agency reviewers conduct their review and make the funding recommendation***.

If you are asked to review a proposal, be forthright, both in terms of your willingness to do so and in your willingness to give a candid critique. Your critique needs to be unflinchingly objective and offered in the spirit of Tom Hank's comment to right-fielder Bitty Schram in the movie, *A League of Their Own*: "Are you crying? Are you crying?! There's no crying in baseball!" The same admonition needs to be heeded by authors requesting a critique of their proposal. Authors must prepare themselves to hear critical responses to their narrative.

When asked to critique a proposal, carefully consider whether you do or do not have the time to offer a thorough review. If you do not have the time, decline the request. This is much better than raising expectations, then keeping the proposal for several days, or longer, doing a harried and guilty skim of the narrative, and responding to the author with a "looks good to me" observation.

If you do have the time to critique the proposal, perhaps the two most important favors you can do the author are to conduct a thorough review in the shortest possible time to avoid slowing progress on the narrative. Depending on your expertise, you can select from many levels of review to benefit the authors.

However detailed your response, ***your first step in reviewing a proposal must involve a careful reading of the solicitation and review criteria before reading the actual draft of the research narrative or project description***. Reading a proposal draft without first understanding the solicitation and review criteria blinkers your response. Consider Lewis Carroll's observation in *Alice in Wonderland*: "If you don't know where you are going, any road will get you there." This gets to one of the more common mistakes made in writing research grants, i.e., ***the research narrative does not respond fully to the solicitation***, which also amounts to one of the more common reasons for denying proposals. Therefore, make every attempt to filter your observations about a draft proposal through the lens of the solicitation, focusing on the agency's research objectives and the review criteria used to judge how well your proposal meets those research objectives. In effect, the solicitation acts as the sacred text that must be understood before competing successfully for funding, or, in more literary terms, the solicitation is the map in Robert Louis Stevenson's *Treasure Island*—***read and follow*** the map to locate the treasure.

Your point of view, or perspective, in critiquing a draft proposal includes both the expertise you bring to the process and the ***important requirement that you also represent the agency's point of view as you understand it from reading the solicitation.*** Think of yourself as representing the interests of the funding agency in your critique of a draft proposal, effectively serving as a surrogate reviewer for the agency, and thereby best serving the interests of the person who asked you to critique a draft proposal. ***After all, it is the agency's research***

priorities, not the author's, that are paramount in the decision to fund or not fund the proposal.

By critiquing a draft proposal from the perspective ***of the funding agency as expressed in the solicitation***, you will maximize your contribution to the narrative's competitiveness by ensuring that the draft maps tightly to the agency's domain as defined by the solicitation, the review criteria, and any other agency-specific requirements of which you may be aware.

Having read the solicitation carefully, you are able to make suggestions to the author ensuring that the research narrative:

- Responds fully to all agency requests for information/questions asked
- Offers information in the order requested
- Provides the required detail and specificity
- Demonstrates the importance of the research to agency objectives
- Integrates all review criteria into the narrative to ensure all criteria are met, and
- Complies with agency formatting requirements.

By ensuring that the draft research narrative responds fully to the solicitation guidelines, ***including all key documents referenced in the solicitation***, you have come a long way towards increasing the author's likelihood of success. The above might be thought of as the macroreview of the draft proposal. This is then followed by a microreview, which entails a much more finely-grained critique that addresses factors not explicitly defined in the solicitation but nonetheless critical to the proposal's success.

These include, for example, how well the proposal is written, how well the proposal is argued, how well the proposal is formatted, how well visuals enhance and complement the narrative text (see *Graphics as a Narrative Integrator* in the November 15, 2011 issue), along with the more intangible requirements about how compelling a case is made for funding (see *Writing a Compelling Project Narrative* in the February 15, 2012 issue).

Critiquing how well a proposal is written involves multiple steps, each of which plays a role in the proposal's success. You might begin with a simple edit for grammar and syntax, e.g., active and passive voice, sentence structure, spelling, careless errors in the mechanics, and related issues addressed in numerous online editing and writing guides, such as the Purdue Owl or William Strunk, Jr. and E. B. White's classic *The Elements of Style,* available free online from many sources, or the *Chicago Manual of Style*. Of course everyone has an opinion about what constitutes good writing, and many have very strongly held opinions, e.g., "*50 Years of Stupid Grammar Advice*" in *The Chronicle* (2009) addressing *The Elements of Style,* written by the co-author of *The Cambridge Grammar of the English Language (2002)*.

To critique a proposal, you needn't enter into a heated discussion about E. B. White as a competent or incompetent grammarian. Agency reviewers thankfully will not be waging these arguments, either. Competent, error-free writing will suffice for proposal authors. Strive for clarity and simplicity. With this in mind, critique a draft narrative to ensure it has been written competently and argued logically. **Judge it for clarity: *does the narrative make easily apparent to you the kind of research to be done, how it will be done, why it will be done, who will do it, and why it is important to the funding agency mission***?

By extension, if clarity functions as the ultimate goal of the well-written research narrative, then ***ambiguity acts as its evil twin, a harbinger of narrative chaos***, the equivalent of Lex Luthor injecting Kryptonite into the narrative text. This becomes particularly important when reading proposals written by authors for whom English is a second language. In these cases, unfamiliar word patterns and usage may distract reviewers who should not be expected to resolve ambiguities in the research narrative, or labor over poorly written text in an attempt to discern the author's intentions. Use your critique to help the author of a draft narrative understand that the key to success in research grant writing lies in ***writing for the reviewers***, i.e., make the research narrative easily accessible to the reviewers; don't fall into the Humpty Dumpty trap of writing for yourself alone: "*When I use a word,*" Humpty Dumpty said in a rather scornful tone, "*it means just what I choose it to mean - neither more nor less*." ***Funding agencies do not reward solipsistic viewpoints.***

Red Teaming Proposals for Funding Success

Red teaming a proposal is particularly helpful on LTGs that represent a significant institutional investment of resources, time, and effort to develop and write. These large, multimillion dollar proposals are typically responding to complex solicitations with multifaceted research and/or educational objectives, making Red Team a must.

The funding solicitation is the key document in the process known as **red teaming**. The term "**red team**" is derived from government and industrial evaluations that use a group—a red team—to review, assess, test, or vet plans, operations, concepts, capabilities, or proposals. Red teaming is essentially a very thorough review and evaluation of a proposal. In this context, successful proposals approach excellence through repeated revisions that eradicate ambiguities and bring focus and clarity to the description of the research or educational vision, goals, and objectives. Narratives relying on excessive generalities and unsupported claims rather than specific and validating detail that advances a research vision will quickly lose reviewers' attention and confidence. The worst response a reviewer can have to a proposal is the one H. L. Mencken had while reviewing a book he described as "*an army of words marching across the page in search of an idea*." The red teaming process can help assure this does not happen to a major proposal. Importantly, red teaming is a scalable process. While most often used for center-level research proposals, or other major institutional initiatives, the step-by-step red team review process can be adapted to smaller proposals as well.

Why conduct a red team review?

LTGs are evaluated under agency review criteria that are extensive, detailed, and searching in assessing the applicant's capacity to meet the performance goals and objectives of the funding agency. A project narrative for an LTG is correspondingly complex to develop and write, and often has page limits far in excess of the typical research proposal. To compete against similar proposals, the applicant must present a clear, integrated vision of the rationale, goals, objectives, and focus of the proposed project. This clarity will typically require that the proposal articulate the benefits of funding a large center structure intended to support multiple research strands rather than a series of discretely proposed research projects unconnected to one another. Writing an integrative research vision statement and supporting narrative presents a major challenge, particularly, as is often the case, when multiple contributors compose the research narrative. In early drafts of the proposal, these research contributions may be siloed or stove piped, or cut and pasted from other proposals, both successful and unsuccessful, in an attempt to force fit them into the current effort, all of which will make the task of producing a polished project narrative more difficult. Ultimately, the narrative of these large proposals must be flawless if they are to succeed, since only a few awards may be made in a competition that is national in scope.

Too often, the first–and final–substantive outside review of these large proposals occurs when the funding agency makes the funding decision. The red team review should intervene before the final submission of a large proposal. The team's role is to give an "***outsider's perspective***" on the quality of the proposal prior to its submission, while the opportunity exists to undergo another thorough revision of the proposal text to ensure that it makes a clear and convincing case for funding.

What are the goals of a red team? A red team conducts a comprehensive, exhaustive, and extremely fine-grained review and evaluation of the proposal narrative prior to submission, including, for example, to:

- Find weaknesses, deficiencies, and ambiguities in the proposal text,
- Identify inconsistencies and omissions between the proposal narrative and the requirements of the solicitation and review criteria,
- Play the devil's advocate when necessary,
- Challenge the vision, assumptions, and other statements in the text that are not well supported or clearly stated, or are poorly argued,
- Make observations on the persuasiveness of the arguments put forward by the author(s) describing the uniqueness of their research and how compellingly they make the case for funding, and
- Offer suggestions that both ***correct identified deficiencies and better amplify identified strengths.***

Red team members enhance the competitiveness of a proposal, with the ultimate goal of helping the author(s) submit a more competitive narrative than would otherwise occur without a red team process. Members of the red team must not be reluctant to criticize a proposal out of a misdirected sense of kindness or sensitivity to the authors' ideas and the presentation of those ideas. The red teaming process needs to be unflinchingly objective and rigorous.

The red team's ability to offer an informed and intelligent "outsider's perspective" by reviewing the document from a fresh and/or different vantage point is a key factor in the proposal's potential success and should be encouraged. The authors of large proposals typically work for months developing ideas and drafting text. In the process, they become so familiar with their own writing and their own descriptions of research vision, rationale, goals, and objectives that ***they can lose the ability to judge how others might perceive what they have written.*** Multiple authors invariably have multiple writing styles; this can result in a proposal lacking cohesion and consistency. Authors may have difficulty understanding how a reviewer could possibly understand the proposal narrative without the clarity and understanding the authors bring to it. A red team helps the authors build in to the proposal an expression of its purpose and importance that will communicate these to someone unfamiliar with its development. ***The red team may also offer a needed boost of energy at the end of the proposal writing process, when the authors' weariness makes them reluctant to face the additional challenge of significant final revisions***.

How to form a red team…Who should be on the red team?

A red team typically will consist of three to six members, but this number can vary and is best determined by the kinds of expertise that would most benefit the review process. Therefore, the proposal itself should dictate the number and composition of the red team. For example, some proposals, while large, may focus upon a narrow set of research objectives, e.g., those written to the NIH, while other large proposals, e.g., those directed to the NSF, may have multiple research strands and include a constellation of activities complementing the research

core, such as K-12 educational outreach, undergraduate research, graduate training, postdoctoral mentoring, curriculum development, diversity initiatives, and societal impacts.

In general, a mix of expertise on a red team will benefit the proposal, but the fundamental requirement is that the reviewers be experienced, intelligent readers, thereby reflecting what typically characterizes an agency review panel. Universities have multiple pools from which to draw in forming a proposal red team: faculty who have served as reviewers or program officers, successful researchers, faculty serving as research administrators, experienced proposal writers and editors, among others. The team may include, when needed, faculty and staff with expertise in specific domains, e.g., educational components, evaluation and assessment, dissemination, project management, societal impacts, or other areas defined as key programmatic elements in the solicitation.

When should the red team conduct the review?

The timing of the red team review is important in order to optimize the benefits of the process. ***Consider four key factors when scheduling a red team review***:

- The proposal narrative should be sufficiently complete and as close to final as possible to allow a through, substantive review;
- The red team must have time to conduct a very finely-grained and exhaustive reading of the solicitation, review criteria, supporting documents, and the narrative, and then generate a detailed review document reflecting its recommendations;
- The red team must have sufficient time to meet with the proposal author(s) and present their recommendations; and
- The authors must allow sufficient time to consider the recommendations of the red team and make those changes to the proposal with which they agree.

How long does it take to conduct a red team review?

The time required for a red team review will vary and will reflect the complexity of the solicitation and the length and complexity of the proposal. In general, it may take several days to complete the red team review process. The first day may be devoted to red team members independently reading the solicitation, proposal narrative, and supporting documents in depth. Another day may be required for a sequestered red team to meet as a group and review the proposal section by section, paragraph by paragraph, and line by line while concurrently recording comments that reflect the observations of each red team member, particularly as those comments relate to strengthening the proposal. Part of another day may be needed for the red team members to debrief the proposal author(s) by meeting with them and going through the proposal and the red team review report, here again line by line, paragraph by paragraph, and section by section, to allow for a full verbal discussion of the written critique and an exchange between the red team members and the proposal team members about ways to strengthen the proposal.

What is the role of red team members? What key factors should red team members address in their review?

The role of the red team members is to evaluate the competitiveness of the proposal by conducting a very probing review of the narrative taking the viewpoint of intelligent readers

with relevant expertise. Red team members must, therefore, reach a consensus on those factors that characterize a successful, competitive proposal, and then apply those competitive factors as markers while undertaking a competitive benchmarking of the proposal. Competitive factors used in the red team's assessment may include the following, among others:

- Clarity of the research vision
- Strength of the case made for the significance of the research
- Clarity and plausibility of substantive claims of research synergy in the proposal
- Completeness of responses to all items/requirements listed in the solicitation
- Clarity of writing and its accessibility to the intelligent reader
- Inclusion of appropriate detail and examples that support the research goals and objectives
- Appropriately synthesized presentation of ideas with performance and operational detail
- Plausibility of the case made for the research team's capacity to perform
- Completeness of demonstrated institutional capacity to support the project
- Strength of the case made for the management team's expertise as equal to or exceeding that needed for success
- Clarity, logic, and plausibility of the proposal's arguments
- Persuasiveness of the claim that the project contributes to the interests and objectives of the funding agency
- Likelihood that the narrative will convince a review panel
- Plausibility of the claim that the proposed project clearly advances the research objectives required by the solicitation.

What key documents are needed for a red team review?

The key documents needed are the solicitation and any documents referenced in the solicitation, a close-to-final draft of the proposal, and any supporting documents, prior proposals, and prior reviews that have informed the proposal process. Based on these documents, red team members may find it helpful to construct a scoring matrix (example below) or table based on the above key factors as well as other factors red team members feel are important based on the specific solicitation. The scoring matrix will help guide the red team members in the review process and give a structure to recording the comments/scoring for each of the key items. For example, each red team member completes a scoring matrix as below. Next, each member of the team shares the score with the entire team as part of developing a team score for each scoring factor, in this case, "*Is the Research Vision Clearly Stated*?," based on discussion with team members, along with a recording of all observations (culling duplicates) by the entire team of the strengths, weaknesses, and suggested improvements the proposal authors might consider in preparing the final document.

Scoring Matrix for Completion by Each Red Team Member and Discussed as Team					
Example Scoring Factor: *Is the Research Vision Clearly Stated?*					
Impact	**Score**	**Descriptor**	**List Strengths**	**List Weaknesses**	**Suggest Improvements**
High Impact	1	Exceptional			
	2	Outstanding			
	3	Excellent			
Moderate Impact	4	Very Good			
	5	Good			
	6	Satisfactory			
Low Impact	7	Fair			
	8	Marginal			
	9	Poor			

What document(s) does the red team produce?

Red team members produce a very detailed report of all recommendations for improving the proposal by identifying weaknesses to correct and strengths to amplify.

What is the role of the red team after the review is complete?

It is helpful when red team members remain engaged in the process of taking the proposal though one or more additional iterations of the narrative.