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Gen-4 Engineering Research Centers (ERC)
Convergent Research and Innovation through Inclusive Partnerships and Workforce Development

PROGRAM SOLICITATION
NSF 19-503

REPLACES DOCUMENT(S):
NSF 15-589

National Science Foundation

Directorate for Engineering
  Engineering Education and Centers

Letter of Intent Due Date(s) *(required)* (due by 5 p.m. submitter's local time):

  November 30, 2018

Preliminary Proposal Due Date(s) *(required)* (due by 5 p.m. submitter's local time):

  January 16, 2019

Full Proposal Deadline(s) (due by 5 p.m. submitter's local time):

  July 12, 2019

IMPORTANT INFORMATION AND REVISION NOTES

IMPORTANT INFORMATION

Cost Sharing: Cost sharing is required. However, inclusion of "voluntary committed cost sharing" is specifically prohibited in NSF's cost sharing policy, as stated in the *NSF Proposal and Award Policies and Procedures Guide*. ERC proposals that include cost sharing amounts more than the specified formula described in this solicitation will be *returned without review*. The formula for required cost sharing is described in the full text of this solicitation.

Webinar: The NSF ERC team plans to broadcast a webinar within approximately 30 days of the release of the solicitation. In the webinar, key features and expectations of ERCs will be discussed. At NSF's discretion, a live and/or recorded webinar(s) may be broadcast. Questions should be submitted in advance of the webinar to nsferc@nsf.gov. FAQs shall be posted as needed.

REVISION NOTES

- **The ERC program has placed greater emphasis on convergence.** Convergent research approaches require the deep integration of knowledge, tools, and ways of thinking beyond engineering (for example, from the physical, mathematical, life/health sciences, computational sciences, and social sciences, among others). Purposeful **team formation** is needed for the convergent approach, supported by diversity and a **culture of inclusion** where all participants are recognized and derive mutual benefits. The convergent approach supports the strong societal impact expected of each ERC.
- **The ERC program has been re-envisioned to emphasize positive societal impact.** ERCs will strive to enable society to have a better quality of life, and be more resilient, productive, and/or safe.
- **The ERC program has strengthened the requirement for demonstrable integration of foundational components.** A strong strategic plan for each ERC outlines the interplay between the four foundational components of the ERC, including the convergent research project, engineering workforce development, the development of a culture of diversity and inclusion, and a focus on value creation within the innovation ecosystem. All these foundational components should together support the ultimate impact on society.
- **The ERC program calls for societal value creation:** Value Creation has often been defined in relation to the business environment, commonly referring to the increase in revenue from products and services or growth in company worth (e.g., stock price). In the context of this solicitation, it is defined as the creation of societal value from innovations (e.g., inventions, goods, services, businesses) that benefit society in a sustainable fashion.
- **The ERC program and this solicitation provide opportunities for effective leadership, management and infrastructure approaches.** Teams are encouraged to be strategic and creative.
- **The ERC program has updated the PI requirements to support the focus on convergence.**
- **The review criteria have been updated to reflect the new ERC emphases.**

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) (NSF 19-1), which is effective for proposals submitted, or due, on or after February 25, 2019.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Gen-4 Engineering Research Centers (ERC)
Convergent Research and Innovation through Inclusive Partnerships and Workforce Development

Synopsis of Program:

The ERC program supports convergent research that will lead to strong societal impact. Each ERC has interacting foundational components that go beyond the research project, including engineering workforce development at all participant stages, a culture of diversity and inclusion where all participants gain mutual benefit, and value creation within an innovation ecosystem that will outlast the lifetime of the ERC. The logical reasoning that links the proposed activities to the identified goals for each ERC should be clear.

Cognizant Program Officer(s):

Please note that the following information is current at the time of publishing. See program website for any updates to the points of contact.

- Sarit B. Bhaduri, telephone: (703) 292-2975, email: sbhaduri@nsf.gov

- Sandra Cruz-Pol, telephone: (703) 292-5729, email: scruzpol@nsf.gov

- Dana L. Denick, telephone: (703) 292-8866, email: ddenick@nsf.gov

- Nadia A. El-Masry, telephone: (703) 292-4975, email: nelmasry@nsf.gov

- Deborah J. Jackson, telephone: (703) 292-7499, email: djackson@nsf.gov

- Eduardo A. Misawa, telephone: (703) 292-5353, email: emisawa@nsf.gov

Applicable Catalog of Federal Domestic Assistance (CFDA) Number(s):

- 47.041 --- Engineering

Award Information

Anticipated Type of Award: Cooperative Agreement

Estimated Number of Awards: 4

Up to 4 depending on the quality of the proposals and the availability of funds. ERCs generally operate for ten years, with an initial award for the first five years and second award based on performance and review of a renewal proposal. This solicitation seeks to make awards for the first five years for up to 4 new ERCs.

Anticipated Funding Amount: $14,000,000

$14,000,000 to support the first year for up to four newly funded ERCs, depending on availability of funds in FY 2020. ERCs generally operate for ten years, with an initial award for the first five years and second award based on performance and review of a renewal proposal.

NSF expects to make the ERC awards in the summer of 2020. The initial ERC award would be for five years. The maximum annual budget allowed is shown in the table below.

Year	Allowable Maximum Budget
1	$3,500,000
2	$4,500,000
3	$6,000,000
4	$6,000,000
5	$6,000,000

Year 1 budget will be committed upon award, and subsequent year budgets are subject to satisfactory annual review of accomplishments and availability of funds. After a gradual ramp up, years three through five are projected to level off at $6,000,000 in each of those years. Pending performance and outcome of a renewal review in the fourth year, support for years six to eight will continue at $6,000,000 per year. Support for years nine and ten will be phased down, with $4,000,000 in year 9 and $2,600,000 in year 10.

Eligibility Information

Who May Submit Proposals:

Proposals may only be submitted by the following:

- Only U.S. universities that grant engineering degrees at the undergraduate, masters, and doctoral engineering level may submit proposals as the lead university. The lead university submits the proposal, and the award is made to the lead university. Support is provided to partnering universities and any affiliated faculty from non-partner institutions through subawards.

  A university that leads two ERCs from the Classes of 2010 through 2017 and the Nanosystems ERC Classes of 2012 and 2015 may not submit a proposal in the lead role. However, the university can participate as a partner in an ERC led by another eligible institution.

Invited full proposals must meet all the following organizational requirements or they will be returned without review:

- A proposed ERC must be multi-institutional, with a lead university and additional domestic university core partners.
- To qualify as a core partner institution, there must be a minimum of three faculty participating in the ERC along with a minimum of three students.
- The lead or at least one of the core partner universities must be a university that serves populations of traditionally underrepresented students interested in STEM (defined as minority serving institutions, women's colleges, or institutions where the majority of the students are students with disabilities).
- Commitments from lead and core partner universities for cost sharing must be in place.

Who May Serve as PI:

The Lead PI must be a tenured faculty member at the lead university. Non-Lead PIs are the PIs listed on the Cover Sheet after the Lead PI and may be from institutions other than the lead university. The Lead PI and the ERC Director are not required to be the same person, however both must be affiliated with the lead institution.

Limit on Number of Proposals per Organization:

None Specified for Preliminary Proposals.

Full Proposals may be submitted only by invitation and only by the lead university designated in the preliminary proposal.

Limit on Number of Proposals per PI or Co-PI:

There are no restrictions or limits.

Proposal Preparation and Submission Instructions

A. Proposal Preparation Instructions

- **Letters of Intent:** Submission of Letters of Intent is required. Please see the full text of this solicitation for further information.

- **Preliminary Proposals:** Submission of Preliminary Proposals is required. Please see the full text of this solicitation for further information.

- **Full Proposals:**

  - Full Proposals submitted via FastLane: *NSF Proposal and Award Policies and Procedures Guide* (PAPPG) guidelines apply. The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.
  - Full Proposals submitted via Research.gov: *NSF Proposal and Award Policies and Procedures Guide* (PAPPG) guidelines apply. The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.
  - Full Proposals submitted via Grants.gov: *NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov* guidelines apply (Note: The *NSF Grants.gov Application Guide* is available on the Grants.gov website and on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide).

B. Budgetary Information

- **Cost Sharing Requirements:**

  Cost Sharing is required. Please see the full text of this solicitation for further information.

- **Indirect Cost (F&A) Limitations:**

  Not Applicable

- **Other Budgetary Limitations:**

  Other budgetary limitations apply. Please see the full text of this solicitation for further information.

C. Due Dates

- **Letter of Intent Due Date(s)** *(required)* (due by 5 p.m. submitter's local time):

  November 30, 2018

- **Preliminary Proposal Due Date(s)** *(required)* (due by 5 p.m. submitter's local time):

  January 16, 2019

- **Full Proposal Deadline(s)** (due by 5 p.m. submitter's local time):

July 12, 2019

Proposal Review Information Criteria

Merit Review Criteria:

National Science Board approved criteria. Additional merit review criteria apply. Please see the full text of this solicitation for further information.

Award Administration Information

Award Conditions:

Standard NSF award conditions apply.

Reporting Requirements:

Additional reporting requirements apply. Please see the full text of this solicitation for further information.

TABLE OF CONTENTS

I. INTRODUCTION

The National Science Foundation (NSF) created the Engineering Research Centers (ERC) program in 1984 to bring technology-based industry and universities together in an effort to strengthen the competitive position of American industry in the global marketplace. These partnerships established cross-disciplinary centers focused on advancing fundamental engineering knowledge and engineered systems technology while exposing students to the integrative aspects of engineered systems and industrial practice. As a result, ERCs have produced a wide range of engineered systems and other technologies aimed at spawning whole new industries or radically transforming the product lines, processes, and practices of current industries. At the same time, they have produced a new generation of engineering graduates who are highly innovative, diverse, globally engaged, and effective as technology leaders in academia and industry.

NSF has continually refined the goals and purposes of the ERC program to meet shifting needs. The NSF-requested 2017 study from the National Academies of Sciences, Engineering, and Medicine (NASEM) "A New Vision for Center-Based Engineering Research" recommends that NSF place a greater emphasis on forming research centers focused on convergent research and education approaches that address challenges with significant societal impact. Convergent problems require the deep integration of knowledge, tools, and ways of thinking across disciplinary boundaries. A detailed explanation of the convergence concept can be found in a 2014 National Academies report, "Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering and Beyond" and in the NSF's 10 Big Ideas Growing Convergence Research at NSF website.

This current iteration of the ERC program reflects the recommendations from the NASEM study as well as other sources. The program continues to focus on advancing an engineered system through inclusive cross-disciplinary and cross-sector partnerships, while placing greater emphasis on research that leads to societal impact through convergent approaches, engaging stakeholder communities, and strengthening team formation.

II. PROGRAM DESCRIPTION

A. ERC Program Model

The ERC program is grounded by the four foundational components of the ERC: **Research, Engineering Workforce Development, Diversity and Culture of Inclusion, and the Innovation Ecosystem** (Figure 1). These foundational components are connected by an integrated, holistic ERC vision and strategic plan. The whole of the ERC has added value and synergies that require a center or institute-like approach as opposed to individual projects.
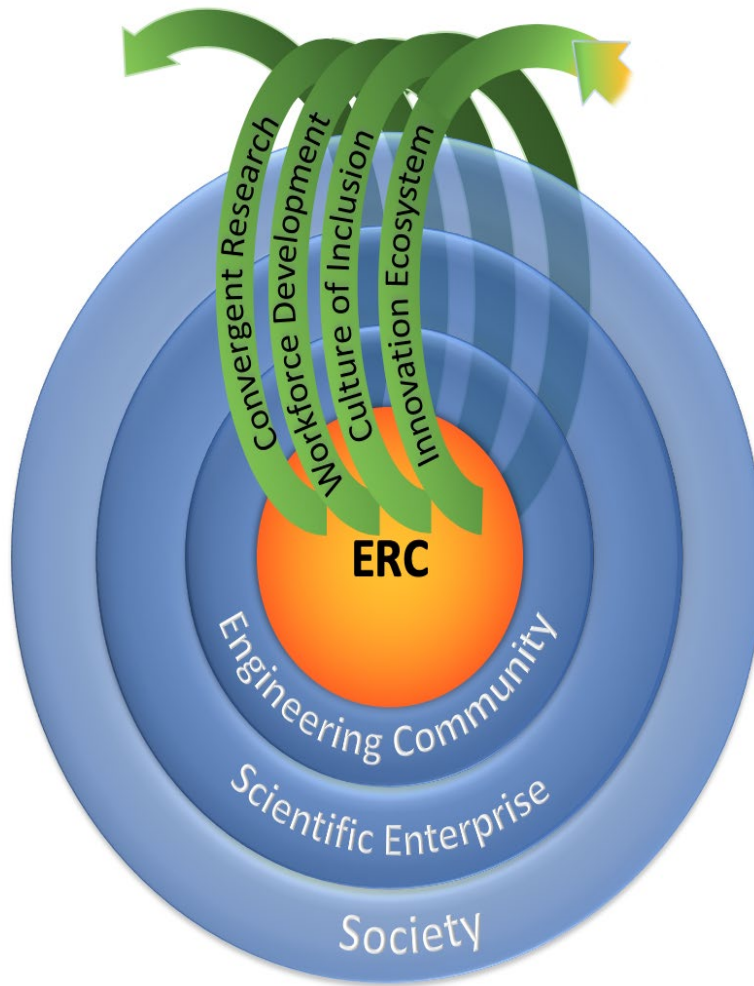

Figure 1: The NSF Engineering Research Center model.

Research: Discovery that pushes the frontiers of engineering knowledge; ERC convergent research is a deeply collaborative and cross/transdisciplinary effort that results in positive societal impact. Convergence blends engineering, science and social science disciplines in a coordinated, reciprocal way and fosters robust collaborations needed for successful inquiry.

Engineering Workforce Development: Human resource capacity development aligned with the targeted engineered system; ERC engineering workforce development strengthens a robust spectrum of engineering education and pathways. Workforce Development occurs at all levels of the Center and provides opportunities for engagement by all ERC members including students, faculty, and external partners as appropriate.

Diversity and Culture of Inclusion: The culture of the ERC and teams within the ERC demonstrate an environment in which all members feel valued and welcomed, creatively contribute, and gain mutual benefit from participating. Because of the ERC's attention to diversity and culture of inclusion, participation from members of groups traditionally underrepresented in engineering as well as diverse scientific and other perspectives is required.

Innovation Ecosystem: Trusted partners that work together to create and enhance the capacity for innovation and new ways for delivering value with positive societal impact. ERC innovation ecosystems include effective translational efforts from ideation to implementation, workforce development that creates the workforce needed for the enterprise, and deliberate efforts to attract funding and resources. ERCs articulate plans for strategic engagement of stakeholder communities while including the legal frameworks needed to protect the participants.

The ERC foundational elements are carried out in concert through ERC activities and in alignment with the Center's vision and targeted societal impact. The overall impact of the ERC program is expected within the **Engineering Community**, the **Scientific Enterprise**, and **Society**, shown in Figure 1 (above). These may be thought of as nested spheres of increasing influence, where the largest-scale of impact is on society itself. Potential outcomes of ERCs are organized within each of the four ERC foundational components.

Engineering Community: ERCs not only create fundamental knowledge and technology, but also impact the engineering community, preparing students and researchers by highlighting new engineering approaches and best practices for engineering workforce development, diversity and inclusion, and

academic-industrial partnerships.

Scientific Enterprise: ERCs should be exemplars of how cohesive, high-performing teams engage in convergent research and innovative approaches to create major impact that informs and inspires the scientific community, engineering and beyond.

Society: ERCs enable society to be more resilient, productive, and safe. Each ERC is expected to have a transformational positive impact on significant societal challenges and opportunities. This is the level where the introduction of **value creation and technology innovation** requires an understanding of socio-technical interactions and how they might impact society at large. In response, new strategies, concepts, ideas and/or re-organizations may be needed to shore-up, extend, or strengthen society. The desired outcome is the ERC's ability to assist society in its drive towards net positive societal impact.

B. Goals

The goal of the ERC program has traditionally been to integrate engineering research and education with technological innovation to transform and improve national prosperity, health, and security. Building upon this tradition, NSF is interested in supporting ERCs to develop and advance engineered systems, which if successful, will have a high **Societal Impact**. The approach to the engineered systems challenges resonates with NSF's emphasis on **Convergent Research**, one of NSF's 10 Big Ideas for future investment announced in May 2016. The complexity of convergent endeavors underscores the importance of purposeful **Team Formation**, including **Effective Leadership/Management**, and the development and nurturing of **Stakeholder Communities**.

ERCs create inclusive cultures not only to integrate scientific discovery with technological innovation through convergent engineered systems research and education, but also to benefit from the full participation of people traditionally underrepresented in engineering, stimulating creativity and fresh perspectives. ERCs build partnerships with industry, practitioners, and other key stakeholders to strengthen the innovative capacity of the United States in a global context. In addition to building capacity for research, innovation, and a diverse workforce, ERCs are expected to produce significant outcomes within the 10-year timeframe of NSF support and beyond.

ERCs should realize a vision of advancing an engineered system driven by clearly articulated societal impact and should have strong synergies or value-added rationale that justifies a center or institute-like approach. As part of creating sustainable positive impacts on society and communities, ERCs should focus on positive outcomes that can be seen within engineering communities, and build and empower human resource capacity for their targeted engineering challenges. Beyond this, ERCs should contribute to the scientific enterprise by advancing research, science, engineering fundamentals, and research communities. ERCs should build knowledge, prepare students and researchers that respect and flourish in an environment with diverse perspectives, impact how engineering research is conducted and provide value for society.

C. Key Elements of an ERC

Vision: The ERC vision guides discovery and technology to uniquely transform US prosperity, health, and/or security in 10 years. The vision describes the compelling new idea and how it relates to national needs.

Strategic Plan: The ERC strategic plan connects and leverages research, engineering workforce development, diversity and culture of inclusion, and innovation ecosystem to address the chosen societal impact. The overall plan should employ three strategic approaches:

- *Convergence***:** "Convergence is an approach to problem solving that cuts across disciplinary boundaries. It integrates knowledge, tools, and ways of thinking across disciplinary boundaries in STEM fields to form a comprehensive synthetic framework for tackling scientific and societal challenges that exist at the interfaces of multiple fields." (National Academies Press NAP, 2014). This aligns with the definition used by the National Academies of Sciences, Engineering, and Medicine (NASEM) in a report from the Committee on a Vision for the Future of Center-based Multidisciplinary Engineering Research, which defined convergent engineering as a deeply collaborative, team-based engineering approach for defining and solving important and complex societal problems (NASEM, 2017). Convergence research blends scientific disciplines in a coordinated, reciprocal way and fosters the robust collaboration needed for successful inquiry and has the strong potential to lead to transformative solutions and new fields of study. The research thrusts, testbeds, team formation, and other major aspects of the research plan should support a convergent approach.
- *Stakeholder Engagement***:** Include all parties who may contribute to the ERC or may be impacted by the ERC along its capacity-building and value creation responsibilities. For example, stakeholders can include but are not limited to relevant researchers across partner institutions with complementary research and education expertise; undergraduate and graduate students, postdoctoral researchers; industry leaders who can guide the innovation effort; partners for innovation, education, workforce development, and diversity and culture of inclusion; and beneficiaries of the ERC outcomes (e.g., community members, users, customers, patients, watchdog organizations and policy-makers).
- *Team Formation***:** The process by which all necessary disciplines, skills, perspectives, and capabilities are brought together. Successful teams are interdependent, multidisciplinary, and diverse and can work and communicate effectively even when geographically dispersed. Team formation includes strategies to overcome barriers to effective, collaborative teaming, including the integration of members with different areas of expertise, different vocabularies and core values and ways of approaching problems, different understanding of the problems to be addressed, different values, and different working styles.

ERC Infrastructure:

Effective Leadership: ERC leaders have intellectual vision, demonstrable leadership, successful entrepreneurial experience, a track record of delivering results, and the ability to communicate clearly and effectively with diverse audiences such as team members, sponsors, partners, host institutions, stakeholders, press and media, and the public. Below are some example practices desired for effective ERC leadership and management teams:

- Empowers all team members to contribute regardless of status and power differences;
- Establishes a culture of deep collaboration and inclusion;
- Builds consensus around goals and problem definition;
- Facilitates communication to ensure a common understanding among all stakeholders; and
- Resolves conflicts and builds trust.

It is rare that a single individual will have all of these attributes; thus, a strong leader will need to assemble an executive team that covers this broad spectrum of skills. The Center Director should understand her/his strengths and limitations and be effective in assembling an executive leadership team that fills in the gaps of her/his limitations.

Organization and Management: An effective management structure begins with a clear understanding of the goals of the ERC and how the structure (including the ERC four foundational components) will support those goals. The structure should have the flexibility to adapt as the needs of the ERC

change, as key people transition into or out of the ERC, or change roles, and to handle other changes as the ERC matures.

There is a tension between ensuring that there are clear lines of authority and ensuring that foundational components of the ERC are fully integrated into the structure of the ERC. It is critical to have one person or team that has clear responsibility for each foundational component of the ERC. However, each ERC participant should also understand the importance of each foundational component and be engaged in their role in carrying it out.

ERC program experience has shown that an important role in the ERC structure is that of an administrative director, as described below. This remains a mandatory piece of the management structure.

Administrative Director: An experienced staff member at the lead university who is responsible for operational management, financial management, data collection, publicity, and reporting, etc. for the ERC. Post-award NSF training is available for this position given the ERC reporting complexities.

Partners:

Lead Institution: The lead institution effectively guides the multiple elements of the ERC. The ERC headquarters are located at the lead institution, and the lead institution is the NSF awardee and is ultimately responsible for the financial and reporting obligations of the ERC award.

Core partners: To qualify as a core partner university, there must be a minimum of three faculty participating in the ERC along with a minimum of three students. Core partners are included in the Cost Sharing requirements and in the Council of Deans.

Other potential partners may include universities contributing affiliated faculty, federal laboratories, private-sector or non-profit organizations, educational partners, and/or foreign collaborators' universities or institutions. While not considered core partners, the involvement of such partners can be valuable.

ERCs should engage industrial/practitioner members from sectors such as the Federal Government, State government, local government, quasi-government research, industry, industry association, medical facility, private foundation, nonprofit, venture capitalists, and others.

Industrial/Practitioner Member: An organization that satisfies all requirements for membership according to the Center's membership agreement which may include financial support (cash or in-kind).

Affiliated Faculty Member: The ERC may include affiliated faculty members, which are faculty members who are contributing to the ERC from institutions other than the lead or core partner universities and are included in the budget.

Institutional Commitment: The lead and all core partner institutions must augment support for the ERC through cost-sharing and other allowed means and sustain the ERC once NSF's support ceases. Lead, core and partner academic institutions must commit to:

- Joining in partnership to support the ERC's vision, strategic plans, and activities in convergent research, engineering workforce development, diversity and culture of inclusion, and innovation ecosystem.
- Assuring cross-university industrial membership and intellectual property (IP) policies that recognize shared rights for joint work.
- Making institute policies to reward faculty, particularly those in the tenure and promotion process, for participating in convergent research and innovation, technological advance, mentoring, university and pre-college education, and delivering on the ERC's plans for workforce development and creating an inclusive and diverse culture.
- Providing institute credit or official recognition for university students engaged in mentoring of other university students and in pre-college outreach.

Community Feedback: Feedback to the ERCs is one of the important mechanisms used by the ERC to provide continual monitoring of the Center's health.

Advisory Boards: Advisory boards are formed to reinforce and support the proper functioning of the ERC's foundational components which are Research, Engineering Workforce Development, Diversity and Culture of Inclusion, and Innovation Ecosystem. Careful consideration must be given to defining each advisory board's functional role and selecting quality board members capable of overseeing that role. An example of a generic ERC feedback loop structure is illustrated in Figure 2. As part of the NSF Management/Oversight, the NSF Program Director and the NSF Site Visit Team (SVT) typically interact with the ERC and give feedback to the ERC once a year at a minimum. The advisory boards provide feedback at least twice a year; usually more often on an as needed basis. Depending on the Center's mission, occasionally it is necessary to form special committees to support special needs of the Center's vision. The staffing of these committees may be either internal or external. The Council of Deans and Student Leadership Council, as defined below, are mandatory advisory groups; however, the ERC can propose other advisory groups beyond these two.
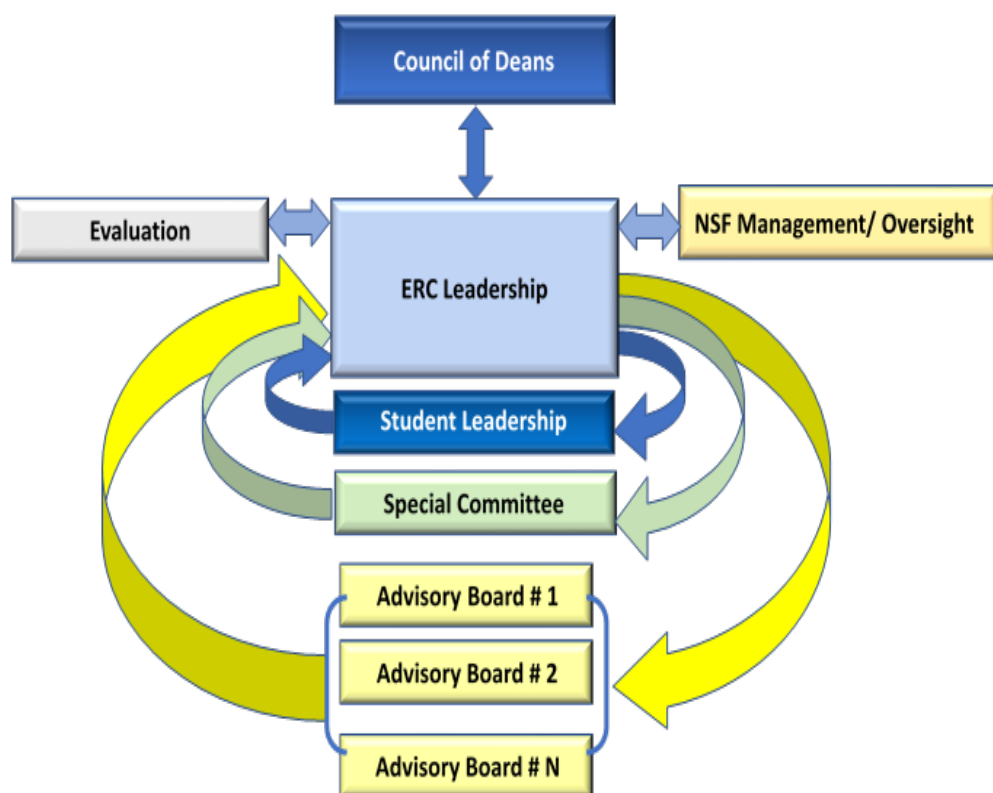
Figure 2: Generic Executive Leadership Team illustrating the advisory board feedback mechanism. Appointees in the blue are from within the ERC Team. Appointees in the yellow boxes are external to the ERC partner institutions.

Student Leadership Council (SLC): Undergraduate and graduate students from all partner universities responsible for coordinating their various activities in support of the ERC. A student president and a student co-president lead the SLC. The SLC will prepare a written Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis and present the SWOT findings during the annual visit of the NSF Site Visit Team (SVT).

Council of Deans: Led by the Dean of Engineering from the lead university, this Council of Deans from the lead and core partner institutions meet collectively as a group to provide administrative support of the ERC and to help facilitate multiple elements of the ERC across the lead and core partner universities. If a Non-Lead PI is also an administrator at the Institution eligible to serve on the Council of Deans, she/he should designate an alternate for serving on the Council of Deans while serving as the Non-Lead PI. The two roles cannot be performed by the same person.

III. AWARD INFORMATION

Estimated program budget, number of awards and average award size/duration are subject to the availability of funds.

$14,000,000 to support the first year for up to four newly funded ERCs, depending on availability of funds in FY 2020. ERCs generally operate for ten years, with an initial award for the first five years and second award based on performance and review of a renewal proposal.

NSF expects to make the ERC awards in the summer of 2020. The initial ERC award would be for five years. The maximum annual budget allowed is shown in the table below.

Year	Allowable Maximum Budget
1	$3,500,000
2	$4,500,000
3	$6,000,000
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Year 1 budget will be committed upon award, and subsequent year budgets are subject to satisfactory annual review of accomplishments and availability of funds. After a gradual ramp up, years three through five are projected to level off at $6,000,000 in each of those years. Pending performance and outcome of a renewal review in the fourth year, support for years six to eight will continue at $6,000,000 per year. Support for years nine and ten will be phased down, with $4,000,000 in year 9 and $2,600,000 in year 10.

IV. ELIGIBILITY INFORMATION

Who May Submit Proposals:

Proposals may only be submitted by the following:

- Only U.S. universities that grant engineering degrees at the undergraduate, masters, and doctoral engineering level may submit proposals as the lead university. The lead university submits the proposal, and the award is made to the lead university. Support is provided to partnering universities and any affiliated faculty from non-partner institutions through subawards.

  A university that leads two ERCs from the Classes of 2010 through 2017 and the Nanosystems ERC Classes of 2012 and 2015 may not submit a proposal in the lead role. However, the university can participate as a partner in an ERC led by another eligible institution.

Invited full proposals must meet all the following organizational requirements or they will be returned without review:

- A proposed ERC must be multi-institutional, with a lead university and additional domestic university core partners.
- To qualify as a core partner institution, there must be a minimum of three faculty participating in the ERC along with a minimum of three students.
- The lead or at least one of the core partner universities must be a university that serves populations of traditionally underrepresented students interested in STEM (defined as minority serving institutions, women's colleges, or institutions where the majority of the students are students with disabilities).
- Commitments from lead and core partner universities for cost sharing must be in place.

Who May Serve as PI:

The Lead PI must be a tenured faculty member at the lead university. Non-Lead PIs are the PIs listed on the Cover Sheet after the Lead PI and may be from institutions other than the lead university. The Lead PI and the ERC Director are not required to be the same person, however both must be affiliated with the lead institution.

Limit on Number of Proposals per Organization:

None Specified for Preliminary Proposals.

Full Proposals may be submitted only by invitation and only by the lead university designated in the preliminary proposal.

Limit on Number of Proposals per PI or Co-PI:

There are no restrictions or limits.

V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. Proposal Preparation Instructions

Letters of Intent *(required)*:

A Letter of Intent (LOI) is required to facilitate the NSF review process. The LOI should be submitted via FastLane no later than the LOI deadline date.

Please note the following conditions:

- LOIs should be submitted through FastLane (not Grants.gov).
- A Minimum of one and Maximum of five PIs are allowed.
- Carnegie Foundation Organizational Attribute (lead University) is required.
- A list of all anticipated Core Partner Universities is required.

The lead university cannot change after submission of the Letter of Intent.

Project Title: The title should begin with "NSF Engineering Research Center for (*insert the rest of the title and the Center's acronym*)".

ERC Director and/or Lead PI and Point of Contact for NSF Inquiries: Please include the Director's name, university, department, phone number, and e-mail address. Please also include the Lead PI's information, if the Lead PI and the Director are different individuals.

Anticipated ERC Non-Lead PIs: Identify up to four Non-Lead PIs. Include their names, universities, departments, and locations (city, state, country). The participating team will be limited to the lead PI and Non-Lead PIs who may come from any or all the domestic core partner universities. The Non-Lead PIs may change upon submission of an invited full proposal.

Anticipated Core Partner Universities: The lead university (not PI) is binding throughout the process. Other partners may change. This section should include only the anticipated core partner universities. For each core partner include the name and location (city, state and country). Each core partner entry can have up to 76 characters (including spaces) to show all requested information.

Synopsis (max 2,500 characters in this section, including any spaces): Provide brief statements of the vision and goals of the ERC, its potential for societal impact, and an integrated plan for the Center. Include an overview of the research program, such as research thrust titles, goals, and fundamental gaps or barriers in knowledge/technology that it meets. Although the engineering workforce development, diversity and culture of inclusion,

and the innovation ecosystem are critical foundational components of an ERC, they do not need to be described in detail in the LOI.

Other Comments (an additional max 2,500 characters including any blank spaces): Continue Synopsis as needed in this section.

Organizational Attribute: Select the appropriate organizational attribute for the lead university from the drop-down list.

Keywords: In order of decreasing emphasis, list four keywords that represent the scientific interdisciplinary content in the proposal.

Letter of Intent Preparation Instructions:

When submitting a Letter of Intent through FastLane in response to this Program Solicitation please note the conditions outlined below:

- Submission by an Authorized Organizational Representative (AOR) is required when submitting Letters of Intent.
- A Minimum of 0 and Maximum of 4 Other Senior Project Personnel are permitted
- A Minimum of 0 and Maximum of 4 Other Participating Organizations are permitted
- Keywords is required when submitting Letters of Intent
- Submission of multiple Letters of Intent is permitted

Preliminary Proposals *(required)*: Preliminary proposals are required and must be submitted via the NSF FastLane system, even if full proposals will be submitted via Grants.gov.

Submission of a Preliminary Proposal is required to be eligible for an invitation to submit a Full Proposal.

Preliminary Proposal Preparation Instructions:

Preliminary proposals must explicitly address the following questions in the project description:

1. What is the compelling new idea and what is the potential high societal impact?
2. Why is an ERC necessary to tackle the idea?
3. How will the ERC's infrastructure integrate and implement convergent research, engineering workforce development, diversity and culture of inclusion, and an innovation ecosystem to achieve its vision and create societal impact, impact on the scientific enterprise, and impact on the engineering community?
4. What is the proposed management structure for the ERC and how will it foster team-formation and convergent research, as well as an integrated approach for items 1-3 above?
5. What are the proposed strategies for engaging and developing the appropriate stakeholder community?
6. How will all ERC participants engage in a unique experience that would otherwise not be available?

Cover Sheet: Select the program solicitation number from the drop-down list. The ERC Program solicitation will automatically appear. Check the box indicated for the preliminary proposal. Entries on the Cover Sheet are limited to the Lead Principal Investigator (PI) and a maximum of four co-principal investigators (Non-Lead PIs). The sum of $2 must be entered on the budget line to allow correct FastLane processing.

Project Title: The title should begin with "NSF Engineering Research Center for (*insert the rest of the title and the Center's acronym*)".

Project Summary (1 page): The Project Summary must have three sections entitled, respectively, "Proposed Vision", "Intellectual Merit", and "Broader Impacts", with the "Proposed Vision" included in the "Proposal Overview" box of FastLane. The summary should be informative to those working in the same or related fields and understandable to a scientifically or technically literate reader. Preliminary proposals that do not contain the Project Summary as described above will not be accepted by FastLane or will be returned without review. Additional instructions for preparation of the Project Summary are available in FastLane.

Project Description: Maximum 10 pages, total, containing the following sections, not necessarily in this order. All figures and tables must be included within the 10-page limit.

The intellectual merit and broader impacts of the ERC must be addressed and described throughout the narrative as an integral part of the proposal, instead of in separate sections in the Project Description. Also, Results from Prior Support is not a required section of the preliminary proposal.

Proposing Team: The description must start with a table that includes: (1) Name of the Lead PI (and ERC Director, if different from the Lead PI) and Non-Lead PIs, (2) Institution(s), (3) Department(s), and (4) Most Relevant Field(s) of Expertise. In addition, please list all committed senior personnel. Do not identify members of advisory boards.

Vision: The proposed vision for the ERC must be explained, with a discussion of the convergent engineering research theme and the anticipated societal impact. Explain the proposed transformative engineered system and the potential for impact on society, the engineering community and the greater scientific community.

Strategic Plan: The plan must define the engineered system and describe how the features of the ERC will be integrated to achieve the vision, in particular the cohesive plan for involving participants at all levels in the four foundational components:

- Research
- Engineering Workforce Development
- Diversity and Culture of Inclusion
- Innovation Ecosystem

Infrastructure (Organization and Management): Describe the proposed management, including the functions of key personnel and the role of any advisory committee (including the required Student Leadership Council and the Council of Deans), executive committee, program committee, or their equivalent.

Research: The role of convergence and team formation in the proposed research must be described. Research activities must address any gaps and barriers to achieve the proposed vision. Research must advance fundamental knowledge and support the development of technology that is proven through proof-of-concept testbeds as part of a well-defined engineered system. Integration of research activities must be graphically depicted on a full page fully legible version of the ERC Program's 3-Plane Strategic Planning Chart (http://erc-assoc.org/content/three-plane-diagram) that is tailored to the proposed ERC.

Engineering Workforce Development: A proposed evidence-based program for building human capacity for the future engineering workforce must be described. Proposed activities should logically lead to targeted outcomes and support diverse pathways and experiences for participants. Educational partnerships may be leveraged to support the program and provide opportunities to engage with potential participants.

Diversity and Culture of Inclusion: Preliminary ideas to create and nurture a culture of inclusion, including a diverse group of scientific backgrounds and training as well as participants from groups that are underrepresented in engineering, must be outlined.

Innovation Ecosystem: An innovation ecosystem development effort must be proposed. However, do not list potential or committed industrial or other supporters.

References Cited: See PAPPG for format guidelines.

Biographical Sketches: Should be included for the Lead PI, Center Director (if different from the Lead PI) and up to four Non-Lead PIs in accordance with the PAPPG guidelines, described in Chapter II.C.2.f.

Budget: No detailed budget and corresponding justification will be submitted; however, please enter $2 in the Requested Amount box on the FastLane Cover Sheet (this entry allows correct FastLane processing).

Supplementary Documents: A letter from the Dean of Engineering of the lead institution **must be** submitted which describes the support for and commitment to the ERC (including space for the ERC headquarters) should it be funded. While the Lead PI does not need to be from the School of Engineering, this letter must be from the Dean of Engineering to demonstrate the Engineering Dean's support for the proposed impact of the ERC on the engineering community. The Dean should NOT include any financial commitments. Instead, the Dean should make a statement as to how the proposed ERC will align with the strategic directions of the college or the university. **Proposals submitted without a letter of commitment from the Dean of Engineering will be returned without review.** No letters of collaboration are allowed.

Single Copy Documents:

Collaborators & Other Affiliations Information: Information regarding collaborators and other affiliations (COA) must be separately provided for each individual identified as senior project personnel, which includes the Lead PI, Center Director if different from the Lead PI, Non-Lead PIs, all members of the ERC Leadership Team, key faculty, and key staff participants. The COA information must be uploaded using the NSF COA template into the Single Copy Documents as described in the PAPPG and the Collaborators and Other Affiliations Information website (https://nsf.gov/bfa/dias/policy/coa.jsp). The accuracy of this section is very important to the integrity of the ERC review process. Please be accurate and complete with the entries.

Institutional Conflicts: Beyond the conflicts captured on the COA form for individual ERC participants, the ERC Lead University must report any institutional conflicts arising from partnerships including any government agencies, international partners, industry partners or other non-academic institutional partners. The institutional conflict information must be entered into the ERC Preliminary Proposal Institutional Conflict template (http://erc-assoc.org/content/erc-gen-4-solicitation) and uploaded into the Single Copy Documents section.

DO NOT SUBMIT other documents, including Letters of Commitment or Collaboration from the domestic partner universities, prospective industrial members, or other future partners. The only allowed item is the required letter from the Dean of Engineering at the Lead Institution.

The following proposal sections are required by the PAPPG and FastLane but not allowed in the preliminary proposals. Please insert the text "Not Applicable" into each of these sections so that FastLane will allow the submission of the preliminary proposal: Current and Pending Support; Facilities, Equipment and Other Resource; Data Management Plan; Postdoctoral Mentoring Plan; and Budget Justification.

The budget should include only the necessary $2 amount.

SUMMARY OF PRELIMINARY PROPOSAL REQUIREMENTS

(Note: This is **NOT** a total list of the ERC preliminary proposal requirements. Refer to the ERC Solicitation and the PAPPG for complete requirements).

Topic	Preliminary Proposal
Letter of commitment from the Dean of Engineering, including a commitment to headquarters space	Yes (but no cost sharing identified in letter)
Letters of collaboration from committed senior personnel	No letters of collaboration allowed for preliminary proposal
Collaborators & Other Affiliations Information for ERC key personnel (see above)	Uploaded as separate files to Single Copy Documents using COA template
Institutional Conflicts for ERC Lead University	Uploaded to Single Copy Documents using ERC template
Academic cost sharing (Lead and domestic core partner universities)	Not described in preliminary proposal
Industrial/Practitioner member cash and in-kind support	Not described in preliminary proposal

Full Proposal Preparation Instructions: Proposers may opt to submit proposals in response to this Program Solicitation via Grants.gov or via the NSF FastLane system.

- Full proposals submitted via FastLane: Proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the general guidelines contained in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG). The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg. Paper copies of the PAPPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov. Proposers are reminded to identify this program solicitation number in the program solicitation block on the NSF Cover Sheet For Proposal to the National Science Foundation. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Failure to submit this information may delay processing.

- Full proposals submitted via Grants.gov: Proposals submitted in response to this program solicitation via Grants.gov should be prepared and submitted in accordance with the *NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov*. The complete text of the *NSF Grants.gov Application Guide* is available on the Grants.gov website and on the NSF website at: (https://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide). To obtain copies of the Application Guide and Application Forms Package, click on the Apply tab on the Grants.gov site, then click on the Apply Step 1: Download a Grant Application Package and Application

Instructions link and enter the funding opportunity number, (the program solicitation number without the NSF prefix) and press the Download Package button. Paper copies of the Grants.gov Application Guide also may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov.

See PAPPG Chapter II.C.2 for guidance on the required sections of a full research proposal submitted to NSF. Please note that the proposal preparation instructions provided in this program solicitation may deviate from the PAPPG instructions.

Full Proposal Preparation Instructions: As a multi-university ERC, the proposal must be submitted as a single integrated proposal by the lead university, with proposed subawards to the other partner institutions. **Separate proposals from each partner will not be accepted.**

Cover Sheet: Select the ERC Program solicitation number from the drop-down list. For planning purposes, September 1, 2020 should be shown as the start date.

Project Title: The title should begin with "NSF Engineering Research Center for (*insert the rest of the title and the Center's acronym*)". The title should reflect the system focus of the proposed ERC.

Project Summary (1 page): The Project Summary must have three sections entitled, respectively, "Proposed Vision", "Intellectual Merit", and "Broader Impacts", with the "Proposed Vision" included in the "Proposal Overview" box of FastLane. The summary should be informative to those working in the same or related fields and understandable to a scientifically or technically literate reader. Full proposals that do not contain the Project Summary as described above will not be accepted by FastLane or will be returned without review. Additional instructions for preparation of the Project Summary are available in FastLane.

Table of Contents: will be generated automatically by FastLane or Grants.gov.

Project Description: Maximum 26 pages, total, containing the following sections, not necessarily in this order. Figures and tables must be included within the 26-page limit.

Intellectual Merit and Broader Impacts: The intellectual merit and broader impacts of the ERC must be addressed and described throughout the narrative as an integral part of the proposal, instead of in separate sections in the Project Description as required in the PAPPG.

Proposing Team: The description must start with a table that includes: (1) Name of the Lead PI (and ERC Director, if different from the Lead PI) and Non-Lead PIs, (2) Institution(s), (3) Department(s), and (4) Most Relevant Field(s) of Expertise. In addition, please list all committed senior personnel. Do not identify members of advisory boards.

After a full proposal has been submitted, no additional partners may be added to the team for the remainder of the review process (i.e., university partners, university affiliates, or industrial, practitioner or innovation partners).

I. Vision

The proposed vision for the ERC must be explained, with a discussion of the convergent engineering research theme and the anticipated societal impact. Explain the proposed transformative engineered system and the potential for impact on society, the engineering community and the greater scientific community.

Rationale: Make the case for why the proposed ERC is appropriate and why a convergent approach is needed for the targeted societal impact. Articulate the additional value of the proposed ERC compared with the sum of parts. Identify some key ideas that will be built upon to form the ERC.

II. Strategic Plan

The plan must define the engineered system and describe how the features of the ERC will be integrated to achieve the vision, in particular the cohesive plan for involving participants at all levels in the four foundational components:

- Research
- Engineering Workforce Development
- Diversity and Culture of Inclusion
- Innovation Ecosystem

The Strategic Plan should include the high-level goals within each of these foundational components that will be described in more detail in later sections and the interrelationships among those goals, as well as the strategic role of partner institutions in achieving these goals. The plan should also include the high-level expected progress of the ERC efforts across the 10-years of support in these four fundamental components. The plan should further include discussions on the overarching convergent approach, the engagement of the stakeholder community, and the plans for convergent team formation. The ERC Strategic Plan should provide a roadmap with major milestones and describe how the ERC will know when it has been successful in meeting its goals. Finally, the ERC Strategic Plan should also articulate the logical reasoning that connects the proposed activities to the identified goals as well as the connections between the goals and the desired impacts expressed in the ERC Vision. The overall strategy must have the flexibility and the agility to evolve over time. An ERC needs to continually refine its vision based on a reliable feedback mechanism to focus on core advances, prune less compelling ERC elements, and refine as necessary the level of detail of its strategic plan over time.

III. Infrastructure

Leadership Team: To properly address the four foundational components of the ERC, among the ERC Leadership Team, there must be identified individuals with: (a) deep expertise in the fundamental science/engineering areas envisioned by the ERC; (b) strategic leadership in innovation including intellectual property; (c) expertise in engineering workforce development and (d) experience in diversity and inclusion. Provide a chart summarizing the composition and expertise of the leadership team. Justify how each of the disciplines in this spectrum is needed for the convergent approach.

Management Plan: Proposals must include a management plan that describes the administration of the Center, including the functions of the leadership team, key personnel and the role of any advisory committees, including the required Student Leadership Council and the Council of Deans, executive committee(s), and/or program committees or their equivalent. While the details of the structure are left to the proposers, the management structure should be designed to facilitate and integrate the ERC's critical and foundational components (Research, Engineering Workforce Development, Diversity and Culture of Inclusion, and Innovation Ecosystem). In addition, the proposed management plan should address the roles, authorities, and accountability for the leadership team that will assure no bottlenecks in decision making.

Specifically, the successful proposal will delineate:

- The overall management and reporting structure of the ERC.
- Which personnel or groups will be responsible for Research, Engineering Workforce Development, Diversity and Culture of Inclusion, and the Innovation Ecosystem. Please explain the relevant experience and expertise of these individuals and how they fit their assigned roles. These individuals should be included in the leadership team.
- An organizational chart, including advisory boards and the reporting/feedback loops involved.

The accompanying narrative for the organization chart should define the functional roles and responsibilities of each leadership position, and how these positions support the integrated strategic plan described earlier. It should also define the functional purpose of any additional advisory bodies that are deemed necessary to support the four foundational components, accomplish the proposed ERC vision, and achieve the desired long-term societal impact. Note that the functional roles of the two mandated ERC Advisory Bodies, the Council of Deans and the Student Leadership Council, are defined earlier in the section on Community Feedback. Since the quality of team member interaction is critical to team effectiveness, describe the managerial processes overlaying the organization chart that will be used to integrate the team. Please provide sufficient detail to allow critical evaluation.

Institutional Configuration: Describe the institutional configuration given the proposed vision for the ERC. Discuss the value added by each core partner university in meeting the goals of the four foundational components. Discuss the value added by any partnerships as described in the Key Elements of an ERC – Partners section.

IV. Research

ERCs are expected to have center-scale convergent engineering research that will support the ERC's overall potential for societal impact. The research program is the core of the ERC from which all ERC activities evolve.

Research Strategy: Clearly describe the proposed engineered system for the ERC. This section must include detailed research strategies, such as the 3-plane diagram (described below), research thrusts, and testbeds. A ten-year roadmap must illustrate the critical path, milestones, contributions from research projects, interdependence of research activities, short- and long-term deliverables, and overarching objectives in knowledge, technology, and proof of principle testbeds included in the ERC's vision. Impacts of the proposed research and technology outcomes on society and the scientific and engineering communities must be included. Discuss how the research strategy will support the proposed societal impact of the ERC, including any potential negative consequences that would arise from the development of new technologies. Include mitigation strategies if appropriate. This section should also include strategies for building and maintaining teams appropriate for the proposed convergent approach and the process for starting, managing, and potentially ending research projects throughout the lifetime of the ERC.

ERC 3-Plane Strategic Planning Chart: Identify and characterize interdependent research thrusts and activities at fundamental knowledge, enabling technology, and systems-level testbed(s) scales. Integration of research activities must be graphically depicted on a full page fully legible version of the ERC Program's 3-Plane Strategic Planning Chart (http://erc-assoc.org/content/three-plane-diagram) that is tailored to the proposed ERC.

Research Thrusts: Each thrust description should start with a table that lists the thrust leader and other faculty/research participants by name, department, and institution. International partners who may be involved in the early stages of the thrust efforts must be listed. Discuss the goals and objectives of the thrust vis-à-vis the goals of the ERC and the convergent research strategic plan. Provide information on fundamental knowledge and technology deliverables. Identify the gaps and barriers the thrust will address in the context of the ERC's strategic plan. Discuss the convergent cross-disciplinary mix of expertise needed to achieve the goals of the thrust, as well as how the proposed team fulfills that need. Describe how future team building will support the convergent approach. Benchmark the research proposed for the thrust with respect to the state of the art (including the contributions of the proposed ERC faculty and others). Discuss the role of the thrust's research relative to the ERC's 3-Plane Strategic Planning Chart.

Project-level descriptions of specific research activities for each thrust must describe the proposed research and link it to the thrust goals. Describe a few exemplar projects in depth to allow judgment of the quality of the effort proposed, rather than superficially describing all projects. For these projects, provide examples of fundamental barriers the research will address, the need for a convergent approach, and project-level methods to address the barriers. Demonstrate that the desired results constitute breakthroughs and are attainable in ten years. Discuss how projects support and integrate with other thrusts, enabling technologies, and systems-level testbeds in an overall convergent research approach.

Testbeds: Enabling- and systems-level testbeds must include a description of proposed proof-of-concept demonstration(s) in each testbed and personnel needed to construct and implement each proposed testbed. The research program budget should support technical staff to work with students and faculty to build these testbeds.

Note: NSF funds may not be used to support clinical trials. If the research involves vertebrate animals or includes human subjects, PAPPG requirements must be followed for the full proposal.

V. Engineering Workforce Development

Engineering workforce activities should contribute to a diverse, globally competitive, and team-oriented engineering workforce that has experience in convergent research, technology advancement, industrial practice, and innovation.

Workforce Development occurs at all levels of the Center and provides opportunities for all ERC members including students, faculty, and external partners as appropriate. A proposed evidence-based program for building human capacity for the future engineering workforce must be described. The proposed program should provide strategic goals for the ERC as well as targeted and specific outcomes related to workforce development and education. Proposed activities should logically lead to targeted outcomes and support diverse pathways and experiences for participants. At least 6 non-ERC students must enroll in a Research Experiences for Undergraduates (REU) program budgeted at a minimum of $42K per year from the ERC base budget. Awarded ERCs are encouraged to submit proposals to the annual Research Experiences for Undergraduates (REU) Site and Research Experiences for Teachers (RET) Site competitions to expand the Center's workforce development impact. Partnerships with inner city, rural, or other high needs schools are especially encouraged, as is participation by underrepresented minorities, women, veterans, and persons with disabilities. Suitable metrics to assess progress towards meeting the ERC's goals should be described, and feedback loops should be in place for program improvement.

Describe how the leadership team will effectively support workforce development and educational programming. This section should also clearly describe how the proposed workforce development program will interact with existing educational or training systems at all partner institutions. Include a description of plans for engaging with partners, recruiting participants, and anticipated participant experiences. Educational partnerships may be leveraged to support the program and provide opportunities to engage with potential participants. All Engineering Workforce Development program participants, whether internal or external to the ERC, should have opportunities that are unique and would otherwise not be possible without the ERC.

No specific program activities or partnerships are required, but there should be a coherence to the program that aligns with the overall goals and vision of

the ERC.

VI. Diversity and Culture of Inclusion

Describe the vision and plans for nurturing a culture of inclusion to ensure diverse participation in the ERC as defined in the ERC Program Model. A culture of inclusion has many important aspects that are essential for deep collaboration, including the participation of members from a diversity of scientific backgrounds and training (necessary for true convergent research and innovation), participation of members of groups traditionally underrepresented in engineering and STEM, and a diversity of partner institutions (including industry and practitioner) that will bring different perspectives to bear on the goals of the ERC. At least one core partner institution that graduates a high number of underrepresented students in engineering and STEM fields must be included. **These partners must be fully integrated into the ERC.** The vision for diversity and inclusion should go well beyond numbers and include a description of the integration and roles of diverse participants in the ERC.

Suitable metrics to assess the ERC's inclusion and diversity goals should be described, and feedback loops should be in place for independent assessment and improvement of diversity and inclusion at all levels of the ERC, including participating faculty, leadership, industry/practitioner members, and students.

In this section, describe how the leadership team will effectively create an inclusive culture for the ERC in which all members feel valued and welcomed, creatively contribute, and gain mutual benefit from participating. Include a description of plans for recruiting, mentoring, and retaining undergraduates, graduate students, and members of the research and leadership team members who are from groups traditionally underrepresented in engineering. Describe the role of partners with high enrollments and graduation rates of underrepresented students, as appropriate, including plans to connect such partners to the ERC's research and innovation goals in a meaningful way.

Groups traditionally underrepresented in engineering include African Americans, Hispanic Americans, American Indians, Alaska Natives, Native Hawaiians, Native Pacific Islanders, women, and persons with disabilities.

VII. Innovation Ecosystem

At its core, the innovation ecosystem is a network formed among trusted partners working together towards the common goal of creating and enhancing the capacity for innovation within the ecosystem.

In this section, discuss how the ERC will foster the creation of societal value from innovations (e.g., inventions, goods, services, businesses) that benefit society in a sustainable fashion (i.e., value creation). Identify the innovation ecosystem stakeholders relevant to realizing the proposed vision and societal impact. Describe the strategy to form relationships with stakeholders to garner support for the Center's vision. Specifically, include the ERC's plans for developing and fostering industrial/practitioner memberships and involvement; technology transfer to member and non-member firms; if included, the role of university and state and local government as facilitators of entrepreneurship and innovation; policy makers or regulatory agencies as influencers of the ERC innovation, end users or customers as beneficiaries of the ERC innovation, and plans for supporting translational research when appropriate.

To maximize positive social impact, any anticipated potential negative consequences caused by the introduction of the ERC technology should be addressed. In these cases, make sure to include stakeholder(s) that will work to mitigate the negative impacts, such as regulatory institutions.

Provide a visualization of how the proposed member firms (e.g., innovation partners, facilitators, influencers, and beneficiaries) align to the proposed ERC's technology area. That is, as the ERC's research program evolves, note at which points in time in the ERC development over its 10-year lifespan different types of stakeholders engage with the ERC to enable success and create societal value. Some stakeholders may be engaged for the entire 10 years, and others may be involved with focused research activities at critical points in time (e.g., testbed development).

Discuss the integration of all stakeholders into the governance and operations of the ERC. Include a letter of collaboration (please make sure to use the template provided in the PAPPG) from each stakeholder that identifies their commitment to work with the ERC as described in the project description. The letters should be uploaded in the Supplementary Documents section.

Legal Frameworks: The different stakeholder groups/organizations/partners operate under very different legal frameworks that can make seamless collaboration difficult. Consequently, the ERC must work within the university structure to create an environment where the frameworks can be modified so that the different entities can come together for productive interaction. In advance of anyone joining the ERC, it is important to put in place legal agreements that protect the interests of the stakeholder entities and the university partners. Therefore, at a minimum, all ERCs require two legal frameworks to handle (1) intellectual property and (2) industry/practitioner membership agreements. The specifics of the ERC vision and the nature of the stakeholder community will determine whether additional legal frameworks are necessary.

Intellectual Property: Describe the overall Intellectual Property (IP) strategy consistent with planned value creation in the ERC, and the corresponding management of the ERC IP across the lead and partner institutions and the approaches that will enable licensing of ERC's IP and/or adopting of other ERC outcomes. This plan must discuss management of possible conflicts-of-interest of any ERC researchers and the ERC's technology transfer endeavors. If an award is made, the IP policy must be prepared and submitted within 90 days of the award.

Industry/Practitioner Membership Agreement: Discuss the terms of the draft membership agreement including the proposed fee structure and benefits. Describe the type(s) of support to be received. A letter of commitment (one page maximum for each) from each firm/practitioner organization committed to joining the ERC as a member and providing (cash and/or in-kind) support in the event that an award is made must be uploaded in Supplementary Documents.

VIII. Evaluation Plan

Based on the goals and desired outcomes of the ERC strategic plan, a proposed evaluation plan is required that includes all four foundational components. The purpose of ERC evaluation is to provide feedback on progress towards meeting Center goals. The evaluation plan should include formative aspects that allow the Center to make evidence-based decisions about changes in its activities and summative aspects to provide evidence of impact across all elements of the ERC. This section should include the evaluation questions, as well as, a description of the type of evaluation design and methods that will be used to address each question. This section should specify the mechanisms and timeline for how the results and recommendations from evaluation and assessment will be fed back into ERC goals, objectives, and milestones to ensure continual progress and attainment of goals, targets, and impacts during the project period. Also, identify the person(s) who will lead the ERC evaluation and briefly describe their academic training and professional experience that qualifies them to serve as an evaluator. Evaluator(s) may be internal or external to ERC institutions, but should be positioned to carry out the evaluation plan as objectively as possible.

Awardees may be required to participate in program-level evaluation activities by which NSF can assess implementation processes and progress toward program level outcomes. NSF, an NSF contractor, or a grantee on behalf of NSF, may periodically conduct program evaluations or special projects that

necessitate access to project level staff and data. This activity may occur at any time during the award period and could occur after NSF support has ended. ERC participation includes responding to inquiries, interview and other methods of common data collection and/or aggregation across ERCs. In addition, PIs and ERC evaluators may be asked to assist in developing program evaluation activities that will mutually benefit the agency and ERC participants.

IX. Financial Support and Functional Allocation of Resources

Discuss the plans for financial and in-kind support from all sources, except the cost sharing. Include plans for allocation of those resources to fulfill the goals of the ERC. Include a functional budget table, showing only the estimated proportional distribution of effort across the functions of the ERC in its first year without showing the support levels from any sources. The table must not show the sources of support, since the reviewers cannot have access to the level of academic support. A template of the table can be found at: http://erc-assoc.org/content/erc-gen-4-solicitation.

This section of the proposal must also include a pie chart showing the allocation of resources and committed levels of support for the first year from industrial or practitioner member firms and any additional non-member commitments from state and/or local governments for cash and/or in-kind support. A template of the table can be found at: http://erc-assoc.org/content/erc-gen-4-solicitation.

Provide a pie chart or a table showing the planned distribution of the requested NSF funds for year one between the lead, each domestic partner university, and each university contributing affiliated faculty.

X. Results from Prior NSF Support

If the **Director** and Lead PI (if different) identified on the proposal have received prior NSF support, including any award with an end date in the past five years or current funding including any no-cost extensions, the intellectual merit and broader impacts accomplished under that award should be discussed. **In cases where the Director and Lead PI have received more than one award (excluding amendments to existing awards), they should only report on the award that is most closely related to the proposal (for each, if the Director and Lead PI are different people)**. See PAPPG II.C.2.d.iii for the required format of this section. Recommended length – no more than one page.

References Cited: See PAPPG for format guidelines.

Biographical Sketches: See PAPPG for format guidelines. Include only for the leadership team and other senior personnel expected to receive support in the first five years from the ERC.

Budgetary Information: Follow the PAPPG guidance for the budget and the budget justification. Travel Funds for ERC Leadership Team's Participation in Biennial Meetings: Members of the ERC Leadership Team are required to participate in the ERC biennial meeting and the cross-ERC Leadership Team retreats (which are typically held annually). The purpose of biennial meeting is to share successes and failures across the ERCs, receive updates on the ERC Program, and provide input for future ERC Program improvements. The purpose of the retreats is to focus on issues and best practices specific to the different leadership team groups. The biennial meetings are held in the Washington DC area for 2.5 days. Retreats are held in various locations for 1-2 days. Travel funds must be included in each annual budget to support participation in alternating biennial and leadership retreats for each person identified.

Note: The budget justification section should only identify items that are not cost shared. A justification and explanation of cost shared items needs to be appended to the cost sharing tables that are submitted in the single-copy document section of the proposal.

Cost sharing is mandatory and is specific to the ERC solicitation. Please see the Budgetary Information section of this solicitation for additional information.

Current and Pending Support. Include only for the leadership team and other senior personnel expected to receive support in the first five years from the ERC.

Facilities, Equipment and Other Resources. In this section, please include ONLY facilities, equipment, and personnel that are directly relevant and unique to the proposed ERC. Briefly discuss such laboratories, facilities, cyberinfrastructure, personnel, and equipment, particularly those shared by the ERC team members. Distinguish existing facilities and equipment from any that will be acquired by the ERC (see PAPPG Chapter II.C.2.i). Space must be identified on the campus of the lead academic institution for the ERC headquarters. Describe the headquarters, including the size, functionality, and features. Discuss how the cyberinfrastructure, facilities, and equipment of the ERC will be used to form and sustain a collaborative ERC team with shared resources and information.

Letters of commitment should be included in the supplementary documents for facilities, equipment, etc. that are being provided by institutions or collaborators which are not from the lead institution or the core partners.

Supplementary Documents. Provide supplemental documents as instructed in the PAPPG. The following items are to be provided as additional supplemental documents.

Table of Academic/Other Participants and Industrial/Practitioner Members: The table should be created using the table format available on the ERC Association website at http://erc-assoc.org/content/erc-gen-4-solicitation. Download and use the Word file named "ERC Participants Table Template for Inclusion in Full Proposal." Provide all the required information in each section of the table.

Letters of Commitment: Submit the following **required** letters as indicated:

- Lead university: Senior university administrators (Dean of Engineering plus one other higher-level university official) for the lead university attesting to the institutional commitment to the goals of the ERC and a commitment to headquarters space in both letters. The letters should not mention cost sharing, as that information cannot be revealed to reviewers. The letters should indicate the institutional commitment to all major aspects of the ERC, including each of the four foundational components, and assure the development of a cross-ERC IP policy within 90 days, if an award is made.
- Each Core Partner University: A senior administrator (Dean or equivalent) attests to the partner's institutional commitment to the goals of the ERC.
- If applicable, officials from any participating federal laboratories indicating their involvement in the ERC and their commitment to provide support for their staff participating in the ERC.
- Member Organizations: A letter of commitment (one page maximum for each) from each firm/practitioner organization committed to joining the ERC as a member and providing (cash and/or in-kind) support.

The following letters of collaboration are required **if applicable** to the proposed ERC. Such letters must follow the format for letters of collaboration given in the PAPPG:

- Officials of firms and agencies able to commit to membership.
- An administrator of each proposed pre-college or community college partners committing to their roles in the ERC as described in the Project Description.
- State or local government agencies and other organizations committed to partnership with the ERC.
- Domestic affiliated faculty if their projects are planned to be in place during years one through five. Note that no letters are required from the administrators of the universities providing affiliated faculty.
- Foreign collaborators.

All letters of commitment should be addressed to:

ERC Program

Division of Engineering Education and Centers

National Science Foundation

All signed letters must be scanned and placed in the Supplementary Documents section of the FastLane proposal or the Grants.gov proposal and submitted electronically, as part of the proposal. Please instruct the letter writers **not** to mail, email, or fax copies to the NSF, as they will not be considered.

Draft Membership Agreement. Submit draft industry/practitioner membership agreement.

Data Management Plan. Provide a Data Management Plan according to guidance in the PAPPG. Go to https://nsf.gov/eng/general/ENG_DMP_Policy.pdf for Engineering-specific guidance.

Postdoctoral Mentoring Plan. If applicable, provide a mentoring plan for postdoctoral researchers who will be supported by ERC funds. See the PAPPG for more guidance.

Single Copy Documents-viewable only by NSF (also refer to the PAPPG Chapter II.C.1 on "Single-Copy Documents" for additional information):

Collaborators & Other Affiliations Information: Information regarding collaborators and other affiliations (COA) must be separately provided for each individual identified as senior project personnel, which includes the Lead PI, Center Director if different from the Lead PI, Non-Lead PIs, all members of the ERC Leadership Team, key faculty, and key staff participants. The COA information must be uploaded into the Single Copy Documents as described in the PAPPG. The accuracy of this section is very important to the integrity of the ERC review process. Please be accurate and complete with the entries.

Optional List of Suggested Reviewers or Reviewers Not to Include: Proposers may include in the single copy documents section a list of suggested reviewers who they believe are especially well qualified to review the proposal. Proposers also may designate persons they would prefer not to review the ERC proposal, indicating why. These suggestions are optional. PAPPG Exhibit II-2 contains information on conflicts of interest that may be useful in preparation of this list. The cognizant Program Officer handling the proposal considers the suggestions and may contact the proposer for further information. However, the decision whether to use the suggestions remains with the Program Officer.

Required Cost Sharing Tables and Justification: Complete and submit the following tables: "Committed Cash and In-Kind Academic Support, Years 1-5" and, if applicable, a table showing the "Nature of In-Kind Support" identifying any in-kind commitments and the sources of the commitments. A template of those tables can be found at: http://erc-assoc.org/content/erc-gen-4-solicitation. The tables should be uploaded into the single copy documents section of the full proposal. Appended to the cost sharing tables will be a justification/explanation of the source, nature, amount, and availability of any proposed cost sharing. **Proposers are directed not to include these tables and the cost sharing justification in any other part of the proposal, as cost sharing commitments are not provided to the reviewers.** Refer to the section on Budgetary Information and Cost Sharing in this solicitation for information on cost sharing requirements and policies.

Post Proposal Submission to NSF: Other Required Documents

Proposal Update: If the proposed ERC is evaluated by a Site Visit Team (SVT), a 10-page reply that integrates changes in the proposed ERC based on comments from the SVT members and the Site Visit Report will be requested to facilitate the final stages of the review process.

SUMMARY OF INVITED FULL PROPOSAL REQUIREMENTS

(Note: This is **NOT** a total list of the ERC proposal requirements. Refer to the ERC Solicitation and the PAPPG for complete requirements).

Topic	Full Proposal
Academic cost sharing (Lead and domestic core partner universities)	Yes, Single Copy Documents
Identification of funded faculty/staff members from the lead and university-level partner institutions	Project Description
Chart summarizing the leadership team	Project Description
Organizational Chart	Project Description
ERC 3-Plane Strategic Planning Chart	Project Description
Research Thrusts Participant Tables	Project Description
Functional Year 1 Budget Table	Project Description
Year 1 Committed Industrial and Other Non-NSF, Non-Academic Support table	Project Description
Year 1 Planned Distribution of NSF Funds	Project Description
Draft membership agreement	Supplementary Documents
Draft IP policy	Required following award
Lead Institution: Two letters of commitment, one from the Dean of Engineering and one from a higher-level administrator, describing committed institutional resources	Yes - (but no cost sharing identified in letters) Supplementary Documents

Core Partner Institutions: Letters of commitment from a senior administrator at the rank of Dean or equivalent from the partner institution, describing committed institutional resources	Yes - (but no cost sharing identified in letters)-Supplementary Documents
Federal Laboratories: Letters of commitment from administrators of federal laboratories contributing support for staff in the ERC, attesting to laboratory support for that staff time	Yes, if applicable -Supplementary Documents
Letters of commitment to membership from firms / agencies / hospitals committed to joining the ERC as members and providing cash and in-kind support to the ERC	Yes, if applicable -Supplementary Documents
Letters of collaboration from firms / agencies / hospitals committed to joining the ERC as members	Yes, if applicable -Supplementary Documents
Letters of collaboration from pre-college partner administrators (school district or individual schools), community college administrators, or other education and outreach partners	Yes, if applicable -Supplementary Documents
Letters of collaboration from state or local government agency or state governor providing non-member financial support to the ERC	Yes, if applicable -Supplementary Documents
Letters of collaboration from foreign collaborators	Yes, if applicable -Supplementary Documents
Table of "Committed Cash and In-Kind Academic Support, Years 1-5" and a table "Nature of In-Kind Support." Also, append to the tables a justification/explanation of any cost shared items	Single-Copy Documents

B. Budgetary Information

Cost Sharing:

Cost Sharing is required.

Invited full proposals will include a budget for each of the five years. FastLane or Grants.gov will automatically provide a cumulative budget. Provide a separate budget for subawards to the domestic core partner institutions and any affiliated institutions whose faculty and students would be supported by the ERC's budget. Allowable budgets for the first five years are as follows: The budget for year one may be no more than $3,500,000, no more than $4,500,000 for year two, no more than $6,000,000 for year three, no more than $6,000,000 for year four, and for year five.

Cost Sharing: Mandatory Cost Sharing is required but inclusion of voluntary committed cost sharing is prohibited.

Mandatory Cost Sharing Requirements and Policies: Cost sharing is required of the lead university and core partner university(ies) to support and sustain the ERC. Cost sharing is not a review criterion for the ERCs; it is an eligibility criterion. Because cost sharing is not a review criterion, details on cost sharing will not be shared with the reviewers.

Upon issuance of the award, the lead university is responsible to secure, retain, manage, and certify to NSF the ERC cost sharing (cash and in-kind), at the level stated in the cooperative agreement. The total level of cost sharing proposed must be calculated using the "Cost Sharing Formula" below. The lead university is responsible for the entire amount; however, cost sharing also can include contributions by any or all of the core partner universities.

Cost sharing must not exceed the mandatory level stated in the ERC cost sharing formula. This would be considered "voluntary committed cost sharing" which is specifically prohibited according to NSF's cost sharing policies. ERC proposals that include cost sharing amounts in excess of the specified formula run the risk of being returned without review or declined.

Instructions for Disclosure and Non-Disclosure of Cost Sharing within the Proposal:

Cost Sharing and Letters of Commitment: Since cost sharing is not to be seen or considered by reviewers, any letters of commitment should not mention any cost sharing (cash or in-kind), since the reviewers will see these letters. See Section V.A for details concerning the letters of commitment.

Cost Sharing in the Budget Submission: The proposed cost sharing (including the estimated value of any in-kind cost sharing), according to the formula below, must be shown on Line M of the NSF proposal budget form. (Line M is masked from reviewers.)

Cumulative cost sharing should be entered for all 5 years on Line M of the first-year budget. Do not include the cost sharing figures on Line M of the budget for years 2-5. Do not include the justification / explanation for any cost-shared items in the budget justification section of the proposal. Only the non-cost shared items should be explained in the budget justification section, identifying the source, nature, amount and availability of non-cost shared items.

Cost Sharing Tables and Justification: The cost sharing commitment of the ERC must be documented in the proposal and the details presented in the tables of committed support. The lead institution is instructed to provide a table of "Committed Cash and In-Kind Academic Support, Years 1-5" (including any partner university providing cash for years 1-5). Proposers must also complete the table "Nature of In-Kind Support" identifying in-kind commitments and the sources of the commitments. A template of those tables can be found at http://erc-assoc.org/content/erc-gen-4-solicitation. The tables should be uploaded into the "Single Copy Documents" section of the proposal. Append to the cost sharing tables a justification / explanation of the source, nature, amount and availability of any proposed cost sharing. Do not include these tables and the cost sharing justification in any other part of the proposal, as cost sharing commitments are not to be provided to reviewers.

Cost Sharing Formula:

ERC cost sharing requirements are graduated based on classification at the time of the LOI submission deadline as defined in the "Carnegie Foundation's Classification of Institutions of Higher Education." Limited financial resources at smaller colleges and universities that lack high research activity may present significant challenges to cost sharing. Therefore:

- RU/VH: Research Universities - required cost sharing level is 20% of the allocation of the NSF budget to the lead or core partner university;
- RU/H: Research Universities - required cost sharing level is 15% of the allocation of the NSF budget to the lead or core partner university;
- DRU: Doctoral/Research Universities - cost sharing level is 10% of the allocation of the NSF budget to that core partner university;
- Master's L: Master's Colleges and Universities - cost sharing level is 10% of the allocation of the NSF budget to that core partner university/college;
- Bac/Diverse: Baccalaureate Colleges--Diverse Fields - cost sharing level is 5% of the allocation of the NSF budget to that core partner college.

If the university is classified in more than one Carnegie category, it must cost share at the highest cost sharing category as described above. The Carnegie classification shall remain throughout the duration of the competition and any subsequent award. The total ERC cost share shall be 20% or less, depending upon the Carnegie classifications for each of the partners.

ERC Support Cost-Sharing Sources:

The proposed cost sharing must be shown on Line M on the proposal budget. For purposes of budget preparation, the cumulative cost sharing amount must be entered on Line M of the first year's budget. Should an award be made, the organization's cost sharing commitment, as specified on the first year's approved budget, must be met prior to award expiration.

Such cost sharing will be an eligibility, rather than a review criterion. Proposers are advised not to exceed the mandatory cost sharing level or amount specified in the solicitation.

When mandatory cost sharing is included on Line M, and accepted by the Foundation, the commitment of funds becomes legally binding and is subject to audit. When applicable, the estimated value of any in-kind contributions also should be included on Line M. An explanation of the source, nature, amount and availability of any proposed cost sharing must be provided in the budget justification. Contributions may be made from any non-Federal source, including non-Federal grants or contracts, and may be cash or in-kind. 2 CFR § 200.306 describes criteria and procedures for the allowability of cash and in-kind contributions in satisfying cost sharing and matching requirements. It should be noted that contributions derived from other Federal funds or counted as cost sharing toward projects of another Federal agency must not be counted towards meeting the specific cost sharing requirements of the NSF award.

Failure to provide the level of cost sharing required by the NSF solicitation and reflected in the NSF award budget may result in termination of the NSF award, disallowance of award costs and/or refund of award funds to NSF by the awardee.

Other Budgetary Limitations:

The overall ERC-level budget should be prepared to assure sufficient funding from all sources to achieve the goals of the ERC. Hence, this budget would include faculty and staff to support the research, education, diversity and culture of inclusion, industrial collaboration/innovation, and management of the ERC. Budgets should include resources for reporting, site visit costs, and travel for cross-ERC collaboration and NSF meetings. The budget submitted to NSF will include an allocation plan for the NSF funding only.

C. Due Dates

- **Letter of Intent Due Date(s)** *(required)* (due by 5 p.m. submitter's local time):

    November 30, 2018

- **Preliminary Proposal Due Date(s)** *(required)* (due by 5 p.m. submitter's local time):

    January 16, 2019

- **Full Proposal Deadline(s)** (due by 5 p.m. submitter's local time):

    July 12, 2019

D. FastLane/Research.gov/Grants.gov Requirements

For Proposals Submitted Via FastLane or Research.gov:

To prepare and submit a proposal via FastLane, see detailed technical instructions available at: https://www.fastlane.nsf.gov/a1/newstan.htm. To prepare and submit a proposal via Research.gov, see detailed technical instructions available at: https://www.research.gov/research-portal/appmanager/base/desktop?_nfpb=true&_pageLabel=research_node_display&_nodePath=/researchGov/Service/Desktop/ProposalPreparationandSubmission.html. For FastLane or Research.gov user support, call the FastLane and Research.gov Help Desk at 1-800-673-6188 or e-mail fastlane@nsf.gov or rgov@nsf.gov. The FastLane and Research.gov Help Desk answers general technical questions related to the use of the FastLane and Research.gov systems. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this funding opportunity.

For Proposals Submitted Via Grants.gov:

Before using Grants.gov for the first time, each organization must register to create an institutional profile. Once registered, the applicant's organization can then apply for any federal grant on the Grants.gov website. Comprehensive information about using Grants.gov is available on the Grants.gov Applicant Resources webpage: https://www.grants.gov/web/grants/applicants.html. In addition, the NSF Grants.gov Application Guide (see link in Section V.A) provides instructions regarding the technical preparation of proposals via Grants.gov. For Grants.gov user support, contact the Grants.gov Contact Center at 1-800-518-4726 or by email: support@grants.gov. The Grants.gov Contact Center answers general technical questions related to the use of Grants.gov. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this solicitation.

Submitting the Proposal: Once all documents have been completed, the Authorized Organizational Representative (AOR) must submit the application to Grants.gov and verify the desired funding opportunity and agency to which the application is submitted. The AOR must then sign and submit the application to Grants.gov. The completed application will be transferred to the NSF FastLane system for further processing.

Proposers that submitted via FastLane or Research.gov may use Research.gov to verify the status of their submission to NSF. For proposers that submitted via Grants.gov, until an application has been received and validated by NSF, the Authorized Organizational Representative may check the

status of an application on Grants.gov. After proposers have received an e-mail notification from NSF, Research.gov should be used to check the status of an application.

VI. NSF PROPOSAL PROCESSING AND REVIEW PROCEDURES

Proposals received by NSF are assigned to the appropriate NSF program for acknowledgement and, if they meet NSF requirements, for review. All proposals are carefully reviewed by a scientist, engineer, or educator serving as an NSF Program Officer, and usually by three to ten other persons outside NSF either as *ad hoc* reviewers, panelists, or both, who are experts in the particular fields represented by the proposal. These reviewers are selected by Program Officers charged with oversight of the review process. Proposers are invited to suggest names of persons they believe are especially well qualified to review the proposal and/or persons they would prefer not review the proposal. These suggestions may serve as one source in the reviewer selection process at the Program Officer's discretion. Submission of such names, however, is optional. Care is taken to ensure that reviewers have no conflicts of interest with the proposal. In addition, Program Officers may obtain comments from site visits before recommending final action on proposals. Senior NSF staff further review recommendations for awards. A flowchart that depicts the entire NSF proposal and award process (and associated timeline) is included in PAPPG Exhibit III-1.

A comprehensive description of the Foundation's merit review process is available on the NSF website at: https://www.nsf.gov/bfa/dias/policy/merit_review/.

Proposers should also be aware of core strategies that are essential to the fulfillment of NSF's mission, as articulated in *Building the Future: Investing in Discovery and Innovation - NSF Strategic Plan for Fiscal Years (FY) 2018 – 2022*. These strategies are integrated in the program planning and implementation process, of which proposal review is one part. NSF's mission is particularly well-implemented through the integration of research and education and broadening participation in NSF programs, projects, and activities.

One of the strategic objectives in support of NSF's mission is to foster integration of research and education through the programs, projects, and activities it supports at academic and research institutions. These institutions must recruit, train, and prepare a diverse STEM workforce to advance the frontiers of science and participate in the U.S. technology-based economy. NSF's contribution to the national innovation ecosystem is to provide cutting-edge research under the guidance of the Nation's most creative scientists and engineers. NSF also supports development of a strong science, technology, engineering, and mathematics (STEM) workforce by investing in building the knowledge that informs improvements in STEM teaching and learning.

NSF's mission calls for the broadening of opportunities and expanding participation of groups, institutions, and geographic regions that are underrepresented in STEM disciplines, which is essential to the health and vitality of science and engineering. NSF is committed to this principle of diversity and deems it central to the programs, projects, and activities it considers and supports.

A. Merit Review Principles and Criteria

The National Science Foundation strives to invest in a robust and diverse portfolio of projects that creates new knowledge and enables breakthroughs in understanding across all areas of science and engineering research and education. To identify which projects to support, NSF relies on a merit review process that incorporates consideration of both the technical aspects of a proposed project and its potential to contribute more broadly to advancing NSF's mission "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." NSF makes every effort to conduct a fair, competitive, transparent merit review process for the selection of projects.

1. Merit Review Principles

These principles are to be given due diligence by PIs and organizations when preparing proposals and managing projects, by reviewers when reading and evaluating proposals, and by NSF program staff when determining whether or not to recommend proposals for funding and while overseeing awards. Given that NSF is the primary federal agency charged with nurturing and supporting excellence in basic research and education, the following three principles apply:

- All NSF projects should be of the highest quality and have the potential to advance, if not transform, the frontiers of knowledge.
- NSF projects, in the aggregate, should contribute more broadly to achieving societal goals. These "Broader Impacts" may be accomplished through the research itself, through activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. The project activities may be based on previously established and/or innovative methods and approaches, but in either case must be well justified.
- Meaningful assessment and evaluation of NSF funded projects should be based on appropriate metrics, keeping in mind the likely correlation between the effect of broader impacts and the resources provided to implement projects. If the size of the activity is limited, evaluation of that activity in isolation is not likely to be meaningful. Thus, assessing the effectiveness of these activities may best be done at a higher, more aggregated, level than the individual project.

With respect to the third principle, even if assessment of Broader Impacts outcomes for particular projects is done at an aggregated level, PIs are expected to be accountable for carrying out the activities described in the funded project. Thus, individual projects should include clearly stated goals, specific descriptions of the activities that the PI intends to do, and a plan in place to document the outputs of those activities.

These three merit review principles provide the basis for the merit review criteria, as well as a context within which the users of the criteria can better understand their intent.

2. Merit Review Criteria

All NSF proposals are evaluated through use of the two National Science Board approved merit review criteria. In some instances, however, NSF will employ additional criteria as required to highlight the specific objectives of certain programs and activities.

The two merit review criteria are listed below. **Both** criteria are to be given **full consideration** during the review and decision-making processes; each criterion is necessary but neither, by itself, is sufficient. Therefore, proposers must fully address both criteria. (PAPPG Chapter II.C.2.d(i). contains additional information for use by proposers in development of the Project Description section of the proposal). Reviewers are strongly encouraged to

review the criteria, including PAPPG Chapter II.C.2.d(i), prior to the review of a proposal.

When evaluating NSF proposals, reviewers will be asked to consider what the proposers want to do, why they want to do it, how they plan to do it, how they will know if they succeed, and what benefits could accrue if the project is successful. These issues apply both to the technical aspects of the proposal and the way in which the project may make broader contributions. To that end, reviewers will be asked to evaluate all proposals against two criteria:

- **Intellectual Merit:** The Intellectual Merit criterion encompasses the potential to advance knowledge; and
- **Broader Impacts:** The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes.

The following elements should be considered in the review for both criteria:

1. What is the potential for the proposed activity to
   a. Advance knowledge and understanding within its own field or across different fields (Intellectual Merit); and
   b. Benefit society or advance desired societal outcomes (Broader Impacts)?
2. To what extent do the proposed activities suggest and explore creative, original, or potentially transformative concepts?
3. Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?
4. How well qualified is the individual, team, or organization to conduct the proposed activities?
5. Are there adequate resources available to the PI (either at the home organization or through collaborations) to carry out the proposed activities?

Broader impacts may be accomplished through the research itself, through the activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. NSF values the advancement of scientific knowledge and activities that contribute to achievement of societally relevant outcomes. Such outcomes include, but are not limited to: full participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM); improved STEM education and educator development at any level; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a diverse, globally competitive STEM workforce; increased partnerships between academia, industry, and others; improved national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education.

Proposers are reminded that reviewers will also be asked to review the Data Management Plan and the Postdoctoral Researcher Mentoring Plan, as appropriate.

Additional Solicitation Specific Review Criteria

Preliminary Proposal Review Criteria:

Reviewers should consider these high-level questions: How well does the preliminary proposal narrative address the following in the project description?

1. *What is the compelling new idea and what is the potential high societal impact?*
2. *Why is an ERC necessary to tackle the idea?*
3. *How will the ERC's infrastructure integrate and implement convergent research, engineering workforce development, diversity and culture of inclusion, and an innovation ecosystem to achieve its vision and create societal impact, impact on the scientific enterprise, and impact on the engineering community?*
4. *What is the proposed management structure for the ERC and how will it foster team-formation and convergent research, as well as an integrated approach for items 1-3 above?*
5. *What are the proposed strategies for engaging and developing the appropriate stakeholder community?*
6. *How will all ERC participants engage in a unique experience that would otherwise not be available?*

Reviewers should also consider these more specific questions:

- Vision: How well does the proposed ERC integrate fundamental science and engineering research with technological innovation to transform national prosperity, health, and/or security? How well does it identify the engineered systems that will drive the research agenda? To what extent is there potential for convergence?
- Strategic Plan: How well does the strategic plan identify context, critical paths, resources, adaptiveness, and leverage recent breakthroughs, to achieve the ERC's vision?
- Research: How well does the 3-Plane Strategic Planning Chart demonstrate that the proposed research is transformative? How well does the proposed research requires and implements convergent research approach? How well does the proposed research use the testbeds to integrate and to advance proofs-of-concept to achieve the vision of the ERC?
- Engineering Workforce Development: How well does the proposed ERC outline a comprehensive, evidence-based, inclusive approach to workforce development?
- Diversity and Culture of Inclusion: How well does the preliminary proposal articulate preliminary ideas on how to create and nurture a culture of inclusion in the proposed ERC?
- Innovation Ecosystem: How well does the proposed ERC outline plans for a strategic engagement of stakeholders (industry, practitioners, regulatory, and non-profits)?
- How well does the proposed ERC integrate all 4 foundational components of the ERC: research, engineering workforce development, diversity and culture of inclusion, and innovation ecosystem?
- Infrastructure (Organization and Management): How well qualified are the Lead PI and the Non-Lead PIs to lead the proposed ERC?
- How well does the proposed ERC address team formation?

Full Proposal Review Criteria:

- Vision
  - How well does the ERC describe a compelling vision?
  - How well does the proposed ERC justify the need for a center or institute-like approach?
  - What is the potential for impact on society/scientific enterprise/engineering community?
- High Societal Impact
  - What is the potential for high societal impact?
  - How realistic is the proposed plan?

Is the scale of the impact appropriate for an ERC? Why or why not?
- Convergence
    - How well justified is the argument that convergence is necessary for the desired impact?
    - How well has the convergent approach been fully integrated into the proposal?
- Stakeholder Engagement
    - Is there an appropriate strategy for engaging all relevant stakeholders? Why or why not?
- Team Formation
    - How is the team appropriate to support the proposed convergent approach?
    - How well has the ERC demonstrated strategies to overcome barriers for effective, dynamic teaming?
- Strategic Plan
    - How well does the Center present an integrated strategic plan for the ERC to address the key elements of each foundational component and their interactions?
- Infrastructure
    - Comment on the qualifications of proposed leadership and management team.
    - How well does the proposal present appropriate and compelling management structure and plan to carry out Center activities?
    - Are effective mechanisms to gather and implement feedback from appropriate stakeholders in place, including advisory boards and external committees?
- Research
    - What is the likelihood the research will lead to significant fundamental advances, new discoveries, and technological developments?
    - Is the research plan appropriate and include appropriate milestones? Why or why not?
    - How appropriate is the selection of research thrusts, projects, and testbeds?
    - How well does the research personnel expertise align with the research strategy?
- Engineering Workforce Development
    - To what extent is the proposed program coherent and aligned with the overall goals and vision of the ERC?
    - Does the proposed plan include appropriate strategies for recruiting participants and engaging with partners?
    - Are the evidence-based proposed activities likely to achieve the desired experiences, outcomes and impact described? Why or why not?
- Diversity and Culture of Inclusion
    - How well does the plan include stakeholders at all levels, including students, faculty, teams, and leadership?
    - How well does the management plan include clear responsibility for this aspect of the ERC?
    - How well does the discussion include diversity of experience (especially in team building and the leadership) as well as the inclusion of members of groups underrepresented in engineering?
- Innovation Ecosystem
    - How well does the proposal describe a plan to build a network of trusted partners for innovation capacity?
    - Comment on the proposed structure and processes for value creation to move from ideation to implementation.
    - How well does the proposal plan for innovation infrastructure including input from stakeholders at the appropriate levels?
- Evaluation Plan
    - How well has the Center developed a logic evaluation framework to guide the implementation of the strategic plan and the evaluation of the Center performance?
    - How well does the evaluation plan include formative aspects that allow the Center to make evidence-based decisions about changes in its activities and summative aspects to provide evidence of impact across all elements of the Center?
- Financial Support and Resources
    - How well does the Center describe strong institutional commitment for all core partner institutions?
    - Does the Center have adequate capital (i.e., facilities, equipment, cyberinfrastructure) and procedural (i.e., safety, environmental) resources? Why or why not?
    - Does the Center have a convincing plan for data sharing and management? Why or why not?

B. Review and Selection Process

Proposals submitted in response to this program solicitation will be reviewed by Ad hoc Review and/or Panel Review, Site Visit Review, or Reverse Site Review.

The anticipated review process consists of a LOI followed by a preliminary proposal. The LOI is used for planning purposes and is not reviewed. Preliminary proposals are reviewed through *Ad hoc* Reviews and/or Panel Reviews. Full proposals are invited after the preliminary proposals are reviewed. The full proposals are first reviewed through *Ad hoc* Reviews and/or Panel Reviews. The most promising full proposals will be selected for pre-award site visit review followed by a reverse site visit panel after which recommendations for awards will be made.

Reviewers will be asked to evaluate proposals using two National Science Board approved merit review criteria and, if applicable, additional program specific criteria. A summary rating and accompanying narrative will generally be completed and submitted by each reviewer and/or panel. The Program Officer assigned to manage the proposal's review will consider the advice of reviewers and will formulate a recommendation.

After scientific, technical and programmatic review and consideration of appropriate factors, the NSF Program Officer recommends to the cognizant Division Director whether the proposal should be declined or recommended for award. NSF strives to be able to tell applicants whether their proposals have been declined or recommended for funding within six months. Large or particularly complex proposals or proposals from new awardees may require additional review and processing time. The time interval begins on the deadline or target date, or receipt date, whichever is later. The interval ends when the Division Director acts upon the Program Officer's recommendation.

After programmatic approval has been obtained, the proposals recommended for funding will be forwarded to the Division of Grants and Agreements for review of business, financial, and policy implications. After an administrative review has occurred, Grants and Agreements Officers perform the processing and issuance of a grant or other agreement. Proposers are cautioned that only a Grants and Agreements Officer may make commitments, obligations or awards on behalf of NSF or authorize the expenditure of funds. No commitment on the part of NSF should be inferred from technical or budgetary discussions with a NSF Program Officer. A Principal Investigator or organization that makes financial or personnel commitments in the absence of a grant or cooperative agreement signed by the NSF Grants and Agreements Officer does so at their own risk.

Once an award or declination decision has been made, Principal Investigators are provided feedback about their proposals. In all cases, reviews are treated as confidential documents. Verbatim copies of reviews, excluding the names of the reviewers or any reviewer-identifying information, are sent to the Principal Investigator/Project Director by the Program Officer. In addition, the proposer will receive an explanation of the decision to award or decline

funding.

VII. AWARD ADMINISTRATION INFORMATION

A. Notification of the Award

Notification of the award is made to *the submitting organization* by a Grants Officer in the Division of Grants and Agreements. Organizations whose proposals are declined will be advised as promptly as possible by the cognizant NSF Program administering the program. Verbatim copies of reviews, not including the identity of the reviewer, will be provided automatically to the Principal Investigator. (See Section VI.B. for additional information on the review process.)

B. Award Conditions

An NSF award consists of: (1) the award notice, which includes any special provisions applicable to the award and any numbered amendments thereto; (2) the budget, which indicates the amounts, by categories of expense, on which NSF has based its support (or otherwise communicates any specific approvals or disapprovals of proposed expenditures); (3) the proposal referenced in the award notice; (4) the applicable award conditions, such as Grant General Conditions (GC-1)*; or Research Terms and Conditions* and (5) any announcement or other NSF issuance that may be incorporated by reference in the award notice. Cooperative agreements also are administered in accordance with NSF Cooperative Agreement Financial and Administrative Terms and Conditions (CA-FATC) and the applicable Programmatic Terms and Conditions. NSF awards are electronically signed by an NSF Grants and Agreements Officer and transmitted electronically to the organization via e-mail.

*These documents may be accessed electronically on NSF's Website at https://www.nsf.gov/awards/managing/award_conditions.jsp?org=NSF. Paper copies may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from nsfpubs@nsf.gov.

More comprehensive information on NSF Award Conditions and other important information on the administration of NSF awards is contained in the NSF *Proposal & Award Policies & Procedures Guide* (PAPPG) Chapter VII, available electronically on the NSF Website at https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.

C. Reporting Requirements

For all multi-year grants (including both standard and continuing grants), the Principal Investigator must submit an annual project report to the cognizant Program Officer no later than 90 days prior to the end of the current budget period. (Some programs or awards require submission of more frequent project reports). No later than 120 days following expiration of a grant, the PI also is required to submit a final project report, and a project outcomes report for the general public.

Failure to provide the required annual or final project reports, or the project outcomes report, will delay NSF review and processing of any future funding increments as well as any pending proposals for all identified PIs and co-PIs on a given award. PIs should examine the formats of the required reports in advance to assure availability of required data.

PIs are required to use NSF's electronic project-reporting system, available through Research.gov, for preparation and submission of annual and final project reports. Such reports provide information on accomplishments, project participants (individual and organizational), publications, and other specific products and impacts of the project. Submission of the report via Research.gov constitutes certification by the PI that the contents of the report are accurate and complete. The project outcomes report also must be prepared and submitted using Research.gov. This report serves as a brief summary, prepared specifically for the public, of the nature and outcomes of the project. This report will be posted on the NSF website exactly as it is submitted by the PI.

More comprehensive information on NSF Reporting Requirements and other important information on the administration of NSF awards is contained in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) Chapter VII, available electronically on the NSF Website at https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.

NSF requires ERCs to submit annual reports that are more extensive in scope than those required of single investigator awards. NSF provides guidelines for these reports. NSF also requires ERCs to collect and submit to NSF data on indicators of progress, outcome, impact, and financial management. NSF provides data definition guidelines and templates for the recording and submission of these data through a secure web site.

VIII. AGENCY CONTACTS

Please note that the program contact information is current at the time of publishing. See program website for any updates to the points of contact.

General inquiries regarding this program should be made to:

- Sarit B. Bhaduri, telephone: (703) 292-2975, email: sbhaduri@nsf.gov

- Sandra Cruz-Pol, telephone: (703) 292-5729, email: scruzpol@nsf.gov

- Dana L. Denick, telephone: (703) 292-8866, email: ddenick@nsf.gov

- Nadia A. El-Masry, telephone: (703) 292-4975, email: nelmasry@nsf.gov

- Deborah J. Jackson, telephone: (703) 292-7499, email: djackson@nsf.gov

- Eduardo A. Misawa, telephone: (703) 292-5353, email: emisawa@nsf.gov

For questions related to the use of FastLane or Research.gov, contact:

- FastLane and Research.gov Help Desk: 1-800-673-6188

  FastLane Help Desk e-mail: fastlane@nsf.gov.

  Research.gov Help Desk e-mail: rgov@nsf.gov

For questions relating to Grants.gov contact:

- Grants.gov Contact Center: If the Authorized Organizational Representatives (AOR) has not received a confirmation message from Grants.gov within 48 hours of submission of application, please contact via telephone: 1-800-518-4726; e-mail: support@grants.gov.

IX. OTHER INFORMATION

The NSF website provides the most comprehensive source of information on NSF Directorates (including contact information), programs and funding opportunities. Use of this website by potential proposers is strongly encouraged. In addition, "NSF Update" is an information-delivery system designed to keep potential proposers and other interested parties apprised of new NSF funding opportunities and publications, important changes in proposal and award policies and procedures, and upcoming NSF Grants Conferences. Subscribers are informed through e-mail or the user's Web browser each time new publications are issued that match their identified interests. "NSF Update" also is available on NSF's website.

Grants.gov provides an additional electronic capability to search for Federal government-wide grant opportunities. NSF funding opportunities may be accessed via this mechanism. Further information on Grants.gov may be obtained at https://www.grants.gov.

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NSF receives approximately 55,000 proposals each year for research, education and training projects, of which approximately 11,000 are funded. In addition, the Foundation receives several thousand applications for graduate and postdoctoral fellowships. The agency operates no laboratories itself but does support National Research Centers, user facilities, certain oceanographic vessels and Arctic and Antarctic research stations. The Foundation also supports cooperative research between universities and industry, US participation in international scientific and engineering efforts, and educational activities at every academic level.

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The National Science Foundation has Telephonic Device for the Deaf (TDD) and Federal Information Relay Service (FIRS) capabilities that enable individuals with hearing impairments to communicate with the Foundation about NSF programs, employment or general information. TDD may be accessed at (703) 292-5090 and (800) 281-8749, FIRS at (800) 877-8339.

The National Science Foundation Information Center may be reached at (703) 292-5111.

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The information requested on proposal forms and project reports is solicited under the authority of the National Science Foundation Act of 1950, as amended. The information on proposal forms will be used in connection with the selection of qualified proposals; and project reports submitted by awardees will be used for program evaluation and reporting within the Executive Branch and to Congress. The information requested may be disclosed to qualified reviewers and staff assistants as part of the proposal review process; to proposer institutions/grantees to provide or obtain data regarding the proposal review process, award decisions, or the administration of awards; to government contractors, experts, volunteers and researchers and educators as necessary to complete assigned work; to other government agencies or other entities needing information regarding applicants or nominees as part of a joint application review process, or in order to coordinate programs or policy; and to another Federal agency, court, or party in a court or Federal administrative proceeding if the government is a party. Information about Principal Investigators may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See System of Record Notices, NSF-50, "Principal Investigator/Proposal File and Associated Records," and NSF-51, "Reviewer/Proposal File and Associated Records." Submission of the information is voluntary. Failure to provide full and complete information, however, may reduce the possibility of receiving an award.

An agency may not conduct or sponsor, and a person is not required to respond to, an information collection unless it displays a valid Office of Management and Budget (OMB) control number. The OMB control number for this collection is 3145-0058. Public reporting burden for this collection of information is estimated to average 120 hours per response, including the time for reviewing instructions. Send comments regarding the burden estimate and any other aspect of this collection of information, including suggestions for reducing this burden, to:

Suzanne H. Plimpton
Reports Clearance Officer
Office of the General Counsel
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