

Quantum Leap Challenge Institutes (QLCI)

PROGRAM SOLICITATION

NSF 19-559



National Science Foundation

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

April 01, 2019

Letters of Intent for Conceptualization Grant proposals.

June 03, 2019

Letters of Intent for Round I QLCI proposals.

August 03, 2020

Letters of Intent for Round II QLCI proposals.

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

August 01, 2019

Preliminary proposals for Round I QLCI proposals.

September 01, 2020

Preliminary proposals for Round II QLCI proposals.

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

June 03, 2019

Conceptualization Grant proposals.

January 02, 2020

Round I QLCI full proposals (by invitation only).

February 01, 2021

Round II QLCI full proposals (by invitation only).

IMPORTANT INFORMATION AND REVISION NOTES

Proposal Due Dates:

Round I (CG and CI proposals):	
Letters of Intent for CG proposals due	Apr 1, 2019
CG proposals due	June 3, 2019
Letters of Intent for CI preliminary proposals (Round I) due	June 3, 2019
CI preliminary proposals (Round I) due	Aug 1, 2019
CI full proposals (by invitation only) due	Jan 2, 2020
Round II (CI proposals only):	
Letters of Intent for CI preliminary proposals (Round II) due	Aug 3, 2020

CI preliminary proposals (Round II) due	Sep 1, 2020
CI full proposals (by invitation only) due	Feb 1, 2021

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) ([NSF 19-1](#)).

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Quantum Leap Challenge Institutes (QLCI)

Synopsis of Program:

Quantum Leap Challenge Institutes are large-scale interdisciplinary research projects that aim to advance the frontiers of quantum information science and engineering. Research at these Institutes will span the focus areas of quantum computation, quantum communication, quantum simulation and/or quantum sensing. The institutes are expected to foster multidisciplinary approaches to specific scientific, technological, educational workforce development goals in these fields. Two types of awards will be supported under this program: (i) 12-month Conceptualization Grants (CGs) to support teams envisioning subsequent Institute proposals and (ii) 5-year Challenge Institute (CI) awards to establish and operate Quantum Leap Challenge Institutes. This activity is part of the Quantum Leap, one of the research Big Ideas promoted by the National Science Foundation (NSF). The NSF Quantum Leap Challenge Institutes program is consistent with the scope of *NSF multidisciplinary centers for quantum research and education* as described in the National Quantum Initiative Act ¹.

In 2016, the NSF unveiled a set of "Big Ideas," ten bold, long-term research and process ideas that identify areas for future investment at the frontiers of science and engineering (see https://www.nsf.gov/news/special_reports/big_ideas/index.jsp). The Big Ideas represent unique opportunities to position our nation at the cutting edge of global science and engineering leadership by bringing together diverse disciplinary perspectives to support convergence research. Although proposals responding to this solicitation must be submitted to the Office of Multidisciplinary Activities (OMA) in the Directorate of Mathematical and Physical Sciences (MPS), they will subsequently be managed by a cross-disciplinary team of NSF Program Directors.

¹ *National Quantum Initiative Act*, H.R. 6227, December 21, 2018.

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.

- Quantum Leap Challenge Institutes, telephone: (703) 292-4861, email: QLCI@nsf.gov

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

- 47.041 --- Engineering
- 47.049 --- Mathematical and Physical Sciences
- 47.050 --- Geosciences
- 47.070 --- Computer and Information Science and Engineering
- 47.074 --- Biological Sciences
- 47.075 --- Social Behavioral and Economic Sciences
- 47.076 --- Education and Human Resources
- 47.079 --- Office of International Science and Engineering
- 47.083 --- Office of Integrative Activities (OIA)

Award Information

Anticipated Type of Award: Standard Grant or Cooperative Agreement

Estimated Number of Awards: 1 to 28

An estimated 15 to 25 Conceptualization Grants (CG) will be awarded. An estimated 1 to 3 Challenge Institute (CI) awards will be granted in each of the two competition rounds.

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

Anticipated Funding Amount: \$94,000,000

The QLCI program will support two types of awards:

- Conceptualization Grants (CGs) funded at a level of \$100,000 - \$150,000 for 12 months.
- Challenge Institute (CI) awards funded at a level of up to \$5,000,000/year for 5 years.

Eligibility Information

Who May Submit Proposals:

Proposals may only be submitted by the following:

- Institutions of Higher Education (IHEs) - Two- and four-year IHEs (including community colleges) accredited in, and having a campus located in the US, acting on behalf of their faculty members. Special Instructions for International Branch Campuses of US IHEs: If the proposal includes funding to be provided to an international branch campus of a US institution of higher education (including through use of subawards and consultant arrangements), the proposer must explain the benefit(s) to the project of performance at the international branch campus and justify why the project activities cannot be performed at the US campus.
- Non-profit, non-academic organizations: Independent museums, observatories, research labs, professional societies and similar organizations in the U.S. associated with educational or research activities.

Who May Serve as PI:

There are no restrictions or limits.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

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

Conceptualization Grant (CG) proposals: An individual may serve as PI, co-PI, or other senior personnel on no more than **two** CG proposals. In cases where an individual appears in more than two CG proposals, only the first two submitted CG proposals will be accepted; all other CG proposals involving that individual will be returned without review.

Challenge Institute (CI) proposals: An individual may serve as PI, co-PI, or other senior personnel on no more than **one** CI preliminary proposal (or CI full proposal). In cases where an individual appears in more than one CI preliminary proposal (or full proposal), only the first submitted CI preliminary/full proposal will be accepted; all other CI preliminary/full proposals involving that individual will be returned without review.

Note: The QLCI program will be conducted in two rounds. In Round 1, both CG and CI proposals will be accepted. Prospective teams may submit either a CG or a CI proposal, but not both, in Round 1.

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:**

Inclusion of voluntary committed cost sharing is prohibited.
- **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):
 - April 01, 2019
 - Letters of Intent for Conceptualization Grant proposals.
 - June 03, 2019
 - Letters of Intent for Round I QLCI proposals.
 - August 03, 2020
 - Letters of Intent for Round II QLCI proposals.
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 - Conceptualization Grant proposals.
 - January 02, 2020
 - Round I QLCI full proposals (by invitation only).
 - February 01, 2021
 - Round II QLCI full proposals (by invitation only).

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:

Additional award conditions apply. Please see the full text of this solicitation for further information.

Reporting Requirements:

Standard NSF reporting requirements apply.

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I. INTRODUCTION

Quantum information science and engineering utilizes profound aspects of quantum physics such as superposition, interference and entanglement to develop revolutionary approaches for information processing². Such approaches include quantum computation, quantum communication, quantum simulation and quantum sensing. These rapidly developing fields have been bolstered by recent discoveries and breakthroughs. However, several foundational and technological challenges must be overcome before the full potential of quantum information science and engineering can be realized. This is the motivation for the Challenge Institutes.

The goal of the Quantum Leap Challenge Institute (QLCI) program is to support timely and bold research agendas aimed at making breakthroughs on clearly identified and compelling challenges within a 5-year period. Quantum Leap Challenge Institutes are expected to: engage an intellectually-diverse community in the pursuit of identified challenges; develop cohesive, collaborative and national-scale approaches to research in quantum information science and engineering; and enable the development of a well-trained workforce with strong cross-disciplinary skill sets needed for quantum information science and engineering.

Now is an opportune time to assemble Challenge Institutes due to several recent advances in the state of the art. For example, several prototype platforms for quantum simulation, quantum computation and secure quantum communication now exist. These developments mark a new era that builds on foundational quantum computing theory and quantum cryptography breakthroughs of the 1980s, the discovery of quantum error correcting codes and many quantum algorithms in the 1990s and the development of several technology platforms for realizing qubits and quantum gates in the 2000's. Recent advances herald new scientific and technological opportunities that were beyond reach ten years ago. These developments also make clear the need to solve several scientific and technological grand challenges. New research and development efforts are being introduced around the globe to explore the opportunities and challenges. Thus, the time is ripe for Challenge Institutes to stimulate and accelerate research, discovery and innovation in the United States.

The Quantum Leap initiative augments a wide range of NSF investments in quantum information science and engineering. These efforts, combined with activities supported by other entities, including other government agencies and industry, indicate that the community of quantum information scientists and engineers is well-positioned to collaboratively identify challenges whose solution will catalyze breakthroughs. The QLCI program is intended to strengthen such cross-disciplinary research efforts, forge new partnerships between universities, non-profit organizations, industry, and government agencies and thus accelerate foundational discoveries, innovations and technological developments. The scope of the Quantum Leap Challenge Institutes is aligned with that of *NSF multidisciplinary centers for quantum research and education* as described in the National Quantum Initiative Act³. The Quantum Leap Challenge Institutes are expected to foster multiple research approaches, integrating expertise from domains such as physics, materials science, engineering, mathematics, chemistry, computer science and biology. The Challenge Institutes, in collaboration with industry and other research institutions, are also expected to develop new cross-disciplinary approaches for education, training and workforce development. Combining these elements, the Quantum Leap Challenge Institutes will promote a sustainable innovation ecosystem where expertise from various disciplines, research institutions, and industry can be leveraged, as needed, to overcome scientific, technological, and workforce challenges in quantum information science and engineering. The multidisciplinary scope of quantum information science and engineering, in turn, holds promise for the development of radically new and more powerful scientific and technological tools that will open new science and engineering vistas.

² *National Strategic Overview for Quantum Information Science*, National Science and Technology Council, September 2018.

³ *National Quantum Initiative Act*, H.R. 6227, December 21, 2018.

II. PROGRAM DESCRIPTION

The Quantum Leap Challenge Institute (QLCI) program will fund Institutes comprised of multidisciplinary groups of scientists and engineers united by a common challenge theme for advancing the research frontiers in quantum communication, quantum computation, quantum simulation and/or quantum sensing. The Challenge Institutes will also facilitate and stimulate the development of a well-trained workforce through cross-disciplinary and collaborative basic research, project-driven training and innovative curricula. The QLCI program is expected to facilitate research, training and education through exposure of trainees to theoretical frameworks, algorithmic techniques and experimental platforms and testbeds, as well as interaction with national laboratories, industry and international partners. The Challenge Institutes will build on significant recent NSF investments in quantum information science and engineering and are expected to coordinate and integrate with ongoing and new NSF Quantum Leap initiatives, including center-scale, infrastructure

and workforce development activities.

The salient **Characteristics of an Institute** and the **Major Activities** performed by an Institute are next described in Sections II.A and II.B.

A. Characteristics of a Quantum Leap Challenge Institute

The QLCI program will support institutes based at universities or eligible non-profit organizations to foster major breakthroughs in critical areas at the intellectual and technological frontiers of quantum information science and engineering using a multidisciplinary approach. Since the QLCI program is designed to foster research at the intellectual frontiers, new types of joint efforts may be needed to address the most promising challenges. Therefore, Challenge Institutes may vary in size and exhibit various forms of organization, collaboration and operation suited to their individual needs.

Each Institute will have a Director who takes overall responsibility for the effort and provides leadership to develop and lead a diverse interdisciplinary team to fulfill the vision of the Institute. There must be a strategic plan that reflects the overall vision of the Institute and describes the key elements of the proposed major activities spanning research, education and workforce development, research coordination and partnerships and infrastructure development. There must be a management and governance plan to indicate how the institute will operate. The plan must contain information on the overall management and reporting structure, how research projects are chosen, the existence and makeup of any advisory board(s) and the Principal Investigators responsible for different parts of the institute's research, education and workforce development activities.

Given the rapidly evolving nature of quantum information science and engineering, the Challenge Institutes are expected to have the ability and mechanisms in place to change course, when warranted, to address the changing research and technological needs within the context of the Institute. This may include the exit of certain PIs and organizations and on-boarding of new PIs and organizations.

Through the major activities discussed below, competitive QLCI proposals will demonstrate:

- **Challenge Research Theme and Cross-Disciplinary Vision:** A long-term vision and a clearly defined and well-motivated challenge research theme for advancing the frontiers of quantum information science and engineering through cross-disciplinary collaborations in basic science and engineering.
- **Compelling Goals and Milestones:** Clear and compelling science-, algorithm- and engineering-driven goals, with specific target milestones for a five-year period of performance.
- **Convergent Research and Community Engagement:** Activities to catalyze the identification, formation and nurturing of diverse and well-integrated research communities for advancing the Institutes vision.
- **Education and Workforce Development:** Innovative and substantive activities to enhance outreach and education, cross-disciplinary training, curriculum development and mentoring for a quantum-smart workforce.
- **Partnerships and Infrastructure Development:** Collaborative arrangements and development of shared infrastructure with other universities and colleges, national laboratories, private sector research laboratories, industrial partners, non-profit organizations, state and local government laboratories, and international partners, in pursuit of the Institutes vision and goals.
- **Value-Added Synergy:** Justification showing how the collective effort of researchers from different disciplines will enable transformative advances in quantum information science and engineering and technological innovation in service to the community and the nation.

B. Major Activities

Each Challenge Institute is expected to carry out its mission through major activities in four areas: 1) Cross-Disciplinary Research, 2) Education and Workforce Development, 3) Research Coordination and 4) Synergistic Partnerships and Infrastructure Development.

1. Research

The foundational understanding of various architectures, technology and hardware platforms and applications for quantum information science and engineering spans a range of maturity levels. Thus, the corresponding nature of research challenges and resources needed to address them may be different. In some cases, there may be a single unifying challenge and in other cases there may be several related challenges that may be addressed under a common intellectual and programmatic umbrella. Suggested research themes for a Challenge Institute include but are not limited to: a) Quantum Communication, b) Quantum Computation, c) Quantum Simulation and d) Quantum Sensing. The focus of a Challenge Institute may be on one theme area, or it may involve topics in multiple theme areas; e.g. quantum computation and simulation, or quantum sensing and communication. Regardless of the focus, the overall unifying challenge research theme for the Institute must be clearly articulated and justified.

a) Quantum Networks for Secure Long-Range Communication

Long-haul and secure quantum communication could be an organizing theme for a Challenge Institute. Development of components such as quantum sources, detectors, memories and repeaters, along with networking protocols for generation, swapping, distillation and verification of entanglement all present formidable challenges. Losses, noise, decoherence and other technical challenges, such as operation at room temperature, may be overcome with the development of new concepts, materials, devices and techniques and algorithms for generation and processing of quantum signals. Achieving a vision, for example, of a global fully secure quantum communication network will require foundational advances and technological innovation in multiple areas, involving both theorists and experimentalists, for the design and development of prototypes and scalable platforms. Furthermore, co-designing platforms and testbeds to accomplish system-level goals for power, bandwidth, security, stability and scalability may benefit from whole new approaches founded on a convergence of engineering, computer science, mathematics, materials science and physics. Fostering such convergence in a Challenge Institute may provide additional benefits, e.g., revolutionary chip-scale photonics platforms that support a range of wavelengths, operational temperature and rates to enable new applications, such as distributed quantum sensing and computing.

b) Software Stacks for Quantum Computers

The challenge to conceptualize, develop and implement a complete set of software solutions necessary for creating an efficient and usable quantum computer is a potential theme for a Challenge Institute. Development of algorithms, compilers, languages and programming solutions in conjunction with hardware platforms, architectures and circuits that are currently or soon-to-be available,

including noisy intermediate scale quantum computing technologies, presents a myriad of scientific and engineering challenges. Development of appropriate abstractions for different technology platforms, programming languages and algorithms for different applications, benchmarking, validation, error correction techniques and fault tolerant hardware platforms and architectures are among the technical challenges. Furthermore, the formulation and identification of problems that are valuable to solve on near-term quantum computers may require a bold cross-disciplinary research program spanning computer science and engineering, mathematics and electrical engineering and domain areas such as chemistry, materials science, and physics. The collection of scientists and engineers at a Challenge Institute may also catalyze the development of new concepts, frameworks and interfaces for utilizing quantum co-processing, distributed quantum computation and cloud-based quantum computing. These efforts, in turn, will enable a wider research community to benefit from quantum computing platforms and thus further accelerate innovation.

c) Algorithms, Architectures and Platforms for Quantum Simulation

Developing algorithms, architectures and platforms for quantum simulators is another potential organizing theme for a Challenge Institute. Efforts to emulate molecules, materials, or nuclear matter with other more-controllable quantum systems such as trapped ions, superconducting circuits, or neutral atoms have identified many foundational challenges. Digital approaches using algorithms for quantum circuits with qubits and quantum gates and analog approaches to Hamiltonian engineering or emulation, as well as hybrid approaches, are all of interest. In each case, challenges include developing simulator architectures, mapping one system to another, initializing quantum states, engineering interactions for controlled evolution of quantum states, suppressing decoherence and measuring results. Moreover, interpreting results and pioneering new applications for quantum simulators may benefit from collaborations involving experts from chemistry, biology, materials science, physics, mathematics, computer science and engineering. Fostering such convergence in a Challenge Institute could provide additional insights, such as a deeper understanding of how entropy, topology, entanglement, imperfections, noise and environmental reservoirs affect the dynamics of strongly-interacting many-body quantum systems. Quantum simulation may also offer transformative ways to study novel states of matter with exotic forms of magnetism or superconductivity and to discover possible new applications, for example, in metrology.

d) Quantum Sensing

Metrology and sensor technology based on quantum systems could be another organizing theme for a Challenge Institute. From precise measurements of fundamental constants to monitoring of environmental variables, the science and engineering of gaining metrological advantages from quantum state preparation, manipulation and detection presents many challenges. Precision measurements with entangled photons, atomic clocks, atom interferometers, nuclear magnetic resonance (NMR) spectrometers and color centers in diamond capitalize on quantum coherence, superposition and interference. However, refining system architectures, making robust devices, engineering optimal input states, utilizing entanglement and pioneering new applications for quantum sensors are stimulating challenges. Some inspiration for novel sensors can be gained from many-body systems where entanglement plays a role, for example in topological insulators, superconducting transition-edge sensors, quantum magnetism, quantum imaging, cavity quantum electrodynamics (QED) and hybrid quantum systems. Chemical, biological and biochemical sensors may be designed using entangled photons and quantum excitations. Pursuing several of these topics concurrently at a Challenge Institute could stimulate transformative advances in sensor technology and measurement science. The foundational and technological principles discovered in the development of quantum sensors could also impact other applications of quantum information science and engineering, including communication, computing and simulation.

2. Education, Training, and Workforce Development

Rapid development of quantum technologies and sustained progress in scientific advances and commercial applications require a growing and qualified workforce with interdisciplinary skill sets. The QLCI program aims to facilitate training of students with the combination of skills required for the conceptualization, development and translation of new quantum technologies. The QLCI program requires activities to promote the training of students in environments that expose them to a convergent set of disciplines and help them acquire qualifications and skills needed in industry, national laboratories and academia. New approaches to collaboration with industry are anticipated in a Challenge Institute not only to increase the translational impact of research, but also as a tool to assure the training and generation of a well-qualified workforce in quantum information science and engineering.

The QLCI program also provides opportunities to foster the growth of a vibrant cross-disciplinary research community through curriculum development, through research projects addressing various topics, as well as their integration. Relevant efforts may include: new degree programs and curriculum development within various academic departments (e.g., computer science and engineering, electrical engineering, physics, materials science and engineering, and mathematics) and coordination across departments to foster cross-disciplinary research; development of a common basic cross-disciplinary curriculum for potential degree programs to be shared across departments; organization of conferences targeted at critical cross-disciplinary research interfaces; development of experimental prototypes and testbeds for exploring different emerging technology platforms that are accessible to the wider research community; and creation of entrepreneurial opportunities for academia-industry collaboration, technology transfer and commercialization.

While worldwide proliferation of quantum technologies is still in the future, the Challenge Institutes are encouraged to address early-stage education, including elementary, middle and high school levels, in the broad area of quantum science and engineering. Collaboration with established organizations such as museums and outreach to broader audiences is also impactful.

Currently, a large fraction of research and teaching in quantum information science and engineering occurs in physics and materials science departments. It is not always clear to a potential graduate student which department to apply to for a doctoral degree in such a cross-disciplinary research field. It is crucial that all relevant areas of science and engineering, including computer science and engineering, electrical engineering, mathematics, chemistry and biology become more engaged in quantum information science and engineering research and education. Furthermore, in order to design, analyze and implement the quantum information processing networks of the future, the research communities in the areas of quantum communications, quantum signal processing, quantum information theory and quantum networking, that are usually housed in electrical engineering, computer engineering and computer science departments, need to be fully engaged in developing curricula and degree programs that will train new generations of *quantum engineers* – computer scientists and electrical engineers with the ability to use quantum devices and systems as basic building blocks in much the same way as transistors, integrated circuits and embedded systems are used today.

As an integral part of their mission, the Challenge Institute teams are expected to develop new and creative approaches and strategies for cross-disciplinary training and workforce development. Successful teams are also expected to provide assessment plans to evaluate the most successful and effective strategies. The QLCI program also provides an invaluable opportunity to engage education scientists to study and evaluate how convergent research teams form and evolve in the context of an Institute aimed at addressing critical cross-

disciplinary challenges to accelerate discovery and innovation.

3. Research Coordination and Community Engagement

The different research communities addressing challenges in the four application areas are at different levels of maturity in terms of research capacity and cross-disciplinary collaboration. Collaboration between different research communities and research coordination will be facilitated by annual meetings of all PI/co-PIs involved in the QLCI program and other Quantum Leap programs, as well as topical meetings and summer schools especially geared towards graduate students, postdoctoral researchers and junior faculty involved in the QLCI and related programs. The Institutes are expected to provide an external networking plan including planned meetings, seminars and seasonal schools, as well as mechanisms for collaboration with other teams and QLCI-relevant efforts across sectors, such as centers, foundries, large teams, institutes, national facilities, industrial partners and government agencies. The Institutes are also required to hold internal annual PI meetings. The overall goal of such activities is not only to facilitate and accelerate discovery and innovation within the core Challenge Institute team, but also to engage the wider research community across the nation in areas of relevance to the Challenge Institutes vision. It is expected that such activities will facilitate the growth of a vibrant multi-disciplinary research community, engage a diverse array of institutions and organizations and foster new cross-cutting and convergent collaborations in various aspects of quantum information science and engineering research and workforce development.

4. Synergistic Partnerships and Infrastructure Development

Research and technology development in quantum information science and engineering is enjoying attention and allocation of resources from industry and governments around the world. It is anticipated that the Challenge Institute teams will develop synergistic partnerships with industry, US national laboratories and international partners for advancing the goals and objectives of the Institute. For example, multiple technology platforms for quantum computing are being developed by US companies and partnerships with Challenge Institutes may accelerate innovation and technology maturation, especially in algorithm and software development and new applications. Similarly, ongoing research and development in the communications industry on secure quantum communications may be the basis of fruitful collaboration with the Challenge Institutes. Other industry sectors, e.g. quantum sensing applications, are expected to grow research and technology development efforts that may open new synergistic opportunities for partnerships with the Challenge Institutes. National institutes and laboratories have unique capabilities in quantum information science and engineering research and technology development that could be the basis of fruitful partnerships. Challenge Institute teams are encouraged to explore such partnerships. Mutually beneficial partnerships with ongoing and new international initiatives are also encouraged, as appropriate.

The Challenge Institute teams are expected to coordinate with their constituent organizations and partners to develop a concrete and workable plan for leveraging existing infrastructure resources in support of the Institute goals and objectives, including relevant laboratory facilities, testbeds and cyberinfrastructure to facilitate training and collaboration.

Partnerships should be based on clearly defined objectives that are matched to the vision of the Challenge Institute. Partnerships are not expected to be permanent and partnership agreements may include sunset provisions as appropriate. The partnership ecosystem around a Challenge Institute is expected to be dynamic and matched at each point in time to the then-current needs of the Institute.

Issues related to intellectual property (IP) can be challenging in partnerships, especially those involving academia and industry. It is expected that each Institute will develop and execute agreements with its partners to address IP issues. Research carried out at a Challenge Institute will primarily be pre-competitive, in which case NSF requires that constituent organizations of an Institute must not be preferentially advantaged (or disadvantaged) in terms of IP rights or access to IP as a consequence of an Institute partnership.

Each Challenge Institute must also ensure it is aware of, and complies with, the International Traffic in Arms Regulations (ITAR) and Export Administration Regulations (EAR) in the context of prototype and technology development.

C. Types of Awards

Conceptualization Grant (CG) Awards:

Recognizing that the four research theme areas are at different levels of technical maturity, and that the corresponding research communities are at different levels of engagement, coordination and capacity, the QLCI program offers a one-time opportunity to apply for a 12-month Conceptualization Grant (CG) prior to submitting a proposal for a Challenge Institute. Conceptualization Grants aim to support the formation of broadly convergent research teams to develop a compelling and comprehensive vision for a Challenge Institute proposal. It is expected that the prospective team members would have been involved in some form of early-stage incubation of the cross-disciplinary research underlying the potential challenge research theme.

Conceptualization Grant proposals are expected to demonstrate a clear plan and potential to develop a research vision and team for a Challenge Institute. The planned activities may include research brainstorming meetings, organizational meetings, team formation, development of stakeholder community networks, development of synergistic partnerships and assessment of research and infrastructure needs, among other aspects. The CG activities may also target the development of an overall Institute research infrastructure spanning the team institutions and involving collaborations with industry, national laboratories, or international partners. As a result of the CG activities, potential Challenge Institute teams would be better equipped to carry out institute-scale convergent research in quantum information science and engineering with broad technological and societal impact. The CG awardees are expected to use the funds to organize catalytic activities that will help crystallize four elements that are crucial to a coherent and compelling Challenge Institute proposal:

- **Stakeholder and community engagement** for brainstorming of ideas for research, community building, infrastructure development and workforce development.
- **Plans to attract and engage research talent** across different disciplines through collaborations, networks, seminars or other approaches.
- **Identification of research theme(s)** for advancing the state-of-the-art at one or more frontiers of quantum information science and engineering within a 5-year period.
- **Formation of cross-disciplinary research teams** for the chosen challenge research theme and the major activities, including research coordination and workforce development.

The most successful CG proposals will reflect concrete plans for development of integrative and multidisciplinary research teams and meaningful stakeholder engagement. Proposals must present a clear strategy for enabling the crystallization of the overall

challenge research theme and focus areas for a future Institute. CGs are not meant to support research on the proposed elements. The primary outcome of a successful CG award will be the development of a vision for a potential Institute through the identification of a challenge research theme and associated focus areas, research team and major activities. The CG awardees will have the opportunity to compete for an Institute by submitting a Challenge Institute preliminary proposal in the second round.

Note: It is not required to submit a CG proposal in order to compete for a Challenge Institute award.

Challenge Institute (CI) Awards:

Challenge Institute awards will be funded for 5 years and will enable the establishment of Quantum Leap Challenge Institutes. The size of these awards as well as the structure of the Institute will be based, in part, on the targeted community and its research, technology and workforce development needs. Awards are expected to be cooperative agreements between NSF and the awardee institution(s). The release of funding increments will be subject to agreed-upon milestones, annual project reviews, site visits, approval by NSF and the availability of funds.

Preliminary proposals are required for CI proposals. Preliminary proposals will undergo full merit review. At the end of this process, proposers will be informed whether or not a full proposal is invited for the project. Only full proposals received in response to an invitation will be considered. The review of invited full CI proposals will include a presentation by the proposing team at the NSF headquarters in Alexandria, VA. Additional details are provided in Sec. V (**Proposal Preparation**) and Sec. VI (**Proposal Review**).

CI Preliminary proposal: The CI preliminary proposal serves as a precursor to the Strategic Plan to be developed in the full proposal. A CI preliminary proposal must address the following elements:

- Identification of a compelling challenge research theme, specific research goals and milestones for advancing the frontiers of quantum information science and engineering within five years.
- Identification of the cross-disciplinary and multi-institution research team forming the Challenge Institute, including any potential mergers between or with CG awardees, if applicable.
- An overview of overarching cross-cutting findings, concepts or preliminary results that shape the Challenge Institutes vision.
- Evidence to indicate that the team can effectively collaborate across the different disciplines.
- An overview of the proposed major activities in the four core areas described in Sec. II.B: research, education and workforce development, research coordination and partnerships and infrastructure.
- Prior experiences of the team with the key elements and frameworks of quantum information science and engineering identified for the Challenge Institute.
- A summary of key activities undertaken by the proposing team, as part of a CG or otherwise, in preparation for the Challenge Institute preliminary proposal submission.

III. AWARD INFORMATION

The QLCI program is an NSF-wide activity. Bold Challenge Institute proposals that combine different quantum information science and engineering disciplines within a 5-year project are solicited. Prospective Principal Investigators (PIs) are encouraged to submit proposals in one of the four broad research theme areas identified above in Sec. II.B.1, or on a distinct challenge research theme cutting across some (or all) of the identified areas. Within the chosen challenge research theme, each Challenge Institute is expected to encompass a sufficiently rich and diverse array of technical areas, technological tools and relevant collaborative partnerships to increase the likelihood of success.

Recognizing that the four themes in quantum information science and engineering are at different levels of scientific and technological maturity, the QLCI program offers the opportunity to apply for a 1-year Conceptualization Grant prior to submitting a full proposal for a Challenge Institute. The CGs are aimed at facilitating the formation of appropriate cross-disciplinary teams to prepare a compelling and comprehensive Challenge Institute proposal.

The QLCI program will support two types of awards:

- i. Conceptualization Grants funded at a level of \$100,000 - \$150,000 for 12 months.
- ii. Challenge Institute awards funded at a level of up to \$5,000,000/year for 5 years.

The QLCI program will be conducted in two rounds. In Round 1, both CG and CI proposals will be accepted. In Round 2, only CI proposals will be accepted.

An estimated 15 to 25 Conceptualization Grants will be awarded. An estimated 1 to 3 Challenge Institute awards will be granted in each of the two competition rounds.

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

IV. ELIGIBILITY INFORMATION

Who May Submit Proposals:

Proposals may only be submitted by the following:

- Institutions of Higher Education (IHEs) - Two- and four-year IHEs (including community colleges) accredited in, and having a campus located in the US, acting on behalf of their faculty members. Special Instructions for

International Branch Campuses of US IHEs: If the proposal includes funding to be provided to an international branch campus of a US institution of higher education (including through use of subawards and consultant arrangements), the proposer must explain the benefit(s) to the project of performance at the international branch campus and justify why the project activities cannot be performed at the US campus.

- Non-profit, non-academic organizations: Independent museums, observatories, research labs, professional societies and similar organizations in the U.S. associated with educational or research activities.

Who May Serve as PI:

There are no restrictions or limits.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

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

Conceptualization Grant (CG) proposals: An individual may serve as PI, co-PI, or other senior personnel on no more than **two** CG proposals. In cases where an individual appears in more than two CG proposals, only the first two submitted CG proposals will be accepted; all other CG proposals involving that individual will be returned without review.

Challenge Institute (CI) proposals: An individual may serve as PI, co-PI, or other senior personnel on no more than **one** CI preliminary proposal (or CI full proposal). In cases where an individual appears in more than one CI preliminary proposal (or full proposal), only the first submitted CI preliminary/full proposal will be accepted; all other CI preliminary/full proposals involving that individual will be returned without review.

Note: The QLCI program will be conducted in two rounds. In Round 1, both CG and CI proposals will be accepted. Prospective teams may submit either a CG or a CI proposal, but not both, in Round 1.

Additional Eligibility Info:

The QLCI program is intended to promote initiatives that empower new research communities and diversify the next generation of quantum information science and engineering researchers. It is also expected that the conceptualization and establishment of an Institute will take significant and sustained effort from the proposing team. Limiting the participation of any one individual in the role of PI, co-PI or other senior personnel, as detailed, will help ensure that QLCI proposals receive the necessary focused attention of all PIs and co-PIs involved and that a wide diverse group of investigators play leading roles in QLCI projects.

V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. Proposal Preparation Instructions

1. Conceptualization Grant (CG) Proposal Letters of Intent (required):

A one-page Letter of Intent is required for both Conceptualization Grant proposals as well as Challenge Institute preliminary proposals. The letter should be submitted to MPS/OMA via FastLane no later than the date specified in this solicitation. The subject heading of the letter should include a brief title of the proposal and the name of the lead institution.

For CG proposals, a Letter of Intent should include the following:

- **Proposal title** - Title must be preceded by the letters "QLCI - CG:".
- **Team** - Names, departmental and organizational affiliation of all team members, including the Principal Investigator, co-Principal Investigators and other Senior Personnel; expertise of the Principal Investigator and at least two co-Principal Investigators.
- **Synopsis** - Brief description of the specific goals of the proposal.

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

the Grants.gov website and on the NSF website at: (https://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide). To obtain copies of the Application Guide and Application Forms Package, click on the Apply tab on the Grants.gov site, then click on the Apply Step 1: Download a Grant Application Package and Application Instructions link and enter the funding opportunity number, (the program solicitation number without the NSF prefix) and press the Download Package button. Paper copies of the Grants.gov Application Guide also may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov.

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

Special instructions for submitting to this Big Idea solicitation

FastLane Users: Proposers are reminded to identify the program solicitation number (located on the first page of this document) in the first block on the NSF Cover Sheet. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Please note that even though proposals must be submitted to the Directorate for Mathematical and Physical Sciences (MPS), Office of Multidisciplinary Activities (OMA), once received the proposals will be managed by a cross-disciplinary team of NSF Program Directors.

Research.gov Users: The Prepare New Proposal setup will prompt you for the program solicitation number (located on the first page of this document). Compliance with this requirement is critical to determining the relevant proposal processing guidelines. As stated previously, even though proposals must be submitted to MPS/OMA, once received the proposals will be managed by a cross-disciplinary team of NSF Program Directors.

Grants.gov Users: The program solicitation number will be pre-populated by Grants.gov on the NSF Grant Application Cover Page, however you will need to locate the Division Code, Program Code, Division Name and Program Name for the specific solicitation you are applying to by visiting <https://www.fastlane.nsf.gov/pgmannounce.jsp>. As stated previously, even though proposals must be submitted to MPS/OMA, once received the proposals will be managed by a cross-disciplinary team of NSF Program Directors.

Important Proposal Preparation Information: FastLane will check for required sections of the proposal, in accordance with PAPPG instructions described in Chapter II.C.2. The PAPPG requires submission of: Cover Sheet; Project Summary; Project Description; References Cited; Biographical Sketch(es); Budget and Budget Justification; Current and Pending Support; Facilities, Equipment and Other Resources; the Data Management Plan and the Postdoctoral Mentoring Plan (if applicable). If a required section is missing, **FastLane will not accept the proposal.**

The following instructions for the submission of CG proposals supplement the NSF *Proposal and Award Policies and Procedures Guide (PAPPG)*:

Proposal Title:

The title of the proposal must be preceded by the letters "**QLCI - CG:**". The rest of the title should describe the project in concise, informative language that is understandable to a technically-literate reader.

Cover Sheet:

The NSF Cover Sheet showing the name of the Principal Investigator and the CG Proposal Title. Identify the program solicitation number in the program announcement/solicitation block.

Project Summary:

The Project Summary consists of an overview, a statement on the intellectual merit of the proposed activity and a statement on the broader impacts of the proposed activity. Include a concise overview of the proposed major CG activities, including exploration of research theme areas, identification and coordination of research communities, training and workforce development initiatives and development of partnerships and infrastructure. **(Limit: 1 page).**

Project Description:

Project Descriptions are limited to 15 pages in length. The page numbers listed (in parentheses) for the different sections are suggested guidelines; the actual page numbers for different sections may deviate from the guidelines, provided the total number of pages does not exceed 15 pages.

In addition to the PAPPG requirements, the Project Description for a CG proposal must include the following clearly-marked sections:

- **Overview:** A clear description of the objectives and a summary of major activities in pursuit of the development of a compelling Challenge Institute proposal. **(1 page).**
- **Research Theme Areas and Team Selection:** A discussion of the potential research theme areas to be explored in the CG project; names and affiliations for the team members and rationale for their selection for the CG project. **(3 pages).**
- **Research Coordination and Community Engagement:** Identification of the various research communities to be engaged in the project. A description of the planned major activities to engage and coordinate relevant research communities in pursuit of the CG project goals. **(3 pages).**
- **Partnerships and Infrastructure:** A description of the planned major activities to explore strategic and synergistic partnerships with industry, national labs and any international partners. A description of the planned major activities to identify and refine the infrastructure needs. **(3 pages).**
- **Education and Workforce Development:** A description of the planned major activities for exploring and refining the scope of education, training and workforce development needs. **(2 pages).**
- **Readiness Milestones:** A description of the milestones for the CG project to assess the readiness of the team for submitting a compelling CI preliminary proposal. **(1 page).**
- **Prior Experience and Results:** A description of the most relevant prior experience of the CG project team members, including results from prior NSF support. **(2 pages).**

References Cited:

List only references cited in the Project Description.

Budget and Budget Justification:

See the Section V.B. (**Budgetary Information**) for instructions on how to prepare these documents.

Supplementary Documents:

- **Management and Integration Plan:** A Management and Integration Plan up to 2 pages in length is required for all CG proposals. The Management and Integration Plan should: a) list all PIs, co-PIs and Senior Personnel on the project; b) describe how the group effort will be coordinated; c) describe how the disciplinary components will be integrated; and d) describe collaborations and partnerships and their integration with the project. **Information must also be provided on who from the research team will be responsible in the execution of the tasks described in the Management and Integration Plan.** A clear timeline of expected outcomes or milestones should be included. **Proposals lacking the Management and Integration Plan may be returned without review.**
- **Letters of Collaboration:** The Project Description must fully detail any substantial collaborations and engagements (included or not included in the budget) with partner organizations. Letters of Collaboration should be provided in the Supplementary Documents section of the proposal and follow the format instructions specified in the NSF PAPPG.
- **Data Management Plan:** All proposals must include a Data Management Plan that describes how the project will provide open and rapid access to quality-controlled and fully documented data and information during and after the project. This plan must be consistent with NSF's policy on dissemination and sharing of research results (<https://www.nsf.gov/bfa/dias/policy/dmp.jsp>) and also NSF's PAPPG.
- **Postdoctoral Mentoring plan:** One-page document describing the postdoctoral mentoring plan is required if funding for postdoctoral researchers is included.

3. Challenge Institute (CI) Proposal Letters of Intent (required):

A one-page Letter of Intent is required for both Conceptualization Grant proposals as well as Challenge Institute preliminary proposals. The letter should be submitted to MPS/OMA via FastLane no later than the date specified in this solicitation. The subject heading of the letter should include a brief title of the proposal and the name of the lead institution.

For CI preliminary proposals, a Letter of Intent should include the following:

- **Proposal Title** - Title must be preceded by the letters "**QLCI - CI**".
- **Team** - Names, departmental and organizational affiliation of all team members, including the Principal Investigator, co-Principal Investigators and other Senior Personnel; expertise of the Principal Investigator and at least two co-Principal Investigators.
- **Synopsis** - Brief description of the challenge research theme and the specific goals of the proposal.

Letter of Intent Preparation Instructions:

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

- Submission by an Authorized Organizational Representative (AOR) is required when submitting Letters of Intent.
- A Minimum of 0 and Maximum of 4 Other Senior Project Personnel are permitted
- A Minimum of 0 and Maximum of 4 Other Participating Organizations are permitted
- Submission of multiple Letters of Intent is not permitted

4. Challenge Institute (CI) Preliminary Proposals

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 Challenge Institute preliminary proposal does not require a prior Conceptualization Grant proposal or award.

Proposal Title:

The title of the proposal must be preceded by the letters "**QLCI - CI**". The rest of the title should describe the project in concise, informative language that is understandable to a technically-literate reader.

Cover Sheet:

The NSF Cover Sheet showing the name of the proposed Challenge Institute Director (Principal Investigator or PI) and the Preliminary Proposal Title. The block indicating that a preliminary proposal is being submitted should be checked. Identify the program solicitation number in the program announcement/solicitation block.

Project Summary:

The Project Summary consists of an overview, a statement on the intellectual merit of the proposed activity and a statement on the broader impacts of the proposed activity. Include a concise overview of the proposed major Institute activities, including the challenge research theme, focus research areas, research coordination, workforce development initiatives and partnerships and infrastructure development. **(Limit: 1 page).**

Project Description:

Project Descriptions are limited to 15 pages in length. The page numbers listed (in parentheses, which add up to 13) for the different sections are only suggested guidelines; the actual page numbers for different sections may deviate from the guidelines, provided the total number of pages does not exceed the limit of 15 pages.

In addition to the PAPPG requirements, the Project Description for a Challenge Institute preliminary proposal must include the following clearly-marked sections:

- a. A description of the **cross-disciplinary and multi-institution research team**, including a list of the PI, any co-PIs and each participating Senior Personnel (faculty level and equivalent) by full name, institutional affiliation and departmental affiliation. Briefly discuss any mergers with Conceptualization Grant awardees in team formation. It is assumed that **all participating members** will have an active role in institute activities, including research, workforce development, research coordination and partnerships. It is expected that the participating members will be able to provide a statement to that effect should a full proposal be invited. This list should be clearly labeled and made the first item in the Project Description. **(1 page)**.
- b. A brief overview of the proposed Challenge Institute, including the **challenge research theme** and the focus research areas, **key cross-cutting concepts or findings** that shape the vision of the cross-disciplinary institute. **(2 pages)**.
- c. A brief overview of the state-of-the-art to provide a context and motivation for the proposed Challenge Institute. What makes the proposed challenge research theme compelling and timely? **(1 page)**.
- d. A brief description of the proposed **major activities in the focus research areas**. **(2 pages)**.
- e. A brief description of the proposed **major activities in training and workforce development**. **(1 page)**.
- f. A brief description of proposed **major activities in research coordination and community engagement**. **(1 page)**.
- g. A brief description of proposed **major partnerships and infrastructure development activities**. **(1 page)**.
- h. **Evidence of cross-disciplinary team engagement and synergy**. Provide information to support the cross-disciplinary engagement and synergy of the team in carrying out the proposed work; provide **evidence to support that the team can effectively work together**. **(1 page)**.
- i. **Milestones and evaluation mechanisms**: An overview of the key milestones in major activities and the mechanisms for evaluation of success. **(1 page)**.
- j. A brief description of pertinent achievements **under prior NSF support**; a summary of key activities undertaken by the team, as part of a CG or otherwise, in preparation for a convergent and cross-disciplinary Challenge Institute proposal submission. **(2 pages)**.

References Cited:

List only references cited in the Project Description.

Budget and Budget Justification:

See the Section V.B. (**Budgetary Information**) for instructions on how to prepare these documents.

Supplementary Documents:

- **One-page synopsis of institutional support and other commitments** to the proposed Challenge Institute. The synopsis should be narrative in nature and must not include any quantifiable financial information.
- **Management and Integration Plan**. A one-page overview of the Institute leadership and management is required for all preliminary proposals. The Management and Integration Plan should: a) describe how the group effort will be coordinated; and b) describe how the disciplinary components will be integrated.
- **Letters of Collaboration**. The Project Description must fully detail any substantial collaborations and engagements (included or not included in the budget) with partner organizations. Letters of Collaboration should be provided in the Supplementary Documents section of the proposal and follow the format instructions specified in the NSF PAPPG.
- **Data Management Plan**. All proposals must include a Data Management Plan that describes how the project will provide open and rapid access to quality-controlled and fully documented data and information during and after the project. This plan must be consistent with NSF's policy on dissemination and sharing of research results (<https://www.nsf.gov/bfa/dias/policy/dmp.jsp>) and also NSF's PAPPG.
- **Postdoctoral Mentoring plan**. One-page document describing the postdoctoral mentoring plan is required if funding for postdoctoral researchers is included.

Please submit the following Single-Copy Documents:

- A List of Collaborators and Other Affiliations for the PI, any co-PIs and each participating Senior Personnel must be included. This should follow the standard NSF PAPPG instructions and list all collaborators with whom the investigator works directly.
- Suggested Reviewers. Submit a list of individuals who would be suitable to act as impartial reviewers. Include their names, affiliations, phone numbers, e-mail addresses and areas of expertise. PIs can also include a short list of reviewers not to be used.

5. Challenge Institute (CI) Full 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 Proposal & Award Policies & Procedures Guide* (PAPPG). The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg. Paper copies of the PAPPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov. Proposers are reminded to identify this program solicitation number in the program solicitation block on the NSF Cover Sheet For Proposal to the National Science Foundation. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Failure to submit this information may delay processing.
- Full proposals submitted via Grants.gov: Proposals submitted in response to this program solicitation via Grants.gov should be prepared and submitted in accordance with the *NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov*. The complete text of the *NSF Grants.gov Application Guide* is available on the Grants.gov website and on the NSF website at: (https://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide). To obtain copies of the Application Guide and Application Forms Package, click on the Apply tab on the Grants.gov site, then click on the Apply Step 1: Download a Grant Application Package and Application Instructions link

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

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

Special instructions for submitting to this Big Idea solicitation

FastLane Users: Proposers are reminded to identify the program solicitation number (located on the first page of this document) in the first block on the NSF Cover Sheet. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Please note that even though proposals must be submitted to the Directorate for Mathematical and Physical Sciences (MPS), Office of Multidisciplinary Activities (OMA), once received the proposals will be managed by a cross-disciplinary team of NSF Program Directors.

Research.gov Users: The Prepare New Proposal setup will prompt you for the program solicitation number (located on the first page of this document). Compliance with this requirement is critical to determining the relevant proposal processing guidelines. As stated previously, even though proposals must be submitted to MPS/OMA, once received the proposals will be managed by a cross-disciplinary team of NSF Program Directors.

Grants.gov Users: The program solicitation number will be pre-populated by Grants.gov on the NSF Grant Application Cover Page, however you will need to locate the Division Code, Program Code, Division Name and Program Name for the specific solicitation you are applying to by visiting <https://www.fastlane.nsf.gov/pgmannounce.jsp>. As stated previously, even though proposals must be submitted to MPS/OMA, once received the proposals will be managed by a cross-disciplinary team of NSF Program Directors.

Important Proposal Preparation Information: FastLane will check for required sections of the proposal, in accordance with PAPPG instructions described in Chapter II.C.2. The PAPPG requires submission of: Cover Sheet; Project Summary; Project Description; References Cited; Biographical Sketch(es); Budget and Budget Justification; Current and Pending Support; Facilities, Equipment and Other Resources; the Data Management Plan and the Postdoctoral Mentoring Plan (if applicable). If a required section is missing, **FastLane will not accept the proposal.**

Note: Full proposals may be submitted only by projects that, following the review of a preliminary proposal, have received an invitation to submit a full proposal. For submissions involving multiple organizations, the proposal should be submitted from only one (lead) institution, with funding for participating organizations made through subawards. Proposals should not be submitted as separately submitted collaborative proposals.

The proposal must conform to the NSF PAPPG formatting requirements and must contain the following items in the order indicated. Proposals that exceed the total page limitations will be ineligible for consideration and may be returned without review.

- a. **NSF Cover Sheet:** The title of the proposal must begin with the letters "QLCI - CI:" The rest of the title should describe the project in concise, informative language that is understandable to a technically-literate reader. Indicate the total amount requested for the five years of NSF support in the box entitled "requested amount." For Grants.gov users, enter the amount in block 16a of the SF424 R&R form.
- b. **Project Summary.** The Project Summary consists of an overview, a statement on the intellectual merit of the proposed activity and a statement on the broader impacts of the proposed activity. Include an overview of the challenge research theme and focus research areas and proposed major activities in the four core components of research, workforce development, research coordination and partnerships and infrastructure. **Limit: 1 page.**
- c. **Project Description.** The Project Description must include the following clearly-marked sections and is limited to no more than **35 pages. The number of pages (listed in parentheses) for each section are only suggested guidelines; the actual page numbers may deviate from the guidelines, provided the total number of pages does not exceed 35 pages.**
 - i. **List of participants.** List the PI, any co-PIs and each participating Senior Personnel (faculty level or equivalent), including institutional and departmental affiliation. (Additional biographical information should be inserted in the Biographical Sketch section.) **(1 page).**
 - ii. **Strategic plan, including a ramp-up plan.** (Please see the list of Strategic Plan Elements at the end of these Proposal Preparation Instructions.) Provide a clear rationale for and description of the proposed Challenge Institute, its challenge research theme and its potential impact on the frontiers of quantum information science and engineering. Briefly describe the institutional setting of the Challenge Institute unit, its organization, leadership and management structure. Provide a brief overview of the major activities in focus research areas, training and workforce development, research coordination and partnerships and infrastructure development. Provide an overview of the prior cross-disciplinary activities of the team that lay the foundations for the proposed Challenge Institute. **(5 pages).**
 - iii. **Results from prior NSF support.** Describe achievements under prior NSF support that pertain to the present proposal. **(3 pages).**
 - iv. **Overview of the key cross-cutting concepts, findings, or initial results that guide the proposed major cross-disciplinary activities.** Describe in detail the key cross-cutting concepts and any associated initial results that build on disciplinary advances and under-pin the proposed convergent cross-disciplinary activities. **(1 page).**
 - v. **Major activities in the focus research areas.** Describe the proposed major activities in the various focus research areas, how they relate to the challenge research theme, and what makes them potentially transformative. **(10 pages).**
 - vi. **Evidence of cross-disciplinary engagement and synergy.** Provide information to support the cross-disciplinary engagement and synergy of the team in carrying out the proposed work. **(1 page).**
 - vii. **Major activities in research coordination and wider community engagement.** **(3 pages).**
 - viii. **Major activities in education, training and workforce development.** **(3 pages).**
 - ix. **Major activities for strategic partnerships and infrastructure development.** **(3 pages).**
 - x. **Leadership and management plan.** A description of: (a) the overall leadership structure and responsibilities; b) how the group effort will be coordinated; c) how the disciplinary components will be integrated; d) how collaborations and partnerships will be integrated with the project; and e) mechanisms for evolution and adaptation of the Institute. **(3 pages).**
 - xi. **Milestones, evaluation mechanisms, and deliverables.** A description of key year-by-year milestones in major activities, personnel responsible, and the mechanisms for evaluation of success. A clear description of the final milestones targeted for a 5-year period and how the prior milestones lead up to them. **(2 pages).**

- d. **References Cited.** List only references cited in the Project Description. See PAPPG for format instructions.
- e. **Biographical Sketch(es).** A Biographical Sketch should be included for the PI, any co-PIs and each of the participating Senior Personnel listed in the Project Description. This should follow the standard NSF guidelines in the PAPPG. **Limit: 2 pages for each individual.** Enter the requested information in the "Biographical Sketch" section. For Grants.gov proposals, the biographical sketch should be attached to the R&R form.
- f. **Budget and Budget Justification.** See the Section V.B. (**Budgetary Information**) for instructions on how to prepare these documents.
- g. **Current and Pending Support.** List current and pending support for the PI, any co-PIs and each participating Senior Personnel. Enter the requested information in the "Current and Pending Support" section. For Grants.gov proposals, current and pending support should be attached to the R&R form.
- h. **Facilities, Equipment, and Other Resources.** Follow the NSF PAPPG instructions. Describe all facilities, equipment, and other resources, such as shared infrastructure, that are critical to the proposed Institute.

Supplementary Documents:

- **Statement on Challenge Institute Role:** A one-paragraph statement (not to exceed one-half page) from each of those listed as participating Senior Personnel outlining how they view their role in the Challenge Institute. This must be specific and not a general statement of support.
- **Letters of Collaboration:** The Project Description must fully detail any substantial collaborations and engagements (included or not included in the budget) with partner organizations. Letters of Collaboration should be provided in the Supplementary Documents section of the proposal and follow the format instructions specified in the NSF PAPPG.
- **Data Management Plan:** All proposals must include a Data Management Plan that describes how the project will provide open and rapid access to quality-controlled and fully documented data and information during and after the project. This plan must be consistent with NSF's policy on dissemination and sharing of research results (<https://www.nsf.gov/bfa/dias/policy/dmp.jsp>) and also NSF's PAPPG.
- **Postdoctoral Mentoring plan:** One-page document describing the postdoctoral mentoring plan is required if funding for postdoctoral researchers is included.

Please submit the following Single-Copy Documents:

- A List of Collaborators and Other Affiliations for the PI, any co-PIs and each participating Senior Personnel must be included. This should follow the standard NSF PAPPG instructions and list all collaborators with whom the individual works directly.
- Suggested Reviewers. Submit a list of individuals who might be suitable to act as impartial reviewers. Include their names, affiliations, phone numbers, e-mail addresses and areas of expertise. PIs can also include a short list of reviewers not to be used.

Strategic Plan Elements:

Each Challenge Institute team is expected to develop a Strategic Plan that will guide the establishment, operation and evolution of the Institute. The Strategic Plan must include, but is not limited to, the following elements:

Challenge Research Theme, Focus Research Areas, and Research Community:

- A concise description of the Institutes challenge research theme and its specific research goals for advancing the state-of-the-art of quantum information science and engineering in one or more frontiers within a 5-year period.
- Identification of the cross-disciplinary research community that the institute will serve and grow.
- Identification of major milestones targeted for a five-year period and year-by-year milestones and corresponding evaluation mechanisms to measure progress in the different major activities.

Institute Management and Sustainability:

- The overall staffing requirements and appropriate recruitment and strategies.
- The leadership and management structure, including any external board of advisors.
- The specific metrics and oversight mechanisms designed to evaluate whether and how the Institute is meeting its stated goals, including ongoing evaluation of projects.
- Mechanisms to enable course correction in research directions as well as team members.
- Identification of the principal risks the institute may encounter in its establishment, operations and achievement of goals, and contingency plans for mitigating the risks.
- Plans for long-term sustainability after expiration of NSF funding under the QLCI program.

Education, Training and Workforce Development:

- Short-term and long-term objectives and mechanisms for cross-disciplinary education, training and workforce development.
- Plans to facilitate integration of research and education.
- Plans for assessing the effectiveness of the activities in growing a convergent and collaborative workforce in quantum information science and engineering.
- Mechanisms for disseminating novel and effective educational and workforce development practices.

Synergistic Partnerships and Infrastructure Development:

- Plans for synergistic partnerships and links with local organizations, national laboratories, government agencies, industry and international partners to leverage expertise in quantum information science, education and workforce development and technology transfer.
- Plans for creating an innovation ecosystem for working with industry, national laboratories and other agencies to translate research into applications.
- Established and planned linkages within and across research communities that would enhance impact, including but not limited to: complementary laboratory facilities and testbed capabilities and complementary components of community infrastructure.
- Specific mechanisms for outreach to the local community and the nation.

Cross-Disciplinary Research Coordination and Growth:

- Mechanisms for promoting active collaboration between researchers from multiple disciplines involved in quantum information science, including physics, engineering, mathematics, computer science, chemistry, materials science, and biology.
- Mechanisms for exchanges among participating organizations by research team members and external visitors.
- Mechanisms for growing the community involved in both research and workforce development.
- Mechanisms for research community integration and coordination of efforts.

Institute Ramp-Up Plan:

- A description of concrete implementation activities necessary to establish the institute and to have it fully operational within six months of the start of the project.
- A list of concrete tasks, personnel responsible, milestones and timeline for the ramp-up phase.
- Plans for creation of an Institute website.
- Plans for staffing and recruitment of personnel, including students, postdoctoral researchers and scientists.
- Identification of key activities for establishing partnerships and associated agreements.
- Identification of any significant elements that may become fully operational after the ramp-up phase, including justification and estimated time-frame.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

Other Budgetary Limitations:

Other budgetary limitations for Conceptualization Grant (CG) Proposals: Up to one-year awards are expected to range in size between \$100,000 - \$150,000. The budget and budget justification for Conceptualization Grants should follow the standard PAPPG guidelines.

Other Budgetary Limitations for Challenge Institute Proposals: Five-year awards are expected to range in size between \$2,000,000/year and \$5,000,000/year. The total budget for the full proposal may not be larger than the total budget listed in the preliminary proposal.

Budget Preparation Instructions:

Challenge Institute (CI) Proposal Budgets: Complete budgets for each year (1-5) of support and a five-year summary budget justification are required (this pertains to both preliminary proposals and full proposals.). A five-year budget summary will be automatically generated by FastLane.

Challenge Institute (CI) Preliminary Proposals: Budgets are required for each of the five years. The summary budget table described below should be included in the budget justification section. Detailed subaward budgets are not required at the preliminary proposal stage. The subaward totals should be added in line G.5 to the lead institution total. While budgets for the separate years may change between the preliminary proposal and the full proposal, the five-year budget total in the full proposal must be the same as in the preliminary proposal.

Challenge Institute (CI) Full Proposals: Provide separate budgets for the Challenge Institute as a whole and for each participating organization. In the summary budget table described below provide the overall support levels planned for each of the major activities and components of the Challenge Institute as a whole (only year 1 and five-year totals are required.). This should be included as part of the budget justification narrative. This information augments but does not replace the official NSF budget. Travel budgets for a representative from each participating organization in a Challenge Institute for attending annual QLCI PI meetings should also be included.

Summary Table of Requested NSF Support:

Activity	Year One Total	Five Year Total
Research Focus Area (repeat for each Research Focus Area)		
Research Capacity Coordination and Community Engagement		
Education, Training and Workforce Development		
Partnerships and Infrastructure Development		
Shared Facilities		
Administration, Management and Evaluation		

Total			
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For each entry in the Table, include indirect costs. Column totals must equal the total budget requested from NSF for the period shown. Include major capital equipment under shared facilities. Support for graduate students should normally be included under research activities, with the understanding that they will be engaged in other aspects as well as part of their professional development. Support for graduate students and/or postdoctoral researchers may be included under Education, Training and Workforce Development if part of related research.

C. Due Dates

- **Letter of Intent Due Date(s) (required)** (due by 5 p.m. submitter's local time):
 - April 01, 2019
 - Letters of Intent for Conceptualization Grant proposals.
 - June 03, 2019
 - Letters of Intent for Round I QLCI proposals.
 - August 03, 2020
 - Letters of Intent for Round II QLCI proposals.
- **Preliminary Proposal Due Date(s) (required)** (due by 5 p.m. submitter's local time):
 - August 01, 2019
 - Preliminary proposals for Round I QLCI proposals.
 - September 01, 2020
 - Preliminary proposals for Round II QLCI proposals.
- **Full Proposal Deadline(s)** (due by 5 p.m. submitter's local time):
 - June 03, 2019
 - Conceptualization Grant proposals.
 - January 02, 2020
 - Round I QLCI full proposals (by invitation only).
 - February 01, 2021
 - Round II QLCI full proposals (by invitation only).

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

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

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

A. Merit Review Principles and Criteria

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

1. Merit Review Principles

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

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

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

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

2. Merit Review Criteria

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

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

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

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

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

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

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

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

Additional Solicitation Specific Review Criteria

In addition to the merit review criteria listed above, reviewers will be asked to use the following criteria for the three types of proposals: CG proposals, CI preliminary proposals and CI full proposals.

A Challenge Institute proposal must exhibit synergy or value-adding features that justify center- or institute-type support, rather than an equivalent level of support for individual investigators or small groups. Proposals must address these points for each major activity of the Challenge Institute and the roles and responsibilities of each senior investigator must be described. Reviewers will be asked to assess each major activity and each senior investigator in their review, along with the potential synergy among the different major activities.

Conceptualization Grant Proposals:

- Does the proposal identify promising potential focus research areas and strategies for crystallizing a challenge research theme?
- Does the research team have adequate expertise and resources available?
- Are the proposed activities for research coordination and community engagement meaningful and compelling?
- Are the proposed activities for exploring strategies for training and workforce development meaningful and compelling?
- Are the proposed activities for developing new partnerships and infrastructure meaningful and compelling?
- Are the proposed milestones for assessing the team readiness for a Challenge Institute at the end of the CG award appropriate and achievable?

Challenge Institute Preliminary Proposals:

- Does the proposal identify a major challenge research theme and specific research goals for advancing the state-of-the-art of quantum information science and engineering in one or more frontiers within a 5-year period? Does it articulate the importance of the proposed challenge research theme and why a Challenge Institute is critical for addressing the challenge?
- Does the challenge research theme require a convergent, cross-disciplinary approach?
- Does the team exhibit the cross-disciplinary expertise required to address the challenge research theme? Has the team provided evidence to support their collaborative engagement and synergy?
- Does the proposal present a convincing plan to catalyze the identification, formation and coordination of diverse, well-integrated and convergent research communities?
- Are the proposed activities in the four core areas – research, workforce development, research coordination and partnerships and infrastructure – well-articulated, meaningful and compelling?
- How integrated and compelling is the cross-disciplinary effort in terms of research and workforce development?
- Does the team make a compelling case for its readiness for establishing a Challenge Institute through its prior activities and collaborations?

Are the milestones for measuring progress in major activities meaningful and the corresponding evaluation mechanisms well-defined and actionable?

Challenge Institute Full Proposals:

- Does the proposal present a compelling long-term vision for advancing one or more frontiers of quantum information science and engineering through cross-disciplinary collaborations in foundational science and engineering and technology development?
- Does the research team exhibit the cross-disciplinary expertise required to carry out the research vision? Has the team provided convincing evidence to support their collaborative engagement and synergy?
- Does the proposal present a convincing plan to catalyze the identification, formation and coordination of diverse, well-integrated and convergent research communities?
- How integrated and compelling is the cross-disciplinary effort in terms of research and workforce development?
- Does the proposal present innovative short-term and long-term activities to enhance education, research training, curriculum development, and mentoring?
- Does the proposal provide a convincing plan for establishing an innovation ecosystem through new partnerships with industry and other organizations, infrastructure development, and technology transfer?
- Is the Institutes strategic plan meaningful and convincing? Is the ramp-up plan well-defined and reasonable?
- Does the project management plan provide a convincing road map for the operation of the Challenge Institute in pursuit of its vision? Does the management plan identify strategies for sustainability beyond the QLCI funding?
- Do the final milestones identified for a five-year period represent potentially transformative achievements consistent with the Challenge Institutes vision? Are the year-by-year milestones and associated evaluation mechanisms meaningful for measuring progress towards the final milestones?

Each Institute will be reviewed annually through reports and site or reverse-site visits based on the goals of the QLCI program and the specific goals, objectives and milestones identified by the Institute team.

B. Review and Selection Process

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

Proposals submitted in response to this program solicitation will be reviewed by panel review, ad hoc review and/or reverse site review.

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=papppg.

Special Award Conditions:

Grantees will be required to include appropriate acknowledgment of NSF support under the Quantum Leap Big Idea in any publication (including World Wide Web pages) of any material based on or developed under the project, in the following terms:

"This material is based upon work supported by the National Science Foundation Quantum Leap Big Idea under Grant No. (Grantee enters NSF grant number.)"

Grantees also will be required to orally acknowledge NSF support using the language specified above during all news media interviews, including popular media such as radio, television and news magazines.

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=papppg.

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:

- Quantum Leap Challenge Institutes, telephone: (703) 292-4861, email: QLCI@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.

The central email alias (QLCI@nsf.gov) provides a single point of contact for community inquiries regarding the Quantum Leap Challenge Institute program. Prospective proposers are encouraged to email their inquiries to QLCI@nsf.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.

Facilitation Awards for Scientists and Engineers with Disabilities (FASSED) provide funding for special assistance or equipment to enable persons with disabilities to work on NSF-supported projects. See the *NSF Proposal & Award Policies & Procedures Guide* Chapter II.E.6 for instructions regarding preparation of these types of proposals.

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

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

The National Science Foundation promotes and advances scientific progress in the United States by competitively awarding grants and cooperative agreements for research and education in the sciences, mathematics, and engineering.

To get the latest information about program deadlines, to download copies of NSF publications, and to access abstracts of awards, visit the NSF Website at <https://www.nsf.gov>

- **Location:** 2415 Eisenhower Avenue, Alexandria, VA 22314
- **For General Information** (NSF Information Center): (703) 292-5111
- **TDD (for the hearing-impaired):** (703) 292-5090
- **To Order Publications or Forms:**
 - Send an e-mail to: nsfpubs@nsf.gov
 - or telephone: (703) 292-7827
- **To Locate NSF Employees:** (703) 292-5111


PRIVACY ACT AND PUBLIC BURDEN STATEMENTS

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.

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

Suzanne H. Plimpton
Reports Clearance Officer
Office of the General Counsel
National Science Foundation
Alexandria, VA 22314

Policies and Important Links	Privacy	FOIA	Help	Contact NSF	Contact Web Master	SiteMap
	National Science Foundation, 2415 Eisenhower Avenue, Alexandria, Virginia 22314, USA Tel: (703) 292-5111, FIRS: (800) 877-8339 TDD: (703) 292-5090 or (800) 281-8749					Text Only