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Gen-3 Engineering Research Centers (ERC)

Partnerships in Transformational Research, Education, and Technology

PROGRAM SOLICITATION
NSF 15-589

REPLACES DOCUMENT(S):
NSF 13-560

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):

September 25, 2015

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

October 23, 2015

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

June 16, 2016

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 revised cost sharing policy, as stated in the NSF Proposal and Award Policies and Procedures Guide. ERC proposals that include cost sharing amounts in excess of the specified formula described in this solicitation will be returned without review.

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 may be broadcast. Questions should be submitted in advance of the webinar to the cognizant Program Officer(s). FAQs shall be posted as needed.

Feedback from NSF: A proposing team may meet with ERC Program staff, via teleconference, only once during the preliminary proposal preparation phase. No other meetings with NSF staff will be allowed during the competition. Proposers can request this teleconference via an email correspondence, addressed to: ***kroper@nsf.gov.*** The email must include: (1) a ≤ 10-sentence summary of the ERC's vision for an inclusive, engineered system with sufficiently detailed research focus, engineering workforce development program, and innovation ecosystem; and (2) an attached 3-plane strategic plan chart.

REVISION NOTES:

Awards under this ERC Solicitation: Awards may be made as Open Topic ERCs or Nanosystems ERCs (NERC). The actual number of each type of ERCs funded will depend on the scale and scope of the proposed centers, the availability of funds, and the quality of the proposals submitted. Proposers must indicate which one of the two types of proposal submission tracks their Letter of Intent (LOI) and any subsequent proposal(s) are being submitted. Unless otherwise noted in the solicitation, the term "ERC" will refer to both types of centers.

Preliminary and Full Proposals: A preliminary proposal must be submitted, which contains a project description that is a maximum of nine (9) pages. A full proposal may only be submitted in response to an invitation that results from the review of the preliminary proposals, which contains a project description that is a maximum of twenty-five (25) pages. Only the lead institution designated in a preliminary proposal will be allowed to submit a full proposal.

Budget Increase: The requested budget for the individual ERC awards starts at $3,500,000 in year 1 and ramps up in $250K/year increments to level off at $4,250,000 by year 4.

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) (NSF 18-1), which is effective for proposals submitted, or due, on or after January 29, 2018.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Engineering Research Centers (ERC)
Partnerships in Transformational Research, Engineering Workforce Development, and Technology

Synopsis of Program:

The goal of the ERC Program is to integrate engineering research and education with technological innovation to transform national prosperity, health, and security. ERCs create an innovative, inclusive culture in engineering to cultivate new ideas and pursue engineering discovery that achieves a significant science, technology, and societal outcome within the 10-year timeframe of NSF support. For information on individual ERCs and their achievements, go to: **ERC-assoc.org**.

Those who submit proposals in response to this solicitation will need to address the following questions:

1. *What is the compelling new idea and how does it relate to national needs?*
2. *Why is a center necessary to tackle the idea?*
3. *How will the ERC's infrastructure integrate and implement research, workforce development and innovation ecosystem development efforts to achieve its vision?*

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.

- Junhong Chen, telephone: (703) 292-4623, email: junchen@nsf.gov
- Deborah Jackson, telephone: (703) 292-7499, email: djackson@nsf.gov
- Erick Jones, telephone: (703) 292-4606, email: ejones@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 of any combination of Open Topic ERCs and/or NERCs - depending on the quality of the proposals and the availability of funds.

Anticipated Funding Amount: $14,000,000

- $14,000,000 to support the first year for up to four newly funded Centers, depending on availability of funds in FY2017.

It is anticipated that the awards would be made in the summer of 2017. The initial award would be for five years, with year one start-up budgets of up to $3,500,000 each. Subsequently, there would be year two budgets of up to $3,750,000, year three budgets of up to $4,000,000 and years four and five budgets of up to $4,250,000 each, pending satisfactory annual performance and availability of funding. Pending performance and the outcome of two renewal reviews in the third and sixth year, support for years six through eight is projected to be up to $4,250,000 in each of those years; and support for year nine and ten would be phased down at a reduced level of 33% of the prior year's support to prepare the ERC for self-sufficiency from ERC program support at the end of 10 years.

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

Eligibility Information

Who May Submit Proposals:

Proposals may only be submitted by the following:

- See the description under the "Organizational Limit" portion of the "Additional Eligibility Information" below.

Who May Serve as PI:

The Lead PI (Center Director) must be a tenured faculty member in an engineering department/school of engineering

at the lead university. The Director's doctoral degree must be in engineering or an associated field of science; if the latter, she/he must have substantial career experience in engineering as evidenced by a primary appointment in an engineering department/school of engineering at the lead university.

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:

A PI may be identified as Center Director **on only one proposal** and may not propose in any other role in any other ERC proposal.

A Co-PI on one proposal can also participate in other proposals.

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 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):

  September 25, 2015

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

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

  June 16, 2016

Proposal Review Information Criteria

Merit Review Criteria:

National Science Board approved criteria. Additional merit review considerations 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.

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I. INTRODUCTION

The ERC Program was started in 1985, when the White House and National Academy of Engineering requested a program to: (1) develop a new interdisciplinary culture in engineering research and education in partnership with industry to strengthen the competitiveness of the U.S. and (2) educate new generations of engineers who would be capable of integrating fundamental knowledge across disciplines to advance systems-level technology. To date, eighty-five percent of ERCs are self-sustaining after expiration of ERC Program support.

The ERC model rests on the systems-driven ERC research culture that integrates research and education and incorporates academic and industrial perspectives. In addition, the model enhances this platform through increased emphasis on translational research. Objectives of ERCs are to strategically integrate research, workforce development, and innovation; accelerate the use of ERC-generated technology; add educational experiences in entrepreneurial training, innovation, and creativity; build long-term pre-college partnerships to attract more students to engineering; and encourage foreign collaborations to give ERC students the opportunity to experience a foreign laboratory research culture.

II. PROGRAM DESCRIPTION

A. Goal and Key Features of ERCs

The goal of the ERC Program is to integrate engineering research and education with technological innovation to transform national prosperity, health, and security. It links scientific discovery to technological innovation and supports engineering graduates who can be leaders in industrial practice and creative pioneers in a global economy. The ERCs awarded through this solicitation shall have an infrastructure that integrates and implements the key features (research, workforce development, and innovation ecosystem development) to address the following gaps/barriers:

- ***Research***
  - To conduct an interdisciplinary research program that aligns systems-motivated fundamental and applied research with enabling and systems technologies to demonstrate proofs-of-principle of the engineered systems developed in

test beds
    - To translate interdisciplinary advances from research in fundamental knowledge, enabling technology, and transformational engineered systems to innovation

- ***Workforce Development***
    - To implement research-based education programs that produce a diverse, globally competitive, and team-oriented engineering workforce that has experience in research, industrial practice, technology advancement, entrepreneurship, and innovation
    - To broaden pathways to engineering for underrepresented students

- ***Innovation Ecosystem Development***
    - To create an innovation ecosystem that brings industrial/practitioner perspectives in research and workforce development to the ERC by leveraging industry resources and research capacity
    - To accelerate transfer of ERC advances in knowledge, technology, and systems to impact key sectors of industry and professional engineering practices and academic curricula

ERCs require the following ***Infrastructure*** to succeed*:*

- A complementary, multi-university configuration: an eligible lead U.S. university and no more than four domestic partner universities, at least one of which serves large numbers of engineering students who are from underrepresented groups;
- Adaptive interactions among academic, industry, and practitioner partners (e.g., sharing know-how, data, models, and test beds) and intellectual property policies that accelerate technology transfer and innovation;
- A culture of inclusion that promotes success for faculty, students, and other participants from all backgrounds;
- Leadership, strategic planning, project selection, financial, and management systems to develop, operate, and sustain the ERC in achieving its vision during its NSF-funded life and beyond;
- Collaborative partnerships with foreign faculty that leverage global expertise and support workforce development with global experience;
- Effective academic policies for interdisciplinary research, industry collaboration, and global education in safe, innovative facilities; and
- Financial and in-kind cost sharing from the lead and partner universities, plus membership fees from industry/practitioner partners.

B. Guidance Regarding ERC Key Features

The ERC Program expects each proposing team to propose innovative modes that integrate best practices from successful Gen-2 and Gen-3 ERCs to effectively realize the ERC Program's goal. For more information, see the list of Centers at: http://www.erc-assoc.org/Centers . Follow the links to each ERC's page. See also: the "Best Practices Manual" that was developed and updated by faculty, staff and students from ERCs (http://erc-assoc.org/best_practices/best-practices-manual).

1. **Research**

   Advances in fundamental knowledge and development of enabling technology in an ERC shall be guided and motivated by goals of the engineered systems vision and its anticipated challenges and outcomes. An ERC cultivates interdisciplinary interactions among teams of partner university faculty and students and industry researchers at fundamental, technological, and test-bed levels. This merges the culture of fundamental research in academe with the systems culture of industry to prepare tomorrow's leaders in research and innovation. Participating researchers and institutions interact adaptively to deliver near-term results and outcomes to meet impending needs of industry and/or society, as well as longer-term advances in fundamental knowledge and technology that support progress toward demonstration of proof-of-concepts of the ERC vision in engineered system test beds.

   1.a. General Vision Guidance: The ten-year vision should drive advances in an emerging and potentially transformative engineered system(s) that has potential to significantly impact the selected research area, establish new industries, or transform public sector services or infrastructure. Realization of the systems vision will overcome gaps and barriers identified in existing engineering practice and lead to increased national economic competitiveness or contributes to the solution of a major societal problem that has national, and possibly international, impact. The vision must incorporate emerging discoveries in science and engineering and must be expansive in scope to include innovation goals. If relevant to the technology proposed, there must be awareness of and compliance with the International Traffic in Arms Regulations (ITAR) and Export Administration Regulations.

   What is an engineered system?

   An engineered system is a combination of components/elements coordinated to work in synergy to collectively perform a useful function. The engineered system can be, for example, a new technology for a new product line or civil infrastructure system. It could lead to new manufacturing processes. It can transform public sector services or infrastructure systems. Part of the complexity of engineered systems research derives from integrating factors that enable their use in products, services, or infrastructures - factoring in their impacts on manufacturing efficiency, service delivery efficiency, resilience of civil infrastructures, the environment, society, or the human body, as appropriate to the system chosen. While fundamental, high-risk/high-reward research on one or more of the enabling components/elements may be required to realize the functionality of the system; focusing on the individual components/elements without their integration into an engineered system is not appropriate for an ERC.

   1.b. Vision Topic Area: Up to four awards will be funded in the following proposal submission areas, and there is no preference for the number of awards in each area.

   Open Topic ERCs: There is no preference for engineered systems topics. The topic must integrate fundamental science and engineering discovery with technological innovation to transform national prosperity, health, and/or security using an engineered systems approach. The topic must not overlap significantly with an existing ERC, graduated ERC, or other

federally funded center or institute.

Nanosystem ERCs: A Nanosystem Engineering Research Center (NERC) must be focused on a transformational engineered system(s) that could not be achieved without a significant level of fundamental knowledge of nanoscale phenomena that feeds into devices and components needed to realize the targeted engineered system(s). A NERC must build on a significant fundamental discovery or engineering breakthrough in nanotechnology and/or nanomanufacturing research that is ready to feed into proof-of-concept engineered system test beds within the 10-year life span of an ERC.

The NERCs will be a part of the National Nanotechnology Initiative (NNI); information about the NNI is available on the NSF web site: https://www.nsf.gov/nano. The NNI is a government-wide activity designed to ensure that investments in this area are made in a coordinated and timely manner and to accelerate the pace of revolutionary nanotechnology discoveries. In a recent review of the NNI, the President's Council of Advisors on Science and Technology (PCAST) called for government agencies, industry, and the research community to identify and pursue nanotechnology Grand Challenges. For more information, please refer to:
https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/pcast_fifth_nni_review_oct2014_final.pdf.

NOTE: The same (or similar) proposal can NOT be submitted in more than one track, even if the research program is changed to increase or decrease the emphasis on a given area.

1.c. Value Added of the Proposed Vision: The vision for the Center must meet the following criteria:

Transformative: The vision should address a challenge of national significance by integrating fundamental research and enabling technology at the frontier in a compelling way. The vision could not be achieved without a significant level of fundamental knowledge that feeds into devices, components/elements, and/or processes supporting the system(s). Incremental improvements that hold little potential to provide clear improvements over the state-of-the-art will not be supported.

Unique: The vision must be novel with significant added value relative to the plans and achievements of NSF- or other agency-funded center(s) that are active or have ended. The added value over state-of-the-art activities, alternative research approaches, and similar or related collaborative activities in major projects, centers, or institutes currently funded or called for by NSF or by other federal agencies must be specifically discussed. The vision of proposing team(s) whose personnel derive largely from a previous or existing center must provide a clear rationale for its novelty and value added to warrant an additional NSF investment. Proposals with significant overlap or duplication or lack of justification relative to existing activity or requests are not supportable as an ERC.

Convergent: Envisioned proofs-of-principle that systematically guide ERC activities to achieve the vision in proposed Center testbeds through integration of emerging fundamental research and enabling technologies within the ten-year period of NSF funding. Integration of envisioned activities must show compelling promise in overcoming well-defined, critical gaps and barriers in existing understanding and yield outcomes that meet industry/practitioner needs in the short- and medium-term. Basic research activities without clearly presented strategies to advance enabling and systems technologies and proofs of concept will not be supported.

Descriptions of Ongoing ERCs and other NSF Funded Centers: Access to the web sites for ongoing ERCs can be found at http://www.erc-assoc.org/Centers. Descriptions of other NSF-funded Centers where engineering research plays a significant role, such as Industry/University Cooperative Research Centers (I/UCRC), NSECs, Science and Technology Centers (STC), Science of Learning Centers (SLC), and Materials Research Science and Engineering Centers (MRSEC), can be found by searching the NSF website at https://www.nsf.gov/. Nanotechnology-related Centers supported by NSF and other federal agencies can be found at: http://www.erc-assoc.org/Centers.

1.d. Research Strategic Plan: An ERC must have a strategic research plan motivated by the engineered systems vision and positioned to advance the state of the art in research, technology, and innovation. The plan must be aligned with strategic plans for workforce (education) development, innovation ecosystem, and inclusion. Elements critical for the strategic plan include:

Context: Relevant state of the art research and practice must be summarized. Key gaps in knowledge and technology and technical, societal, and regulatory barriers to achieving the proposed vision should be identified. Proposed activities that leverage available knowledge and technologies outside the ERC should be included to complement Center capabilities, accelerate progress, and avoid duplication.

Critical path: Fundamental insights that enable the ERC to achieve its vision must be elucidated. Clearly-defined research and development activities to fill specific gaps and bridge specified barriers must be articulated. Research thrusts must link advances in knowledge with development of enabling technologies to support exploration, testing, and demonstration(s) of envisioned systems in the testbeds. Metrics that benchmark milestones for critical-path activities must be specific, measurable, attainable, and relevant to Center vision. Milestones must integrate advances in research thrust activities and mark timely progress toward demonstrating proof of principle of the Center vision within 10 years and beyond.

Resources: Personnel, equipment, facilities, and capital requirements to support activities at fundamental, technological, and system testbed levels must be defined and justified. Management of Center intellectual property (IP) across lead and partner institutions to enable domain licensing and its translation to societal use must be addressed. The ERC team shall include faculty, students, and staff who come from different disciplines and perspectives on research, education, technological innovation, and administration and who also bring the rich perspectives offered by diversity in gender, race, ethnicity, and other aspects. Institutional support must be evident.

Adaptive: The strategic plan must evolve to keep activities, metrics, milestones, personnel, frameworks, and resources (Center components) at the forefront of the sector defined in the Center's vision. A maturing ERC must refine its vision to focus on core advances, prunes less compelling Center components, and increase the level of detail and complexity of its strategic plan. Center leadership must actively involve advisory boards in regular evaluation of progress of teams and activities, in annual competitive project selection, and in implementation of ERC advances. Contingency plans shall be supported by intermediate go/no-go decision points to terminate projects, activities, thrusts, and testbeds as required to achieve Center

vision. Plans to evolve leadership, participating faculty, and IP management as activities are sunset and progress is benchmarked need to be supported collectively by ERC personnel and advisory boards.

1.e. Research Activities: ERC research activities that address gaps and barriers to advance fundamental knowledge and enabling technologies must be organized into coordinated thrusts and testbeds to achieve milestones, intermediate deliverables, and long-term objectives of the Center's envisioned engineered system(s). Attributes critical to defined research activities include:

Synergy: ERC projects, activities, and thrusts must be pursued by faculty and students who are integrated into highly collaborative, actively networked teams. ERC teams shall have the interdisciplinary composition, expertise, and networks required to address gaps as well as technical, societal, pedagogical, institutional, and regulatory barriers to progress. Synthesis of disciplinary perspectives, technologies, and terminologies from respective team members in the ERC shall challenge conventional approaches and accelerate progress in addressing gaps and barriers to achieve project milestones. Individual projects and activities must be interdependent with outcomes integrated to advance synergistically. A collection of projects or thrusts at geographically separate institutions that has little integration or which provides little added value beyond the sum of the parts is not supportable as an ERC. Faculty who advocate individual research interests that are misaligned with Center's strategic plan are not supportable in an ERC.

Partnership: ERC teams synthesize their disciplinary perspectives, technologies, and terminologies with those of participants from partnering and affiliated institutions through mentoring, shared advising, and mutually-beneficial, co-adaptive interactions using frameworks that are sustainable during and after 10 years of NSF funding. Industrial, academic, and institutional partners, advisory boards, and networks provide access to leverage existing or imminently available knowledge and technologies that complement Center capabilities. Faculty who advocate individual research interests in competition with achieving progress in the Center's strategic plan are not supportable in an ERC. Providing resources to participating faculty out of alignment with the strategic plan is not supportable in an ERC.

System at scale: Projects and activities are characterized and undertaken in sufficient depth in the respective constituent disciplines to support major advances in fundamental knowledge and enabling technologies. Exploration, testing, and demonstration of integrated knowledge and technology in engineered systems at the testbed scale goes beyond the typical bench or laboratory scale in terms of viability and complexity. But testbed demonstration of ERC vision does not attain industrial product and process realization stages. These are expected to be supported by industry/practitioner partners who license and/or implement the technology. Testbeds illustrate proof of concept at sufficient scale and complexity to accelerate technology transfer directly into the industry sector defined by the ERC. They may generate new directions at fundamental and technological levels, such as when system level barriers are not realistically surmountable. Centers that lack transformative advances at knowledge and technology levels and/or demonstration of engineered systems-level proof of principle within a 10-year funded period are not supportable as an ERC.

Note: NSF funds may not be used to support clinical trials. If the research involves vertebrate animals, an Institutional Animal Care and Use Committee (IACUC) approval for vertebrate animal research must be included in the proposal. If the research includes human subjects, an Institutional Review Board (IRB) approval must be included in the invited full proposal as well.

2. **Engineering Workforce Development**

ERCs produce graduates who will be U.S. innovators in a globally competitive economy through an Engineering Workforce Development (Education) program. This program encompasses graduate research, education, and professional formation; undergraduate classroom and research experiences; and outreach to attract pre-college and nontraditional students, particularly those from backgrounds underrepresented in engineering.

2.a. University Education Program: Students in an ERC attain disciplinary depth, broad professional skills, and systems expertise by participating in curriculum and training in an ERC education program. The program must include these key components:

Education Strategic plan: An ERC strategic education plan aligned with its plans for research, innovation, and inclusion must demonstrate commitment and resources to carry out efforts to achieve its goals. The goals of the plan shall be to deliver graduates prepared for industry and academia who are technically prepared; able to integrate knowledge across disciplines to advance technology; knowledgeable in industrial practice; experienced in advancing technology; adept at working in highly functional teams; ethical; effective communicators; creative, innovative, and entrepreneurial; lifelong learners; and experienced in working in non-U.S. research cultures. The plan must coordinate student activities and interactions with partners and advisory boards, particularly the Workforce Development Advisory Board, to attract, retain, progress, and graduate ERC students. Particular attention must be paid to broadening participation from populations underrepresented in engineering to cultivate a climate of inclusion with diverse representation.

Curricular impact: The ERC university education program must be carried out in collaboration with the ongoing education programs of the domestic partner universities. It is structured to involve ERC engineering and associated discipline students at B.S., M.S., and Ph.D. levels at each partner institution. Undergraduate ERC students must participate in significant research experiences during the academic year. Graduate and undergraduate students engaged in research during the academic year should be at a ratio of two graduate students to one undergraduate student. At least 6 non-ERC students must enroll in a Research Experiences for Undergraduates (REU) program budgeted at minimum $42K per year from the ERC base budget. This may be augmented from other sources. Each ERC will identify the impact on the curricula at lead and partner universities from integration of Center research. Examples include new courses, course modules/content for insertion in existing courses, and/or new certificate and degree programs. Coordination of university education programs with local community colleges and/or technical colleges is encouraged to strengthen pathways between 2- and 4-year institutions, as is inclusion of veterans as participants in ERC research and education programs.

Skill sets: Key technical, professional, and transferable professional skills that undergraduate and graduate students shall possess upon graduation to achieve the strategic plan goals must be determined. Research-based pedagogical and experiential approaches to impart these skill sets must be identified. This includes curriculum, research training, advising, mentoring, internships and other ERC student experiences that assure these desired skill sets are acquired. There should be actionable plans to effectively mentor students in research and attend to their professional formation as researchers and

engineers.

Global exchange: The ERC program must integrate education and training across the core and partner institutions using course cross-listings, cyberinfrastructure, internet modules, lab exchanges, and other support structures. ERC students should have opportunities to conduct ERC-relevant research in labs of foreign collaborators for a time sufficient to build global networks and provide knowledge of global research practices, capacities, and other competencies.

2.b. Pre-college Education Program: Each ERC workforce (education) development program must include a pre-college education program designed to build engineering workforce capacity by stimulating student interest in engineering careers and increasing the diversity of students studying engineering at the college level. Attributes critical to pre-college education must include:

Engagement: ERCs shall integrate best practices and effective ongoing efforts to (1) enhance student learning of engineering concepts derived from the ERC; (2) increase student interest and engagement in engineering; and (3) support teacher professional development that translates to sustained teaching of engineering at the pre-college level. Pre-college students excited by engineering and technological innovation through innovative methods such as inquiry based learning are motivated to pursue engineering degree programs in community colleges, colleges, and universities. The ERC should ensure its faculty and students participate in the full scope of the pre-college education program and their home institutions recognize and reward their efforts.

Partnership: To achieve its pre-college goals, lead and partner universities of the ERC must form effective long-term partnerships with up to five pre-college institutions (e.g., school districts, individual schools, ongoing programs) that leverage participating industry partners, state and local funding sources, and existing evidence- based P-12 programs. Partner institutions must agree to work with the Center to (1) allow their STEM teachers to participate in structured ERC research and education programs; (2) provide engineering learning and activity experiences for their students; (3) integrate new course modules based on ERC research into their curriculum; (4) develop strategies to embrace underrepresented groups, both teachers and students, into these engineering experiences; (5) enable talented high school students to pursue research experiences in the ERC's laboratories. One partnership must consist of an RET program that (a) provides in-service and/or pre-service to K-12 STEM teachers and community college faculty (if included) with engineering research experiences in ERC research labs/facilities; (b) results in increased knowledge of engineering for the teachers, strong engineering content modules for the classroom derived from ERC research, and effective engineering experiences for students; and (c) includes substantive plans for sustained follow-up between faculty and pre-college teachers and any community/technical college faculty to ensure research experiences are translated into classroom practice.

2.c. Assessment: The ERC must have program of formative and summative assessment that monitors progress and achievement of SMART (Specific, Measurable, Achievable, Realistic, Timely) goals of the strategic plan within the Center lifetime at university and pre-college levels. Assessment shall be conducted by a qualified group outside the ERC. Measures to assess progress and impacts through longitudinal data shall be identified. Mechanisms to incorporate feedback from assessment and the Workforce Development Advisory Board to improve the workforce development program content and delivery must be outlined. Note: Due to the nature of these activities, an Institutional Review Board approval for research involving human subjects must be included in the full proposal.

3. **Innovation Ecosystem Development**

An ERC must cultivate a vibrant innovation ecosystem that coordinates transformative engineering with innovation for large scale impact on a targeted sector of the national economy. This ecosystem shall have the following key components:

3.a. Strategic plan: The ERC must have a strategic plan for an innovation ecosystem that positions it for disruptive impact in a sector of the U.S. economy critical to its future interests. This plan shall analyze influential industry, regulatory, and nonprofit stakeholders in the sector to reveal critical existing gaps in capabilities as well as technical, societal, and regulatory barriers to the envisioned disruption. It shall also identify tangible benchmarks with which to evaluate milestones in Center progress toward bridging these gaps and barriers. Market and societal aspects of the Center beyond control of ERC participants (i.e., the chosen market Sector) shall be identified, including rules, societal norms, practices, regulations or policies that govern decision-making and that could help or hinder adoption of ERC technology. This is especially important when the ERC is intended to benefit the public good.

Strategic innovation plans must align with strategies in research and workforce development to form and cultivate an alliance of key stakeholders necessary to drive innovation, build the economy, and assure U.S. competitiveness in the sector. This includes actionable plans to recruit, engage, and retain stakeholders as partners. It also includes frameworks and infrastructure to translate foundational knowledge and enabling technologies developed in the ERC to the targeted applications.

3.b. Stakeholder community: The stakeholder community participating in an ERC innovation ecosystem consists of the core university partners, university affiliates, industry partners, government /non-profit practitioners (e.g., hospitals), civil society (e.g. state and local governments), associations (industry, professional, non-profit, or public), and end users that synergistically implement the ERC vision to achieve disruptive, large-scale impact. The ERC must define the expected value-added and/or role each stakeholder will contribute to the development and sustenance of the proposed Center's innovation ecosystem.

(3.b.1) Industrial/Practitioner Advisory Board (IPAB): The IPAB must be a fee-based membership program. Participating industry / practitioner members must contribute financial and in-kind support to the Center. Regular guidance from IPAB members must be coordinated with ERC leadership decisions on strategic planning, research directions, workforce development, and the role of innovation within the Center. This guidance is key to industrial/practitioner pre-competitive collaborative research with the Center. IPAB members are expected to:

- Participate in the ERC;
- Provide knowledge of fundamental research gaps, manufacturing, product design, validation, regulatory approval, economic evaluation, and/or the practices involved in transfer of knowledge/technology and delivery of service, as appropriate to the vision;

- Contribute to workforce development programs by providing guidance on the desired skill sets needed for success in industry and innovation;
- Participate as mentors to ERC undergraduate and graduate students and host industrial internships for ERC students; and
- Assist in establishing the cultures of innovation and inclusion required for the ERC's students, faculty, and staff.

IPAB membership must be strategically designed to include key firms in the value chain relevant to the ERC's vision in order to promote innovation and accelerate commercialization. Active engagement of member firms / practitioner organizations through the research program, student internships, and the employment of ERC graduates in industry and other practitioner organizations will be the primary mechanisms to accelerate transfer of ERC research to industry and other users.

(3.b.2) University, State and Local Government Facilitators of Entrepreneurship and Innovation: In addition to the IPAB, the ERC innovation ecosystem must include formal partnerships with university and/or state and local government organizations and/or programs devoted to facilitating entrepreneurship, innovation, and economic development at local and regional levels (e.g., I-Corps site/node, I/UCRC, etc.). These partnerships should leverage Center research to stimulate innovation, promote entrepreneurship, and impact local economic development and job creation. Partners should be involved with the ERC's workforce development programs to bring awareness and knowledge of entrepreneurship and innovation to the ERC's students and faculty. These partners are not member firms/practitioner partners in the IPAB; they do not pay annual membership fees to the Center.

3.c. Innovation frameworks: The ERC must define the rules of interaction and operation within the ERC ecosystem. This includes detailing the levels of IPAB membership and their corresponding requirements and privileges; defining management and translation of intellectual property developed in and between participating ERC institutions; and establishing a systematic process to identify, document, and manage conflicts of interests that may arise between ERC team members and members of the stakeholder community. Certification must be provided from an appropriate university official that conflicts of interest will be managed by the university or, if unmanageable, reported to NSF. These frameworks must be consistent with the NSF Proposal and Award Policies and Procedures Guide and the CA-FATC.

(3.c.1) IPAB Membership Agreement: Participation in an ERC IPAB must be governed by a Center-wide Membership Agreement that details the tiered membership levels for IPAB participation with corresponding annual fee schedule, rights, duties, and opportunities and policies for management and translation of intellectual property. Guidance on effective agreements and IP policies is available in the Innovation Ecosystem chapter of the ERC Best Practices Manual, which can be found at http://erc-assoc.org/best_practices/chapter-3-research-management.

- The Membership Agreement must include a scaled fee structure for member firms/agencies/hospitals that recognizes the differing capacity for participation according to their size.
- Industry commitments must start with cash membership fees. These may be augmented by in-kind contributions according to the size of the firm and the terms of the agreement.
- Agency/hospital (practitioner) member fees may be cash or in-kind.
- All members may contribute augmented support through sponsored research projects.
- There may be firms that provide support for sponsored research projects but do not pay membership fees to join the Center. These firms are not considered IPAB members.
- Proposals must demonstrate financial commitment by industry / practitioner members; however, there is no required formula in relation to NSF support.
- Fee-paying IPAB members have first option to license ERC-generated IP under the terms of the agreement.

(3.c.2) Technology Transfer and Translational Research Partnerships: Technology transfer to the IPAB member firms/practitioner partners will be the primary means of commercialization of ERC research. In the event that ERC member firms / practitioners do not exercise the option to license promising ERC-generated IP, the Center may choose to pursue a variety of partnerships to license the IP. These may include large and/or small companies who are committed to bring the IP to market. In addition, the ERC may pursue translational research partnerships with small-business member or non-member firms.

C. ERC Infrastructure

Infrastructure required to support participating domestic university partners and affiliates and foreign collaborators in an ERC includes a strong leadership team; advisory boards; a culture of inclusion; well-coordinated management systems; facilities, equipment, and headquarter space; and institutional commitment.

1. **Configuration**

1.a. Domestic Partner Universities: The domestic partner universities must include the lead university and at least one, but no more than four, additional domestic partner universities as defined in the "Eligibility, Organization Limit" §IV. This does not imply that the proposal must include five partners; however, a configuration of one lead and no partner universities is not acceptable. Each partner institution must have a minimum of three ERC faculty and a total of at least three students. Each partner is expected to be an active participant in all features of the ERC.

The lead or at least one of the domestic partners must be a university that serves large numbers of underrepresented minority students who are majoring in engineering fields AND are from collective groups underrepresented in engineering in the U.S. (i.e. African Americans, Pacific Islanders, Native Americans, Hispanic Americans, and persons with disabilities who are U.S. citizens or Permanent Residents). A university may qualify as an ERC underrepresented minority -serving partner if there is a significant combined percentage of these underrepresented groups engaged in Engineering studies, but the percentage is less than required by the Department of Education's official classifications of universities with significant populations of underrepresented minority groups. In such a case, the proposal must justify the selection with data, including a demonstrated graduation track record. Consequently, this approach expands the set of universities eligible to be an ERC partner university. The Department of Education's official classifications of universities with significant populations of underrepresented groups

can be found at: http://www2.ed.gov/about/offices/list/ocr/edlite-minorityinst.html. The lead and each of the partner universities must be committed to an integrated configuration to fulfill the research, workforce (education) development, innovation, and inclusion goals of the ERC.

1.b. Affiliated Domestic Institutions (Not Required): These institutions are not considered partners and are not required to cost share. While not a required feature, strategic insertion of faculty/staff from non- partner affiliated institutions into research, workforce (education) development, and innovation aspects of the ERC may provide technical expertise on a temporary basis as the Center evolves. These institutions may be universities, colleges, federal laboratories, funded centers with whom synergies arise, and/or institutes for innovation, manufacturing, education, etc. The number of faculty/staff in this category should be kept to a level that minimizes additional management complexity while infusing the ERC with complementary state-of-the art expertise needed to achieve overall objectives. Contributions of participants from affiliated institutions may be in research, workforce development, and/or innovation. These individuals are not required to have a long-term commitment to the ERC. NSF funds cannot be used to support staff from federal laboratories who participate in an ERC.

1.c. Foreign Collaborations (Required): The ERC shall provide opportunities for domestic students and faculty to collaborate in a globally connected university research and education environment. These collaborations are not expected to be in place in the proposal; rather collaborations between ERC faculty and faculty in foreign universities that include student involvement in research are expected to evolve over time as the research program evolves. Collaborations may be with researchers in foreign institutes to engage in pre-competitive research, as opposed to new product development. There is no required number of these partnerships, but the number of collaborations must be manageable.

International partnerships may be formally established between the ERC and a foreign university through a Memorandum of Understanding (MOU) managed consistent with Financial & Administrative Terms and Conditions (FATC), for example, or they may be less formal ERC faculty-to-foreign faculty collaborations. In either case, the foreign collaboration must add value to the research and offer ERC students opportunities to work in a foreign laboratory for a period of time sufficient to gain meaningful international research experience that is relevant to the student's research in the ERC. In both cases, there should be mutually protective Intellectual Property (IP) policies with advance written approval from center advisory boards.

NSF funds may be used to support ERC faculty and students in these collaborations at both the U.S. and foreign sites of the collaboration. NSF funds may be used to support the time that international collaborators carry out research and/or educational activities at the ERC's sites in the U.S.; otherwise, support for collaborative activities at foreign collaborator institutions must be obtained from their respective funding organizations. **1.d. Other Required Partnerships**: The ERC shall partner with pre-college educational institutions to bring engineering concepts to the classroom and stimulate student interest enrolling in college-level engineering degree programs and in engineering careers. In addition, there may be partnerships with community and/or technical colleges to strengthen the technical workforce and stimulate interest in careers in engineering.

2. **Leadership, Culture, Organization, Facilities and Commitment**

2.a. Leadership Team: Each ERC shall have the following leadership team comprised of members who are diverse in gender, race and ethnicity (from groups underrepresented in engineering) and persons with disabilities. Except for the Administrative Director, the Industrial Collaboration and Innovation Director, and the leaders of the Student Leadership Council, who may be designated after notification of the award, the leadership team must be specified in the full proposal. Among the leadership team (i.e., the PI and co-PIs as well as the below designated leaders) there must be identified individuals with deep expertise in fundamental science/engineering areas envisioned by the ERC; strategic leadership in innovation including intellectual property; and workforce development that includes creating a culture of inclusion, graduate education, and broadening participation. Funds budgeted to support leadership roles are one indication of commitment. Changes after proposal submission are subject to advance approval in writing by the site visit team and ERC program management, in accordance with a succession plan that names replacements for each leadership team member in the event of departure, and is maintained in the Center.

***(2.a.1.) Center Director**:* In compliance with the PI eligibility criteria, the Center Director must be a tenured engineering faculty member and the Lead NSF Principal Investigator (PI) who is responsible for leading the ERC and administering the award in accordance with the terms and conditions of the Cooperative Agreement issued by the NSF in the event of an award.

***(2.a.2.) Deputy Director/Executive Manager**:* The Center may have a Deputy Director who is a faculty member and shares the leadership and management responsibilities of the Center with the Director. If there is no faculty member suitable for this role, the Center may propose to include an Executive Manager instead of the Deputy Director, who will be a staff member dedicated to working with the Director in executing the mission of the Center.

***(2.a.3.) Research Thrust Leaders**:* Faculty members from across the domestic partner universities who are responsible for leading and managing major research thrusts and test beds of the ERC.

***(2.a.4.) Workforce Development Program Director**:* A faculty member who is responsible for the development and execution of the ERC's university education program and supported by other faculty, students, and staff in the execution of the ERC's efforts.

***(2.a.5) Industrial Liaison Officer**:* A staff member, not faculty, at the lead university who is responsible for developing the ERC's innovation ecosystem, marketing the ERC to industry / practitioners, gaining their financial support, developing and coordinating industrial / practitioner involvement with faculty and students, and managing the other partnerships for innovation and the translational research program.

***(2.a.6) Diversity Director**:* A staff or faculty member who is experienced in the development, implementation, and assessment of proven activities that can create a culture of inclusion and recruit/retain underrepresented groups in engineering or STEM fields.

***(2.a.7) Administrative Director**:* A staff member at the lead university who is responsible for operational management, financial management, data collection, publicity, and reporting, etc. for the ERC.

***(2.a.8) Student Leadership Council (SLC)**:* Undergraduate and graduate students from all the partner universities

responsible for coordinating their various activities in support of the ERC research, education, and innovation agenda. A student President and a student co-President lead the SLC. The SLC will prepare a written Strengths- Weaknesses-Opportunities-Threats (SWOT) analysis and present the SWOT during the annual visit of the NSF site visit team (SVT).

2.b. Advisory Boards: Each ERC shall receive and incorporate regular guidance from external and internal advisory boards and councils.

***(2.b.1.) Scientific Advisory Board**:* The Scientific Advisory Board (SAB) will be comprised of outside experts who are selected by the ERC Leadership Team. The SAB must meet as a group with the Center at least once a year and once each year with the NSF SVT at the annual site visit. (Note: Do not contact potential members or appoint this advisory board during the proposal preparation and review process or list potential members in the participant table.)

***(2.b.2.) Industrial/Practitioner Advisory Board**:* The Industrial/Practitioner Advisory Board (IPAB) will be comprised of representatives of member companies/agencies/hospitals. The IPAB shall meet collectively as a group twice each year to advise the ERC's leadership team; to prepare a written Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis; and to present the SWOT in an annual meeting with the NSF SVT. The IPAB will have a chair who organizes the board's activities in coordination with the Industrial Liaison Officer and the Center Director. The IPAB must participate in the ERC's annual project selection/review process by providing input on project quality and industrial relevance.

***(2.b.3.) Academic Policy Board**:* Administrators from the lead university, including the Dean of Engineering, will meet collectively as a group with the ERC Director to coordinate ERC plans and policies with departmental and university leaders.

(2.b.4.) Council of Deans: Led by the Dean of Engineering from the lead university, this Council of Deans from the lead and partner academic institutions meets collectively as a group to provide administrative support of the ERC and to help facilitate the ERC's research, education, and innovation efforts across the lead and partner universities.

***(2.b.5.) Workforce Development Advisory Board (WDAB)**:* The WDAB will be comprised of experts in workforce development (education) and broadening participation selected by the ERC Leadership Team from outside the core and partner institutions and other advisory boards. They may represent activities funded by NSF (e.g., NSF Research Traineeships) or other federal agencies or public, non-profit, or private groups. The WDAB will meet as a group at least once a year with the Center and once each year with the NSF SVT. (Note: Do not contact potential members or appoint this advisory board during the proposal preparation and review process or list potential members in the participant table.)

2.c. Culture of Inclusion: ERCs must promote a culture of inclusion where faculty, students, and staff from all backgrounds have an opportunity to succeed in research, education, innovation, and administration. Thus, the leadership team, faculty, students, and staff involved in an ERC, as well as the above specified advisory boards and councils, must be diverse in their experiences as well as diverse in gender, race, and ethnicity - i.e., women, African Americans, Native Americans, Pacific Islanders, Alaskan Natives, Hispanic Americans, veterans, or persons with disabilities who are U.S. citizens or permanent residents. The ERC must also be made multicultural through the involvement of faculty and students from other countries by virtue of their role as faculty or students in the Center's domestic institutions. ***Vision**:* The ERC will articulate a vision to achieve broadening participation of groups underrepresented in engineering that exceeds the academic engineering-wide national averages and continues through time on an upward slope in relationship to those national averages. This diversity must be present among participants from the lead and each of the partner academic institutions. While at least one of the partner institutions must serve large numbers of students majoring in STEM fields who are from groups underrepresented in engineering, that institution cannot be the predominant contributor to the diversity of the ERC. The ERC will partner with pre-college institutions that have diverse student bodies, as discussed above. Note: proposals cannot include numerical projections. Collaborating foreign faculty are expected to respect the diversity of the ERC's faculty and students and provide inclusive research and education environments. The multicultural nature of ERCs mandates that the language of discourse in ERC laboratories will be English to maintain an inclusive environment for all. ***Strategic plan**:* The ERC workforce development (education) strategic plan must include plans to cultivate a culture of inclusivity that integrates faculty, students and staff who come from different disciplines and perspectives on research, education, and technological innovation. Plans must support integration of rich perspectives offered by diversity in gender, race, ethnicity, and other demographics. Gaps and barriers to creating this culture must be identified and addressed via goals, non-quantitative milestones, and intended actions to successfully build a culture of inclusion. Diversity at all levels of students, staff and faculty must be considered. Programs, some of them NSF-funded (e.g., ADVANCE, etc.), and offices (e.g., Minority, Multicultural or Women in Engineering Programs, etc.) at lead and domestic partner universities, should be leveraged in support of the plan at each campus. The roles and commitments of the deans and collaborating department chairs should be specified in the plan.

2.d. Organization and Management Systems: The ERC Director must report to the Dean of Engineering of the lead university. The ERC must have sound management systems to assure effective integration. These include systems for financial management, data reporting, project selection and assessment that include regular input from all leadership team members and the Scientific and Industrial/Practitioner Advisory Boards.

2.e. Facilities, Equipment, Safety, and Headquarters: The lead university must commit to provide sufficient headquarters space and resources to support the leadership, management, and collaboration functions of the ERC. The ERC's research teams will be supported by appropriate research equipment and shared facilities, shared data, shared experimentation, shared simulations and test beds. The ERC will assure safe laboratory environments and safety training for its students across domestic partner universities and abroad. The Center will work with the administration at each university to monitor and assure safety.

A robust cyberinfrastructure, with appropriate software and staff, should be in place to facilitate collaboration. The NERCs will link with the resources of the Network for Computational Nanotechnology (NCN) as the main cyber platform for development and dissemination of any computational and simulation tools and educational materials developed by the NERC. Information about the NCN can be found at https://nanohub.org/groups/ncn. The NERC equipment plan will include efforts to leverage the experimental resources of the National Nanotechnology Infrastructure Network (NNIN) and the computational resources of the NCN. Information about the NNIN can be found at http://www.nnin.org/.

2.f. Institutional Commitment: The lead and partner universities must support the Center's research, education, and innovation culture; augment NSF's support during the award period through cost-sharing and other means; and sustain the

ERC once NSF's support ceases. University students engaged in mentoring of other university students and in pre-college outreach should receive credit or official recognition for such activities. Core and partner academic institutions must commit to:

- Join in partnership to support the ERC's vision, strategic plans, and activities in research, workforce development and innovation.
- Assure cross-university industrial membership and IP policies that recognize shared rights for joint work;
- Support the ERC's plans for diversity and building a culture for inclusion and success for all;
- Institute policies to reward faculty, particularly those in the tenure and promotion process, for participating in cross-disciplinary research and innovation, technological advance and innovation, mentoring, university and pre-college education, and delivering on the ERC's plans for workforce development and inclusiveness.

D. Financial Scope and Scale of the ERC

1. **NSF Award Size**: Start-up base support will not exceed $3,500,000 for year one. Pending satisfactory annual performance, need, and availability of funds, the base support may increase to $3,750,000 (year 2), $4,000,000 (year 3), $4,250,000 (year 4), and $4,250,000 (year 5). Pending performance and the outcome of two renewal reviews in the third and sixth year, support for years six through eight is projected to be up to $4,250,000 in each of those years; and support for year nine and ten will be phased down at a reduced level of 33% of the prior year's support to prepare the ERC for self-sufficiency from ERC program support at the end of 10 years.
2. **Cost Sharing**: The lead and partner domestic universities will be committed to support and sustain the ERC through financial and in-kind cost sharing. Evidence of this cost sharing is required in the invited full proposal. The financial support allocated by the Center Director to the lead and partner university faculty will depend upon their roles in the ERC; and, post award, that support will depend upon performance and need and likely will vary over time. This will impact cost sharing over time.
3. **Total Support**: Post-award, ERCs establish a Center-level account into which is deposited the ERC program base support and any other support provided directly by other sources (e.g., IPAB membership fees) to the Center to carry out its activities. In addition, ERCs may include support provided to a PI's department for supplementary projects that will be carried out under the ERC's Strategic Plan. This support is classified as associated project support in post-award financial reporting.

III. AWARD INFORMATION

Anticipated Type of Award: Cooperative Agreement

Estimated Number of Awards: 4

Up to 4 of any combination of Open Topic ERCs and/or NERCs - depending on the quality of the proposals and the availability of funds, with a start date targeted for Summer 2017.

Anticipated ERC Award Funding Amount: $3,500,000/ERC for the first year

IV. ELIGIBILITY INFORMATION

Who May Submit Proposals:

Proposals may only be submitted by the following:

- See the description under the "Organizational Limit" portion of the "Additional Eligibility Information" below.

Who May Serve as PI:

The Lead PI (Center Director) must be a tenured faculty member in an engineering department/school of engineering at the lead university. The Director's doctoral degree must be in engineering or an associated field of science; if the latter, she/he must have substantial career experience in engineering as evidenced by a primary appointment in an engineering department/school of engineering at the lead university.

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:

A PI may be identified as Center Director **on only one proposal** and may not propose in any other role in any other ERC proposal.

A Co-PI on one proposal can also participate in other proposals.

Additional Eligibility Info:

Organization Limit:

Only U.S. universities with undergraduate, masters, and doctoral engineering programs with the breadth and depth appropriate to support the Center's vision 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 the partnering universities and any affiliated faculty from non-partner institutions through subawards.

A university that has two funded ERCs from the Classes of 2006 through 2015 and the NERC 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 of the following organizational requirements or they will be returned without review:

- A proposed ERC must be multi-institutional, with a lead university and no more than four additional domestic university partners.
- To qualify as a partner institution, there must be a minimum of three faculty participating in the ERC along with at least a total of three students;
- The lead or at least one of the domestic partner universities must be a university that serves large numbers of students from groups that are predominantly underrepresented in engineering in the U.S. (i.e. women, African Americans, Pacific Islanders, Native Americans, Hispanic Americans, or persons with disabilities who are U.S. citizens or Permanent Residents of the U.S.) who are studying in STEM fields;
- Commitment to include, in the full proposal or in the future, collaborations with foreign faculty to enable U.S. students to have an opportunity to carry out research in foreign laboratories;
- Commitments from domestic lead and partner universities for cost sharing must be in place, as instructed below;
- Firm and/or practitioner fee-paying members of the center are required. These intended memberships must be documented in letters of commitment as part of the full proposal (See "Supplementary Documents.");
- Innovation partners, such as university and/or state and local government organizations devoted to promoting innovation and entrepreneurship, are required. These partners are not required to be fee-paying members of the center. However, they are to document their commitments in letters to be submitted with the full proposal (See "Supplementary Documents");
- Pre-college education partners are required. Letters documenting these intended commitments are required as part of the full proposal (See "Supplementary Documents.").

The following organizational features are **not required** but may be proposed:

- The ERC may include institutions participating in research and/or education programs as affiliated organizations, such as: (1) Federal Laboratories (although NSF funds may not support the participation of staff of these laboratories in the Center); and/or (2) universities or colleges that are contributing affiliated faculty in groups of less than three;
- To increase the impact of the ERC on the technical workforce, the ERC may partner with community colleges and or technical colleges.

Other organizational guidance:

- If the Lead PI (Center Director) departs the university or decides to transfer to another university during the review process or after an award is made, the proposal/award remains with the lead submitting university;
- The lead university cannot change after submission of the Letter of Intent;
- The partner universities may change after the invitation to submit a full proposal. However, NSF must be notified of any changes within one month of the date of the invitation.
- A lead university can receive only one award through this solicitation. There is no limit on the number of ERC partnerships a partner university can join.
- Among the Lead PI and co-PIs there must be identified individuals with deep expertise in fundamental science/engineering discovery in areas envisioned by the ERC; strategic leadership in innovation including intellectual property; and workforce development that includes creating a culture of inclusion, graduate education, and broadening participation.
- 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).

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 letter should be submitted via FastLane (not Grants.gov) no later than the LOI deadline date specified in this solicitation. The LOI allows NSF to screen the proposals with respect to eligibility requirements, to categorize the proposals according to general topical areas, and to identify conflicts -of-interest so as to prepare for the proposal review processes. The topics themselves will not be pre-screened.

Submit information for your LOI through FastLane under these categories and only under these categories (note the character limits,

which include spaces, as stated below):

- **Project Title**: For an open topic ERC, the title should begin with "NSF Engineering Research Center for *(insert the rest of the title and the Center's acronym)*". For an NERC, the title should begin with "NSF Nanosystems Engineering Research Center for *(insert the rest of the title and the Center's acronym)*".
- **Center PI and Point of Contact for NSF Inquiries**: Center Director's name, university, department, phone number, and e-mail address
- **Anticipated Center Co-PIs** (maximum of four official Co-PIs): Because the proposal cover sheet only allows a total of five PIs (the PI and up to four Co-PIs), identify up to four Co-PIs. Include their names, universities, departments, and locations (city, state, country).
- **Anticipated Domestic Academic Partner Universities**: This section should include only the domestic "academic partner universities" anticipated to partner in the ERC (not the universities that are contributing affiliated faculty, or federal laboratories, or foreign collaborators' universities). For each academic partner university include the name and location (city, state and country). Identify the partner university that would serve as the ERC underrepresented minority -serving institution. Each university entry can have up to 76 characters (including spaces) to show all requested information. Abbreviations can be used, as needed. A search for the organization can be done in FastLane, and if found in the search, then it can be added when selected from the list.
- **Synopsis** (max 2,500 characters in this section, including any spaces): Provide brief statements of the vision and goals of the ERC; its research program including research thrust titles, goals, and fundamental gaps or barriers in knowledge/technology that it meet; workforce development plan (university and pre-college education), and the innovation ecosystem programs. Detail must be sufficient to understand the proposed ERC at this early stage.
- **Other Comments** (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. See Sec. V.B. below and http://carnegieclassifications.iu.edu/.

Submitter Information: This section does not require input from the LOI author. This information is automatically added to the final LOI submission by FastLane.

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 not required when submitting Letters of Intent.
- A Minimum of 0 and Maximum of 4 Other Senior Project Personnel are permitted
- A Minimum of 1 and Maximum of 4 Other Participating Organizations are permitted
- Carnegie Foundation Organizational Attribute (lead University) is required when submitting Letters of Intent
- Anticipated Domestic Academic Partner University (Required) is required when submitting Letters of Intent
- Anticipated Domestic Academic Partner Universities (List all others - optional) is required when submitting Letters of Intent
- Submission of multiple Letters of Intent is not 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 invitation for a Full Proposal. The preliminary proposal review provides peer feedback to the proposing team and substantially reduces the burden of preparing a full proposal if the proposed team, vision, and strategic plans are not meritorious, according to the criteria in §VI.A.

Proposals will need to address the following questions:

- What is the compelling new idea and how does it relate to national needs?
- Why is a center necessary to tackle the idea?
- How will the ERC's infrastructure integrate and implement research, workforce development and innovation ecosystem development efforts to achieve its vision?

Preliminary proposals must contain the items listed below and adhere strictly to the specified page limitations. No additional information may be provided as an appendix or by links to Web pages. Figures and tables must be included within the applicable page limit (described below). Preliminary proposals that are not compliant with the guidelines will be returned without review, thus making the proposing team automatically ineligible for submitting a full proposal. The submitting organization is responsible to ensure compliance with the guidelines.

The Center configuration at the preliminary proposal stage shall include only the lead and up to four anticipated domestic partner universities as described in §II.C.1. The lead university (not PI) is binding throughout the process, but domestic partners may change. The participating team will be limited to the PI and up to four co-PIs who may come from any or all of the domestic partner universities and have expertise as described in §II.C.2.a. The co-PIs may change upon submission of an invited full proposal.

Cover Sheet: Select the program solicitation number from the pull-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 Principal Investigator (PI) and a maximum of four co-principal investigators. The sum of $2 should be entered on the budget line to allow correct FastLane processing.

Title of Proposed Project: For an Open Topic proposal, the title should begin with the "Engineering Research Center for *(insert the rest of the title and the Center's acronym)*." For a Nanosystems ERC the title should begin with "Nanosystems Engineering Research Center for *(insert the rest of the title and the Center's acronym)*."

Project Summary (1 page): The Project Summaries must have three sections entitled, respectively, “Proposed Vision”, “Intellectual Merit”, and “Broader Impacts”. The summary should be written in the third person, informative to those working in the same or related field(s), 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 9 pages total, containing the following sections):

1. ***Proposing Team***: The description must start with a table that that has four columns: (1) Name of the PI or co-PIs, (2) Institution, (3) Department(s), and (4) Most Relevant Field(s) of Expertise. There will be up to five rows, one for the PI (Center Director) and one each for up to four co-PIs.
2. ***Vision***: The proposed vision for a transformational engineered system must be explained(see §II.B.1.a). The transformative, unique, and convergent aspects of the vision that constitute its value added (§II.B.1.c) must be addressed, including recent breakthroughs with high potential impacts.
3. ***Strategic Plans***: Strategic plans for research (§II.B.1.d), workforce development (§II.B.2.a), and innovation ecosystem development (§II.B.3.a) must be identified and integrated to show how the proposed vision will be achieved.
4. ***Research***: Research activities must be proposed (§II.B.1.e) to bridge gaps and barriers to achieve the vision. Research must advance fundamental knowledge and technology to support proof-of-concept in system test beds. Integration of research activities must be graphically depicted on a fully legible version of the ERC Program's 3-Plane Strategic Planning Chart that is tailored to the proposed ERC. This chart is not included in the 9-page limit. A sample chart is available at: http://erc-assoc.org/content/three-plane-diagram
5. ***Workforce Development*** (Education): Activities must be proposed to support workforce development in pre-college through university education and research training (§II.B.2).
6. ***Innovation Ecosystem Development***: An innovation ecosystem development effort must be proposed (§II.B.3). However, do not list potential or committed industrial or other supporters. Members of Council of Deans and Academic Policy Board may be identified, but do not identify members of other advisory boards.

References Cited (maximum 3 pages): See PAPPG for format guidelines.

Biographical Sketches (2-page limit for each): Should be included for the PI and up to four co-PIs, according to the PAPPG, Chapter II.C.2.f. Advisors, advisees, and collaborators should not be listed on this document, as this information will be submitted separately through a conflict of interest template described below.

No budget should be submitted: No budget and no 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 Document: Include a letter from the Dean of Engineering of the lead institution indicating a commitment to the Center should it be invited for a full proposal submission and subsequently funded. The Dean should NOT include any financial commitments. Instead, the Dean should make a statement as to how the proposed Center will align with the strategic directions of the college and the university.

PI and co-PI Conflict of Interest document: Please use the template found at http://erc-assoc.org/content/templates-proposal-preparation-0. Download and use the file named "ERC Preliminary Proposal Participants with Conflicts" to use to prepare the conflict information submission. Please read the Instructions carefully and follow guidance. Using the template, compile an Excel Workbook that identifies conflicts of interest (COIs) for the PI and up to four co-PIs. Conflicts would be listed according to the guidelines provided in the PAPPG, Exhibit II-2.

If the proposing team includes participants in addition to the PI and co-PIs identified in the preliminary proposal, please identify the additional faculty members and other participants on sheet 2 of the workbook so that they will not be contacted to participate in the review process.

Following the Instructions provided in the template, the completed Excel Workbook should be emailed to ercintent@nsf.gov immediately after the proposal is submitted, but no later than the proposal deadline. Please include in the subject line the proposal number, the name of the lead institution, and the words "Participant table with conflicts."

No other items, appendices, supplementary documents are permitted: If any supplementary documents (except the Dean's letter) and appendices are submitted, the preliminary proposal *will be returned without review .*

DO NOT SEND other documents, including Letters of Commitment from the domestic partner universities, prospective industrial members, or other future partners; Current and Pending Support Statements; Facilities Equipment and Other Resource; Budget and Budget Justification; Data Management Plan; Postdoctoral Mentoring Plan for preliminary proposals.

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 Grant Proposal 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 Chapter II.C.2 of the PAPPG 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.

Invited Full Proposal Preparation Instructions (*by invitation only*): Full proposals may be submitted only by invitation.

As a multi-university ERC, the proposal must be submitted as a single integrated proposal by the lead university, with proposed sub awards to the other partner institutions. Separate proposals from each partner will not be accepted, since separately submitted collaborative ERC proposals are not allowed.

Required Proposal Format:

1. **Cover Sheet:** Select the ERC Program solicitation number from the pull down list. For an open topic ERC, the proposal title should begin with "Engineering Research Center for *(insert the rest of the title and the Center's acronym)*." For a NERC, the proposal title should begin with "NSF Nanosystems Engineering Research Center for *(insert the rest of the title and the Centers acronym)*". The title should reflect the system focus of the proposed Center. For planning purposes, August 1, 2017 should be shown as the start date. The proposed Center Director must be shown as the Lead Principal Investigator.
2. **Project Summary (limited to one page):** The summary should be written in the third person (i.e., the use of the pronoun "it" not "we" to represent the ERC) and should make a compelling case for the ERC. The summary should be informative to persons working in the same or related fields; and, insofar as possible, understandable to a scientifically or technically literate lay reader.

   In the overview section, include the Center's title, the Center Director's name, the lead university's name, and the names of the partner universities. Write a brief clear description of the ERC, stating its vision and goals, the transformational nature of the systems technology, the fundamental barriers in the way of realization, and its impact on innovation and the engineering workforce through its education program.

   In separate statements, under the respective headings "Intellectual Merit" and "Broader Impacts", provide highlights of the proposed research, university and pre-college education goals, diversity strategy, industrial collaboration, technology transfer and innovation goals and strategies.

   Proposals that do not contain the Project Summary, including an overview and separate statements on Intellectual Merit and Broader Impacts will not be accepted by FastLane or will be returned without review. Additional instructions for preparation of the Project Summary are available in FastLane.

3. **Table of Contents:** will be generated automatically by FastLane or Grants.gov.
4. **Project Description**

   The project description must contain sections (4.a) to (4.f) as described below. Section (4.a) is the Table of Academic/Other Participants and Industrial/Practitioner Members. The remainder of the Project Description is **limited to 25 pages** (Secs. 4.b. to 4.f.). It is subject to font and page limitations as discussed in the PAPPG. The 25 -page limit includes all figures, charts, and other tables required as a part of the narrative. ***If the Project Description exceeds the page limit, the proposal will be returned without review***.

   The intellectual merit and broader impacts of the ERC must be addressed and described as an integral part of the narrative. However, a separate section on prior NSF support must **not** be included in the project description; rather this information must be integrated into discussion of state of the art in research and education. At the proposal section normally reserved for NSF support, the reader should be referred to the state of the art section of the proposal.

   4.a. Table of Academic/Other Participants and Industrial/Practitioner Members (Not included in the 25-page limit)**.** The table should be inserted at the beginning of the Project Description using the table format available on the ERC Association website at https://www.erc-assoc.org/content/templates-proposal-preparation-0. Download and use the Word file named "ERC Participants Table Template for Inclusion in Full Proposal." Provide all of the required information. The table will list: (i) lead university; (ii) domestic partner universities (iii) universities or National Laboratories contributing affiliated faculty or staff; (iv) partner pre-college institutions; (v) foreign university partners, if known; (vi) name, department, and institutional affiliation of each member of the leadership team and of each ERC participant (faculty and staff) who will receive support from the ERC budget to carry out the research, education, and other functions of the Center; (vii) Innovation Ecosystem Partners (names and locations of the firms/agencies/hospitals committed to be industrial/practitioner members and names innovation partner organizations (state and local government or other organizations partnering to promote innovation).

   [**Note**: After the proposal is submitted and the final proposal number is obtained, submit an Excel spreadsheet, with the same information as the table above plus additional conflict of interest (COI) information for funded faculty, other non-faculty members of the Leadership team and research staff according to the PAPPG, Exhibit II-2. This spreadsheet is available on the ERC Association website above. Use the file named "ERC Participants Table Template with Conflicts of Interest.]

   Please submit this table to ercintent@nsf.gov the same day you submit the proposal. Include in the subject line: the proposal number, the name of the lead institution, and the words, "Participant Table."

   The following additional sections (4.b.) through (4.f.), **limited to 25 pages maximum**, of the Project Description should be prepared with reference to the review criteria and the guidance provided in this and the preceding sections of this solicitation. The intellectual merit and broader impacts of the ERC must be addressed and described as an integral part of the narrative.

   4.b. Vision and Rationale for the ERC. Articulate the vision of the proposed ERC and its engineered system, including the compelling national challenge(s) it addresses. The rationale for the value added of the proposed vision must include consideration of transformative, unique, and convergent characteristics.

   Compliance with International Traffic in Arms Regulations (ITAR) and Export Administration Regulations (EAR), if applicable: If the proposed topical area has obvious dual use in both the military and civilian sectors, then note the following: The ERC solicitation requires international collaboration and offers the opportunity to establish a partnership with foreign researchers. Furthermore, there are often foreign students engaged in an ERC. Hence, PIs need to be cognizant of appropriate Department of State regulations, specifically the International Traffic in Arms Regulations (ITAR), and Department of Commerce regulations, specifically, Export Administration Regulations (EAR). If relevant to the technology proposed, the proposal should indicate awareness and compliance with the ITAR and EAR regulations in the section where the ERC's international

collaboration is discussed. An ERC awardee under this solicitation will be responsible for ensuring compliance with the appropriate regulations. Please direct your specific questions on how to comply with these regulations to your university research administration office.

4.c. Research Program Broader Impact. The research program is the core of the ERC from which all center activities evolve. First, the strategic research plan must be presented using the ERC 3-plane chart framework followed by the details of the research program itself.

(4.c.1) Strategic Research Plan: Provide the strategic research plan of the proposed ERC. Ensure the elements critical to the strategic research plan – context, critical path, resources, and adaptive - are addressed in entirety. A ten-year milestone chart (displayed in a font size that is readable) must illustrate the critical path, 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 Center's vision. More clarity and specificity of milestones are expected for years 1 to 5. The format is not specified, but it must clearly indicate points of integration. A linear Gantt chart lacking points of interface or transitions is not effective. Impacts of the proposed research and technology outcomes on environment, human health and potential beneficiaries must be summarized.

If an open topic ERC or a NERC develops nanoscale research simulation tools suitable for hosting on the cyber platform (https://nanohub.org/) of the Network for Computational Nanotechnology (NCN), those tools will be delivered to the NCN, where a broader community will have access to them in an open source mode for research and educational purposes. If applicable to the proposed ERC, include these plans in the proposal.

(4.c.2) Research Activities: Identify and characterize interdependent research thrusts and activities at fundamental knowledge, enabling technology, and systems-level test beds scales. Ensure the elements critical to the research activities – synergy, partnership, and system at scale - are comprehensively addressed. Integration of research activities must be graphically depicted on a fully legible version of the **ERC Program's 3-Plane Strategic Planning Chart** that is tailored to the proposed ERC. A sample chart is at:
https://www.erc-assoc.org/content/templates-proposal-preparation-0.

Each research thrust narrative must provide the following information. A **readable table upfront** must list the thrust leader and other faculty/research participants by name, their departments, and institutions. 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 strategic research plan. 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 three-plane chart. Provide information on projected thrust -level fundamental knowledge and technology deliverables and on the gaps and barriers the thrust will address in the context of the ERC's strategic plan. Discuss the cross-disciplinary mix of expertise needed to achieve the goals of the thrust.

Project-level descriptions of specific research activities for each thrust must describe the proposed research and link it to the thrust goals. In the context of known results and theory, provide examples of fundamental barriers the research will address and project-level methods to address them. 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 test beds. Describe a few exemplar projects in depth to allow judgment of the quality of the effort proposed, rather than superficially describing all projects.

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

(4.c.3) Foreign collaborations*:* Describe the strategy to develop foreign collaborations over time and justify their value added in research and workforce development. Foreign collaborations are not required to be in place by the time of the submission of the proposal; however such collaborations may be discussed if extant at the time of submission.

4.d. Engineering Workforce Development (EWD) Broader Impact.

(4.d.1) University Education: Provide the strategic goals of the Center for contributing desired characteristics, the anticipated curricular impact of the ERC, and targeted skill sets of ERC graduate and undergraduate students along with enabling plans and approaches (§II.B.2.a). Provide for global exchange of education and training including cyberinfrastructure and interaction with the NCN.

(4.d.2) Pre-college (and Community College - optional) Education: Provide the ERC's pre-college education program goals and strategies for engagement and partnership (§II.B.2.b). Provide information on the school districts and/or individual schools that will partner with the ERC. Discuss the roles of the ERC's faculty and students and of the pre-college institutions administrators, teachers, and students. It is expected that this education plan will include evidence based engineering experiences to engage teachers and students.

(4.d.3) University and Pre-college Education Program Assessment: Present the assessment plan to monitor progress and impacts of the EWD Programs to make improvements through time and assess their long-term impacts (§II.B.2.c). (Note: Because of this type of process, Institutional Review Board (IRB) approval for research involving human subjects will have to be obtained.)

(4.d.4) Dissemination: Both the university and pre-college programs will disseminate EWD program outcomes and curriculum/outreach products to the participating partner and outreach institutions and as materials for workforce training. If a NERC or an open topic ERC develops nanoscale education simulation tools suitable for hosting on the cyber platform (http://www.nanohub.org/) of the Network for Computational Nanotechnology (NCN), those tools will be delivered to the NCN, where a broader community will have access to them in an open source mode for educational purposes. If applicable to the proposed ERC, include these plans in the proposal.

4.e. Innovation Ecosystem Development - Industrial/Practitioner Members and Innovation Program Broader Impact.

Provide the ERC's innovation ecosystem strategic plan and goals for industrial/practitioner memberships and involvement; technology transfer to member and non-member firms; university and state and local government facilitators of entrepreneurship and innovation; and translational research (§II.B.3).

Provide a visualization of how the proposed member firms align to the value chain relevant to the proposed Center vision. That is, as the Center research program evolves, note at which points in time in the ERC program development over the 10-year period of NSF funding the different types of firms would engage with the Center to enable success. Some firms may be engaged for the entire 10 years, and some may be involved with focused research activities at critical points in time (e.g., test bed development).

Discuss integration of the IPAB (§II.B.3.b.1) in governance processes of the ERC, including the specific roles. 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 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. Do not include letters from those only interested in a partnership.

Discuss integration of other stakeholders (§II.B.3.b.2) into governance and operation of the ERC. Include a letter from each stakeholder that identifies their commitment to promote entrepreneurship, nurture start-up firms, etc. to accelerate innovation in partnership with the ERC in Supplementary Documents.

Describe the management of ERC intellectual property (IP) across the lead and partner institutions and the approaches to be taken to enable licensing of Center IP and/or adopting of other Center outcomes. This plan must discuss management of conflicts-of-interest of ERC researchers and technology transfer. Include a draft membership agreement in the Supplementary Documents section. Indicate that the draft agreement has been reviewed by the lead and partner universities and discussed with representative industrial/practitioner firms committed to membership.

Discuss the ERC's key terms of the planned IP policy for: (1) IPAB members, (2) sponsored research projects funded by IPAB members and by non-members, and (3) translational research. A chart, ERC IP Process Flow Chart, that depicts the decision points in the technology transfer, sponsored research, and translational research process can be found on the ERC Association Website at http://www.erc-assoc.org/content/templates-proposal-preparation-0. The proposal will not include a draft IP policy; rather, if an award is made, the IP policy is expected to be fully prepared within 90 days of the award.

4.f. Infrastructure.

(4.f.1) Institutional Configuration: Justify the institutional configuration given the vision. Discuss the value added by each domestic partner university in research, education, and innovation. For minority-serving domestic partner universities, present the demographic data of the underrepresented groups enrolled in, and graduating from, an engineering discipline. Finally, discuss the value added by partnerships with domestic affiliated faculty and any foreign collaboration that might be in place at proposal submission or planned for year one.

(4.f.2) Team Composition: Briefly discuss the composition and roles of each leadership team member. Provide a pie chart summarizing the disciplinary composition of the faculty team, based on his/her departmental affiliations or degrees, as appropriate for each person.

(4.f.3) Diversity and Culture of Inclusion: Provide the ERC's vision and strategic plan to develop a culture of inclusivity. Provide a table that inventories diversity-related programs and offices and diversity awards at each of the partner institutions. Describe in the plan how the ERC will work with those programs, offices, and awardees identified as partners and leverage their resources/infrastructure to create a culture of inclusion.

Include a table (format below) showing the diversity of the ERC Leadership Team who are U.S. citizens and Permanent Residents from lead and university-level domestic partner institutions, relative to the entire leadership team of the proposed ERC. Note: NSF is committed to providing equal opportunities for participation in its programs and promoting the full use of the Nation's research and engineering resources. To aid in meeting these objectives, NSF requests information on the gender, race, ethnicity and disability status of individuals named as PIs / co-PIs on proposals and awards. Submission of the information on this table is voluntary.

ERC Name	Total No. *	Males	Females	African Americans	Native American, Pacific islanders	Hispanic Americans	Persons with Disabilities **
Leadership Team							
Thrust Leaders							
Faculty							
Totals							

***** It is understood that the total will equal the total of males and females who are U.S. citizens or Permanent Residents of the U.S., and the totals for racial and ethnic minorities and persons with disabilities will be larger than that total due to double counting.

****** A person with a disability is someone who has one or more impairments that affect substantially one or more activities of daily living, and the impairment(s) is/are not completely correctable with assistive devices.

At the proposal stage which students will be involved in the ERC is not clear; therefore, do not include students in the data. Also, do not include data for the following: foreign nationals, non-tenure-track faculty, research staff, post-doctoral students,

technicians, office staff, or pre-college teachers or students.

(4.f.4) Mentoring: Provide information on how the untenured faculty, students and postdoctoral researchers will be mentored for success. Indicate in this section and the university commitment letters how the university faculty and students shall be rewarded for their educational/mentoring efforts by the university administrations involved. If the ERC budget supports postdoctoral researcher(s), a separate Postdoctoral Mentoring Statement must be included in the Supplementary Documents Section of the proposal, or the proposal will be returned without review. Refer to the PAPPG for additional information.

(4.f.5) Organizational Structure and Management System: Describe the proposed organizational structure including information on how the members from participating universities and pre-college institutions will be developed into an integrated team. Include an organization chart for the ERC. Discuss the roles of the members of the ERC's Leadership Team and the boards and councils. Describe the management systems in sufficient detail to allow critical evaluation. Ensure that annual competitive project selection supports critical strategic plan elements, involves the Stakeholder community, and incorporates and annual SWOT analyses by IPAB and SLC.

Note that potential IPAB members may be contacted to determine their willingness to join as members and to obtain their input on the proposal. However, **the SAB must not be formed and potential members of the SAB must not be contacted during the proposal preparation and review stages,** as this compromises the review process (i.e., presents conflicts of interest).

(*4.f.6) 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://www.erc-assoc.org/content/templates-proposal-preparation-0.

This section of the proposal must also include a table showing the committed levels of support for the first year from IPAB member firms/agencies 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://www.erc-assoc.org/content/templates-proposal-preparation-0

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.

(4.f.7) Facilities, Equipment, Safety, and Headquarters Infrastructure: Briefly discuss the laboratories, facilities, and equipment for the ERC, particularly those shared by ERC team members. See the required section on "Facilities, Equipment and Other Resources" in the FastLane proposal template for more detail. Distinguish existing facilities and equipment from any that will be acquired by the Center. Space must be identified on the campus of the lead academic institution for ERC headquarters. Describe its size, functionality, and features. Discuss how the facilities and equipment of the ERC and the cyberinfrastructure will be used to form a collaborative team with shared resources and information.

Include a brief discussion of procedures in place for the ERC's laboratories/facilities to assure safe research practices, especially when the ERC involves the use of recombinant moieties, toxic or dangerous chemicals, high pressure, and/or other dangerous materials or equipment. Safety policies can be included in "Supplementary Documents," Sec. V.A (10.e), as appropriate.

(4.f.8) Institutional Commitment: Discuss the commitment of the lead and partner institutions (universities, pre-college partners, any community/technical college partners, and innovation facilitation partners) to the research, education, diversity and innovation goals of the proposed ERC. Discuss how these institutions / organizations will assure that their policies and practices will support the Center in achieving its goals. Include a discussion of tenure and mentoring policies in light of the cross-disciplinary structure of the ERC and its mission to go beyond a traditional research culture: integrating research and education, stimulating collaboration with industry, patenting IP, and innovating technologies. Do not discuss cost sharing in this section.

(Note: This is the end of the requirements for Sec. (4) Project Description Section.)

5. **References Cited**. Follow PAPPG guidance, and cite those references most relevant to the goals of the center.
6. **Biographical Sketches** (two-page limit per person). The basic PAPPG guidelines for preparation of biographical material apply. Biographical sketches are required of all the faculty and key staff participants (e.g., the Center Director, Deputy Director (or Executive Director), the University Education Director, the Pre-College Education Director, Industrial Collaboration and Innovation Director (if known), the Research Thrust Leaders, the Diversity Director, the Administrative Director (if known), and faculty expected to receive support in years one through five from the ERC. For faculty, products listed should be those most highly relevant to the proposal.
7. **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 annual ERC meetings: ERC biennial meeting alternating with cross-ERC leadership team retreats. 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 Program improvements. The purpose of the retreats is to focus on issues 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 will be appended to the cost sharing tables that are submitted in the single-copy document section of the proposal. If additional space is required for the budget justification, put the information in the "Supplementary Documents" section of the proposal. Then, in the budget justification section, direct reviewers to the "Supplementary Documents" section of the proposal for the additional justification.

Cost sharing is mandatory and is specialized. Please see Section V.B. for additional information.

8. **Current and Pending Support**. Include only for the Center Director, Deputy Director, and Research Thrust Leaders, and other faculty expected to receive support in the first five years from the ERC.
9. **Facilities, Equipment and Other Resources.** Follow PAPPG guidance.
10. **Supplementary Documents.** Provide supplemental documents as instructed in the PAPPG. The following items are to be provided as additional supplemental documents.

    10.a. Letters of Commitment. Submit the following letters as indicated:

    - Lead university: Senior university administrators (Dean of Engineering and 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 how tenure and promotion policies will support the ERC, commit to the ERC's diversity and mentoring plans, assure the safety of laboratories where ERC students and faculty work, and assure the development of a cross-Center IP policy within 90 days, if an award is made.
    - Each Partner University: A senior administrator (Dean of Engineering) attests to each item as in the lead university letter, above, except for a commitment to headquarters space.
    - Partner university organization and/or state or local government agencies committed to partnership with the ERC to facilitate its impact on entrepreneurship, innovation, job creation, and local economic development.
    - Administrator of each proposed pre-college or community college partners committing to their roles in the ERC as discussed in the pre-college education guidance section above.
    - Officials of firms and agencies able to commit to membership.
    - Officials from any participating federal laboratories indicating their involvement in the ERC and their commitment to provide financial support for their staff participating in 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, if the projects are planned to be in place during years one through five.

    The letters of commitment should be addressed to:

    Dr. D. Keith Roper, Leader of the ERC Program
    Division of Engineering Education and Centers
    National Science Foundation
    4201 Wilson Boulevard, Suite 585
    Arlington VA 22230

    All letters must be placed in the Supplementary Documents section of the FastLane proposal or the Grants.gov proposal and submitted electronically, as part of the proposal. If submitting through Grants.gov, refer to the NSF Grants.gov Application Guide. Please instruct the authors of these letters not to mail, email, or fax copies to the NSF.

    10.b. Draft Membership Agreement. Upload the draft membership agreement in "Supplemental Documents".

    10.c. Postdoctoral Mentoring Plan. Provide a mentoring plan for post docs who will be supported by ERC funds. See the PAPPG for more guidance.

    10.d. 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.

    10.e. Laboratory Safety Policy. As appropriate, per Sec. V.A (4.f.7), provide the policy that will be used to ensure standard laboratory safety practices throughout the ERC lead and partner institutions.

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

    11.a. 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 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 or not to use the suggestions remains with the Program Officer.

    11.b. 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://www.erc-assoc.org/, under the button marked "Funding Opportunities (second bullet)." 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 to be provided to reviewers.** Refer to section B. Budgetary Information and Cost Sharing in this solicitation for information on cost sharing requirements and policies.

12. **Post Proposal Submission to NSF: Other Required Documents -**

    12.a. Email Correspondence: On receipt of the proposal number after submission, send an email to ercintent@nsf.gov. The subject heading of the email should note the proposal number and the lead institution. Attach the table of participants containing conflict of interest information as instructed above.

    12.b. Proposal Update: If the proposal is site visited, a 10-page proposal update that integrates changes in the proposal

resulting from reviewer input, including 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 partner universities)	Yes
Industrial/Practitioner member cash and in-kind support	Yes
Identification of funded faculty/staff members from the lead and university-level partner institutions	Years 1-5
Names of participating pre-college institutions	Yes
Names of pre-college teachers	No
Names of participating innovation facilitation partner(s), i.e. university, and/or state and local government organizations devoted to entrepreneurship, stimulating innovation, etc.	Yes
Names of firms/practitioner organizations committed to membership in the ERC	Yes
Letter of Intent (LOI) must be submitted through FastLane	Yes
Full Proposals can be submitted through FastLane or Grants.gov (see solicitation for instructions)	Yes
Draft membership agreement	Yes
Draft IP policy	No
Letter of commitment from the Dean of Engineering and one other higher level administrator, including a commitment to headquarters space in each letter	Yes - (but no cost sharing identified in letters)
Letters of commitment from the partner universities' Deans of Engineering and one other higher level administrator (per institution) (no letters are required from administrators from universities contributing affiliated faculty)	Yes - (but no cost sharing identified in letters)
Letter of commitment from domestic faculty from affiliated universities, if the project(s) will be supported in years one through five	Required only if there are these types of collaborations proposed
Letters of commitment from foreign faculty collaborators if the project(s) will be in place in year one.	Required only if there are these types of collaborations are identified for year one
Letters of commitment from administrators of federal laboratories contributing support for staff to carry out research and other roles in the ERC, attesting to laboratory support for that staff time	Required only if there are these types of collaborations proposed
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
Letters from firms/agencies/hospitals only interested but not committed to joining the ERC	No
Letters of commitment to partnership from pre-college partner administrators (school district or individual schools) committing to the RET, Young Scholars and student participation programs and to including engineering in pre-college education	Yes
Letters of commitment from community college administrators	Only if included in the ERC
Letters of commitment from state or local government agency or state governor providing non-member financial support to the ERC	This type of support is not required but if it is proposed, a letter of commitment is required
Letters of commitment from innovation facilitation partner(s), i.e. university, and/or state and local government organizations devoted to entrepreneurship, stimulating innovation, etc.	Yes
Pie Chart/Table of Year 1 Planned Distribution of NSF Funds	In the "Financial Support and Functional Allocation of Resources" section of the Project Description
Functional Budget Table	Included in Project Description
Year 1 Committed Industrial and Other Non-NSF, Non-Academic Support table	Included in the Project Description
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.	Submitted in the "Single-Copy Documents" section

B. Budgetary Information

Cost Sharing:

Cost Sharing is required.

NOTE: Cost Sharing is required for Invited Full Proposals

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 subcontracts to the domestic partner institutions and any affiliated institutions whose faculty and would be supported by the ERC's budget. The budget for year one may be no more than $3,500,000, no more than $3,750,000 for year two, no more than $4,000,000 for year three, no more than $4,250,000 for year four, and no more than $4,250,000 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:

Pursuant to the National Science Board's (NSB's) Recommendation 5 (as stated in NSB 09 -20) mandatory cost sharing for the NSF Engineering Research Centers (ERC) Program has been reinstated, since cost sharing is foundational to the strategic programmatic goals of the ERC Program.

Cost sharing is required of the lead university and core domestic partner university(ies) to support and sustain the ERC. Cost sharing is not a review criterion for ERCs; it is an eligibility criterion. Because cost sharing is not a review criterion, details on cost sharing will not be shared with reviewers. Institutions that provide affiliated faculty, pre-college partners, and university, state and local government organizations devoted to entrepreneurship and innovation do not cost share.

Upon issuance of the award, the lead university is responsible to secure, retain, manage, certify, and deliver 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 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 revised cost sharing principles. 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 §V.A.10.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/templates-proposal-preparation-0. 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 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 (very high research activity) - required cost sharing level is 20% of the allocation of the NSF budget to the lead or partner university;
- RU/H: Research Universities (high research activity) - required cost sharing level is 15% of the allocation of the NSF budget to the lead or partner university;
- DRU: Doctoral/Research Universities - cost sharing level is 10% of the allocation of the NSF budget to that partner university;
- Master's L: Master's Colleges and Universities (larger programs) - cost sharing level is 10% of the allocation of the NSF budget to that partner university/college;
- Bac/Diverse: Baccalaureate Colleges--Diverse Fields - cost sharing level is 5% of the allocation of the NSF budget to that 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.

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 Center-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, 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):

  September 25, 2015

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

  October 23, 2015

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

  June 16, 2016

D. FastLane / Grants.gov Requirements

For Proposals Submitted Via FastLane:

To prepare and submit a proposal via FastLane, see detailed technical instructions available at: https://www.fastlane.nsf.gov/a1/newstan.htm. For FastLane user support, call the FastLane Help Desk at 1-800-673-6188 or e-mail fastlane@nsf.gov. The FastLane Help Desk answers general technical questions related to the use of the FastLane system. 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: http://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 are strongly encouraged to use FastLane 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 *Investing in Science, Engineering, and Education for the Nation's Future: NSF Strategic Plan for 2014-2018*. 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 Proposals

- **Infrastructure** (Leadership): Among the PI and four co-PIs there must be identified individual(s) with deep expertise in fundamental science/engineering discovery, workforce development, and innovation.
- **Research**:
    - Vision - The proposed ERC must integrate fundamental science and engineering discovery with technological innovation to transform national prosperity, health, and/or security. An engineered systems approach (§II.B.1.a) must be used. Potential for transformative impact (§II.B.1.c) from emerging discoveries must be clear.
    - Strategic Plan - The strategic plan must leverage recent breakthroughs for high impact. It must include a 3-plane strategic plan chart. It must exhibit context, critical path, resources, and adaptiveness (§II.B.1.d).
    - Scope - Research at fundamental and technological levels must be integrated to advance toward proofs-of-concept in system testbeds. Potential impact as well as synergy, partnership, and system at scale must be shown (§II.B.1.e).
- **Engineering Workforce Development** (Education): A literature-based, inclusive approach to workforce development must be outlined, including strategies for curricular impact, skill sets, global reach, and assessment.
- **Innovation Ecosystem Development**: Plans for strategic configuration of stakeholders (industry, practitioners, regulatory, and non-profits) and innovation frameworks must be outlined.

Invited Full Proposals **-** The review criteria from the pre-proposal apply. In addition, review criteria for ERC proposals are as follows:

- **Research**
    - Strategic Plan - In addition to requirements in for preliminary proposals, the strategic research plan must include a ten-year milestone strategic chart and components (described in §V.A.4.c.1). Integration with NCN is required, as appropriate.
    - Research Efforts - In-depth descriptions of each research thrust must include impact, goals, benchmarks vs. state-of-the-art, barriers addressed, list of interdisciplinary participating personnel, and exemplar projects(§V.A.4.c.2). System test beds must guide thrust research as outlined in a 3-plane chart.
- **Engineering Workforce Development**
    - Strategic Plan - The strategic education plan must coordinate plans for university and pre-college education with research and cultivation of a culture of inclusion to accomplish ERC goals (§V.A.4.d.1).
    - Approach - The approach must be evidence-based, feature a strategic plan, curricular impact, global exchange, and skill sets, and have engagement and partnership characterizing pre-college education.
    - Assessment and Dissemination - Plans for assessment (§V.A.4.d.3) and dissemination (§V.A.4.d.4) must be comprehensive.
- **Innovation Ecosystem Development**

- Strategic Plan - The plans must identify a sector-specific alliance of stakeholders to realize the vision with potential to achieve scale-able, sustainable results (as outlined in §V.A.4.e). The value of the ERC to dues-paying IPAB members must be enunciated.
- Stakeholder Community - The required university partners and affiliates, industry partners, government /non-profit practitioners, associations (industry, professional, or public), and end users must be identified including their respective roles.
- Innovation frameworks - A membership agreement must be drafted. Processes to manage interactions with boards and councils, IP, and conflicts of interest must be proposed.

- **Infrastructure**
  - Leadership team - Capable and diverse Center leadership are identified to support the ERC vision.
  - Organization and management - There must be clear, executable management systems to organize and integrate resources and components across partner institutions; and regular guidance from advisory boards and councils into decision-making.
  - Culture of inclusion - Plans for a culture of inclusion must be integral to research, education and innovation activities. All partner institutions must be committed to mentoring at all levels, education, and innovation.
  - Institutional commitment - Core and partner institutions are committed to each element of the ERC program. In particular:
    - Levels of committed industrial/practitioner financial and in-kind support is commensurate with typical levels of support for academic research in the fields involved in the ERC
    - Capital (i.e., facilities, equipment, cyberinfrastructure) and procedural (i.e., safety, environmental) resources are either in place or their realization has been secured.
  - Data Sharing - Appropriate policies are in place for universities receiving ERC funds to share findings, data and other research products.

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.

Proposals submitted in response to this solicitation will need to address the following overarching questions:

- *What is the compelling new idea and how does it relate to national needs?*
- *Why is a center necessary to tackle the idea?*
- *How will the ERC's infrastructure integrate and implement research, workforce development and innovation ecosystem development efforts to achieve its vision?*

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) 292-7827 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:

- Junhong Chen, telephone: (703) 292-4623, email: junchen@nsf.gov
- Deborah Jackson, telephone: (703) 292-7499, email: djackson@nsf.gov
- Erick Jones, telephone: (703) 292-4606, email: ejones@nsf.gov
- Eduardo A. Misawa, telephone: (703) 292-5353, email: emisawa@nsf.gov

For questions related to the use of FastLane, contact:

- FastLane Help Desk, telephone: 1-800-673-6188; e-mail: fastlane@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 http://www.grants.gov.

ABOUT THE NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) is an independent Federal agency created by the National Science Foundation Act of 1950, as amended (42 USC 1861-75). The Act states the purpose of the NSF is "to promote the progress of science; [and] to advance the national health, prosperity, and welfare by supporting research and education in all fields of science and engineering."

NSF funds research and education in most fields of science and engineering. It does this through grants and cooperative agreements to more than 2,000 colleges, universities, K-12 school systems, businesses, informal science organizations and other research organizations throughout the US. The Foundation accounts for about one-fourth of Federal support to academic institutions for basic research.

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 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 Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004), and NSF-51, "Reviewer/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004). Submission of the information is voluntary. Failure to provide full and complete information, however, may reduce the possibility of receiving an award.

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