Report of NSF Workshop on a National Networks of Research Institutes (NNRI)

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1. Introduction

The challenge. The US faces global challenges in science, engineering, technology, and education with important implications for accelerating technological changes, economic and industrial competitiveness, and national security. At the same time, we are facing pressing needs in the areas of sustainable economic growth and high-quality jobs, food, energy, water, environment, personal and population health and well-being, as well as inequality of opportunity. Driven in part by these considerations, numerous recent reports and legislation have identified the critical need to increase investment in US science and engineering research, with an emphasis on *use-inspired basic research* and *lab-to-market pathways* that identify, pull, develop, and translate this use-inspired research into products and services to ensure that our Nation continues to reap myriad future benefits of a world-leading R&D enterprise.

National Networks of Research Institutes (NNRI). There is an opportunity for *new* types of research institutes that have the coupled goals of engaging in use-inspired basic research *and* the active, intentional translation of that research into products and services. Another key goal of the NNRI ecosystem is to develop a diverse STEM and entrepreneurial workforce within its focus area and its communities. To realize these goals, each institute would be expected to forge strong partnerships in a consortium among universities, private industry, venture capital, state and local government, philanthropic foundations, and non-profit organizations. The institutes would operate at a scale, timeframe, and investment level required to truly "move the needle" via use-inspired research advances, innovation, and translation in its area. Individual institutes focused on complementary goals, particularly within a common technology sector, should be *networked* together to achieve greater national impact. The formation of such networks should be done by intentionally designed processes. Together, these institutes and networks comprise the National Networks of Research Institutes (NNRI).

NSF NNRI Workshop: A draft white paper (Appendix A) with initial framing ideas and questions on the NNRI concept was used to convene (online) an NSF-sponsored *NNRI Workshop* on May 12 and 13, 2021. Reflecting the goals of the NNRI, the workshop brought together a remarkably diverse group of leading thinkers (Appendix B) from academia, industry, philanthropic foundations, federal agencies, and non-profit organizations, as well as entrepreneurs and venture capitalists. The workshop agenda (Appendix C) consisted of keynote talks, panel sessions, and parallel breakout sessions organized around five themes.

The keynote talks and panel presentations provided important motivating context for the five parallel three-hour breakout sessions:

a. Industry and Venture Engagement
b. Regional and Sites-based Innovation
c. Management of Institutes and Networks
d. Cultivation and Development of Human Talent
e. Institute and Network Success Metrics

Each break-out session was repeated on the first and second days of the workshop, so that participants could engage in-depth for discussions in more than one topic area. This format also allowed the same questions to be considered by two different groups of participants. Additional details about the workshop can be found at the workshop website: http://gaia.cs.umass.edu/NNRI.

This report documents the workshop's findings and recommendations on NNRIs. Section 2 highlights several major themes emerging from the workshop. Section 3 provides more detailed findings and recommendations across five major break-out topics. Section 4 briefly summarizes this report.

2. Principal High-Level Recommendations

Over the course of two days of substantive, energetic, and enthusiastic discussions, workshop participants explored various dimensions of the NNRI concept. These dimensions included: global technological competition, national context, societal needs, regions and clusters, use-inspired research, technological innovation, translation, partnerships, existing research center models, STEM workforce, and more. These discussions led to the identification of key overarching recommendations that are crucial to achieving the full potential of the NNRI vision.

1. **NSF should clearly define and articulate key goals for NNRI.** NSF should emphasize that this is not yet another "business-as-usual" NSF center program. Clear statements on expected impacts, achievements, priorities, and timelines will be critical. These, along with a small number of clearly prioritized metrics, will inspire and guide science and engineering communities across the nation towards well designed research and innovation strategies as well as workforce development programs, that will attract partners from the academic, private, government, public, non-profit, and civic society sectors to ensure mutually beneficial, common goals that span research, innovation, partnerships, and implementation.
2. **Strategic and intentional decisions should be made in the initial period to quickly set the trajectory for NNRI to realize its fullest potential.** The NNRI concept is a *once-in-a-generation* transformational opportunity for the creation of long-term, high impact, marquee science and engineering research-based innovation and partnership programs in the United States. Sub-optimal decisions in early years will limit the potential for long-term benefits and impacts from NNRI.
3. **NNRI should foster diverse, flexible, and adaptive structures and approaches.** Translation and innovation pathways have industry-specific characteristics, including strategies for workforce development. Also, there is a wide spectrum of opportunities and challenges from regional perspectives. Moreover, translation and innovation are necessarily unpredictable, nonlinear, and iterative. As a result, a "one size fits all" framework for institutes and networks will not work. Adaptation, flexibility, and diversity should be expected and built into the NNRI by design. Special attention should be paid to speed and agility.
4. **NNRI should make critical enabling investments to create and facilitate broadly accessible research infrastructure platforms.** In certain emerging technology areas (e.g., quantum information science, synthetic biology, etc.), some communities of promising researchers and innovators are excluded due to lack of research infrastructure. In contrast to conventional infrastructure, cross disciplinary teams of scientists, professional engineers and developers should work together to design and build new kinds of accessible foundries and platforms that allow researchers and companies to rapidly explore novel application domains for emerging technologies. Some of these infrastructure platforms could be housed outside universities. Partnerships should be encouraged between institutes and existing federal research facilities and testing environments.
5. **Inclusion and diversity must be hallmarks threaded throughout the NNRI program.** Each institute should have clear programming to develop and attract diverse and untapped talent into high performance integrated teams from across all sectors of society, ensuring that the

benefits of technological innovation are shared across the nation. Networks should leverage synergies across institutes to scale the impact of individual institutes.

6. **NSF should play a leadership role to reduce barriers arising from burdensome intellectual property (IP) issues endemic to science and engineering research and innovation ecosystems.** Academic and private sectors can struggle with IP hand-offs, costing critical time. NSF has the convening authority and unique stature to surmount onerous barriers related to IP and push the nation forward in translation and innovation.
7. **The most enduring products of NNRI will be new generations of scientists and engineers who have a deep understanding of the processes involved in research-based innovation.** NNRI and NSF should proactively integrate cutting-edge insights from innovation ecosystems and pathways, convergence research, STEM education and training to educate these research and innovation leaders.

3. **Specific Findings and Recommendations in Five Major Themes**

The NNRI Workshop included 10 total breakout sessions, in addition to panel discussions and keynote talks. Each breakout session was organized for participant engagement to exchange ideas on focused sets of questions for deeper explorations of critical issues. Reports from breakout sessions have been distilled and synthesized with the ideas from panel discussions and keynote talks into five major themes. These syntheses are presented below.

3.a Partnerships: Framework and Engagement for Translation and Innovation

Ultimately, successful implementation of NNRI will depend on a significant number of effective and durable partnerships. While many public-private partnerships exist today, few deliver on their potential. Thus, new constructs to identify, invite, establish, maintain, and continually align incentives for partnerships are necessary. Some of these constructs can be encouraged by NSF in future programming, while others will emerge from creativity and engagement across partners to align interests and reduce barriers.

Findings:

1. **Clear definition of the objectives and deliverables of NNRI within the arc of development from research to deployment will be critical to set expectations among partners and align objectives and incentives**. Several discussions can be summed up in one question: "*What is the 'product' from the NNRI?"* The consensus was that the NNRIs should not all be the same, with a suggestion that NSF should put forward options from which applicants can choose and then set consistent structure, metrics etc. as they submit proposals. There was also discussion that the NNRIs could build upon existing NSF innovation structures to focus on the 'translation' and then engage with 'downstream' partners for further advancement. Clear definition of these 'handoffs' is essential to overcome the typical fault lines in going from research to development.
2. **NNRI must demonstrate greater inclusivity amongst participating universities, industries, and government agencies.** It's critical that the NNRI foster environments that attract and actively engage stakeholders from across the spectrum of translation: academic (from university to two-year community colleges), government (federal, state, and local), corporate, venture capitalists,

entrepreneurs, community, and users. It is essential that NNRI enable non-traditional partnerships, both in structure and participating entities.

3. **Innovation ecosystems revolve around joint need.** For example, industries are a place of deployment and universities are a place of discovery. Collaborating across their joint needs can create ecosystems in a given technology domain and/or geographical region. Other ecosystem partners should also be engaged to find common ground on joint needs. These ecosystems can nurture virtuous cycles of research to translation to deployment.
4. **Partnership contracting is a traditional barrier to innovation and could derail NNRI aspirations for new, diverse partnerships.** Time is often a barrier to innovation where various stakeholders have different and often unstated time horizons. This is especially true when IP is involved (see next). 'Time to contract' should be a lens for NSF's approach to defining any NNRI solicitation and encouraging innovative approaches.
5. **Norms and operating procedures for management of intellectual property and facilitating collaboration must be established at the start of an NNRI to engage partners successfully.** Significant discussion in almost all sessions involved questions related to intellectual property. Simplification of the IP process, such as standardization of licensing, economics, and portability of research, may be major contributions of NNRI to broader society.

Recommendations:

1. **The first NNRI solicitation should facilitate competition and creativity.** The structure, infrastructure and partners of the institute will depend on the theme/topic. For example, in a sector like healthcare, philanthropy can be a significant funder of early research. The 'partnership ecosystem' needs to be appropriately defined for each center.
2. **Engage beyond NSF's usual audience for solicitations and establish an extensive engagement and outreach plan.** Language in the solicitation should be carefully considered (through eligibility guidelines, signaling in the solicitation, engagement, and outreach) to be encouraging to applicants beyond those usually applying to NSF programs. It should attract non-traditional applied research stakeholders to step up to partner and shape some of these institutes. NSF should consider outreach across the innovation ecosystem to ensure the NNRI goals are well-understood, and the solicitation is seen in new channels.
3. **Write a solicitation which encourages partners to agree on baseline contracting terms, while also identifying some 'experiments' which can evolve.** NSF should consider the use of 'planning grants' to allow some of these experiments to be tested and then evaluated for funding into full institutes. These could also add to the best practices for implementing future NNRI programming.
4. **The term "Industry" is diverse and needs to be addressed as such.** Each industrial sector is quite different in how that 'industry's companies relate. A true partnership framework should ensure that corporates, investors, startups, and others (all part of 'industry') have aligned goals with the institute and are engaged in genuine partnerships.
    a. Membership should be tiered and flexible. Some partners might benefit from daily engagement, others quarterly, and some might just "stop-and-shop."
    b. Clearly define the membership levels, expectations, and benefits
5. **NSF should partner with other federal agencies to build ecosystem strengths.** Partnerships between NSF and other federal agencies could provide unique opportunities to accelerate translation of research and reach key objectives around workforce and economic development.

a. Engage agencies who provide core and interstitial funding in innovation ecosystems (e.g., NIH, DoE, USDA/NIFA, DoD, NIST, NASA, DOT, EPA, DHS, etc.) This engagement would leverage all assets, reduce administrative burden, and potentially bring downstream partners who currently work with these other agencies. For example, NIH and NSF could work jointly on life science or synthetic biology innovation in a region developing fundamental research capacity, translational mechanisms, industry partnerships, startup growth, and workforce development.
b. Partner with the US small business administration (SBIR and STTR) and US economic and development administration (EDA) to drive follow-on engagement.
c. Strive to reduce compliance and reporting requirements as well as overall administrative burden. Consider the government entities who work in the complementary areas that the teams would need to build the centers and then engage these entities in advance. Agencies could work to create "umbrella" MOUs that could be used for participation in multiple institutes.
d. Understand models from other entities, such as Manufacturing USA institutes and what practices may be enabling for NNRI.

6. **Co-creation and an intellectual property framework must be part of institute vision and structures**. Each institute needs to determine what these elements will look like and consider what role IP plays in different sectors. The IP and its licenses are important, but the people trained in its use are also central to technology-value creation. Policies to facilitate translation of IP must be clearly defined at the start. Ideas to consider include:
    a. Developing templates/master agreements to start negotiations and recognize that these might be different depending on the sector; maintain a focus on enabling commercialization.
    b. Consider "evolutionary IP" – a structure that allows for modification over time.
    c. Solicitation should not be prescriptive about how IP should be managed, since it may deter potential partners from participating.

3.b Regional and Place-Based Innovation

Large regions and condensed communities across the United States can be characterized by their distinct economic assets, historic and contemporary industry clusters, a trained workforce as well as untapped potential, institutions of higher education, national labs, and other public, private, and non-profit organizations. The institutes and networks that define the NNRI framework can leverage these regional and local ecosystems to create thriving communities that are economically prospering to advance national competitiveness. In the post COVID-19 world, these regional and place-based innovation ecosystems can expand with remote work and collaboration to develop larger distributed networks.

Findings:

1. **Regional and place-based innovation centers exist across the nation with untapped potential that are poised for growth.** Strategic investments that build on existing infrastructure and mine untapped human potential will significantly enhance economic development, community prosperity and national competitiveness.
2. **Boundaries that define regional innovation centers will be variable and may range from highly localized economic development sites or a collection of cities or to inclusion of multiple states**

with common economic interests. Common themes and innovation sectors across the nation can be identified from regional economic development plans and local investment, infrastructure, and talent strengths. Themes defined strategically by NSF such as energy, agriculture, quantum computing, transportation, manufacturing, artificial intelligence, communications, robotics, etc. will drive the natural formation of consortia that comprise the institute. Importantly, themes should also be encouraged and included that are radical re-imagining of approaches to global challenges, potentially creating powerful new industries that drive national competitiveness.

3. **Each region will have its own unique opportunities and challenges.** Idiosyncratic considerations will include geographic proximity, workforce pools of tapped and untapped talent, educational institutions, industry clusters, access and investment in infrastructures, and level of economic development.

Recommendations:

1. **Each institute should harness and develop its own unique assets with idiosyncratic methodologies and approaches that bridge the *push* of new technologies (often from university-centered or partnered innovations) to market *pull* resulting from regional, national, and global demands.** Build-out of a robust mesh of connected nodes that define each NNRI is expected to be orchestrated by an entrepreneurial CEO–like leader who has experience bridging innovation and translation across the corporate and academic sectors, coordinating and building supply chains, as well as critical workforce development (including K-12). Federal investment should be designed in part to stimulate critical partnerships in ways that foster collaboration and build a self-sustaining community for economic development, poised for innovation, translation, and commercialization.
2. **Institutes should consider membership models that are assembled strategically based on natural geographic connections with shared economic interests and supply chains, as well as inclusion of more remote partners when appropriate for targeted themes to provide critical bridging pieces of the supply chain and/or infrastructure that leverage regional assets.** NNRI geographic umbrellas will be defined by regional economics, supply chain, and workforce development (in particular *untapped* talent) to create an economic engine that is sustainable, as well as transformative to the nation. With the goal of establishing and growing geographically distributed economic centers, the scale of the mesh and its composition of nodes is anticipated to be variable and dependent on the assets of the region or site(s) that define the institute.
4. **Institutes and networks should establish an *all-in* culture that unites its mesh-structured community with shared investment and vision by the private sector, academic institutions, federal agencies, and government partners.** A holistic systems approach should be employed to manage and integrate discontinuous innovation successes toward translation and commercialization that will result in a greater number of geographically distributed regional economic engines to drive national competitiveness.
5. **Geographically distributed institutes and networks should take advantage of local and regional infrastructure and truly *untapped* talent.** This talent begins with K-12 and extends to regional universities, community colleges, and certificate programs that are positioned to attract and on-ramp this talent to develop sustainable economic centers in collaboration with R1 and R2 universities, as well as dedicated partnerships with MSI's and EPSCOR states that can integrate and implement inclusion programs. A "Braided River" (Recommendation 4 in Subsection 3.d) supply chain of talent should deliberately harness non-traditional career path entry points into the economic and training center of the NNRI. Clear outcomes with specific metrics (see Subsection 3.e) should be defined that are relevant to the regional and place-based innovation

site of the NNRI to yield a robust and truly diverse translational ecosystem that emerges with a goal of self-sustainability beyond the anticipated funding period of up to ten years.

3.c Management of Institutes and Networks

Management of institutes and networks was a key theme in many discussions during the workshop. Given the distinct nature of the goals and anticipated activities of NNRIs, one critical question was whether institutes should be managed differently from NSF's historical approach towards NSF Engineering Research Centers (ERCs) and NSF Science and Technology Centers (STCs). Another major discussion area was NSF oversight.

Findings

1. **Typical NSF ERC and STC management models are not likely to be optimal for NNRI institutes.** A typical NSF ERC or STC is led by a senior academic researcher, who has several other obligations at the university. Since NNRI institutes will have a significant mandate that includes translation, innovation, and partnerships, an NNRI will likely require a different management and leadership approach. They will need to attract strong, dedicated leaders with research translation experience and the ability to interact with both the academic and private sectors. These leaders may come from outside the academic research community.
2. **Management of networks will require a different approach than for individual institutes.** Networks are likely to focus heavily on coordination, communication, sharing of best practices, and leveraging of partnerships. This coordination among institutes will require a different approach to management than the research and innovation focus of individual Institutes.
3. **Typical funding models for ERCs and STCs may not be appropriate for NNRI.** Since an NNRI will bridge the innovation and translation arenas, greater flexibility and variability in funding levels and models will be necessary. Funding levels may not be precisely known at the outset and may change in response to progress and opportunity. Agility and adaptivity will be needed as translational opportunities flourish or even emerge unexpectedly.

Recommendations:

1. **NSF should embrace an entrepreneurial 'CEO' model of leadership**. An institute would ideally be managed by a leader who can make a full-time commitment to the mission of the institute, its mesh, and the overall NNRI. The goals and strategies of the NNRI must be compelling enough for the institute leader, who might not necessarily be a faculty member, to make it their primary commitment. Institutes may or may not be led by a university. Components may be university-adjacent, or university-based, as well as options for this CEO-led institute to be centered in a not-for-profit non-academic entity.
2. **NNRI management structure should be designed to achieve the desired outcomes from the institutes.** NNRI will be primarily focused on translation, innovation, and commercialization of the use-inspired research, rather than just the research. Management structures may differ as appropriate to match idiosyncratic end goals that are dependent on the technology sector, societal problem, and/or regional opportunities. NSF must explicitly signal to partners and to leaders from outside of academia that these institutes will be managed differently, such that they attract interest and partnership from the private sector.
3. **Flexibility and agility must be maintained in the financial funding model and the organization and management of individual institutes.** In addition to the traditional model of ramp-up,

steady-state, and ramp down, NNRI must have budget mechanisms that allow for appropriately increased or decreased funding. Budget agility will respond to emergent opportunities, and the need to sunset unproductive activities. Depending on the NNRI theme, budget plans and timelines are expected to vary. One size will not fit all. Transition plans, including sunsetting and personnel changes, to facilitate critical pivots should be included and updated regularly over time.

4. **NSF should be mindful of the culture and mission of other agencies.** Any partnerships should be in the service of the mission of the NNRI. Specifically, these partnerships should not cause delays, rather they should facilitate acceleration.
5. **Accountability should be primarily for outcomes.** Accountability is important to drive outcomes. Specific processes for each institute should be designed for the desired outcomes. Processes should be assessed based on outcomes. Institutes will develop hypotheses on how their approach will yield measurable results toward their specified outcomes. Accountability will in part be based on an institute's agility to pivot and change hypotheses and strategies as experience is rapidly gained. Regional institutes are dependent on economic drivers, which should define regional needs and challenges to calibrate outcomes. There could be a combination of a region defining their desired outcomes and NSF providing some cross-cutting outcomes (e.g., DEI).
6. **Engaged oversight by NSF and regular reviews in partnership with the institutes should be carried out to foster productivity, while reducing administrative burden.** Oversight should be ongoing and engaged, while striking an optimal balance between accountability and flexibility. Reviews should be carried out regularly, engaging personnel and expertise on the team to manage them. This may require NSF program officers with broad expertise, extending beyond research goals to innovation and translation metrics that measure entrepreneurial and commercialization accomplishments.
7. **Institute teams must be formed intentionally and with programming to establish synergy and growth.** Capacity building for intentional team formation with regional focus, should include partnerships with industry and other government entities, including local governments. Team-building strategies should be included on the proposal, with pre-award team building encouraged. Post award, teams should be augmented continually with NSF and its program managers empowered to fund new partner connections within the institute.
8. **Building and communication of networks needs to be organized.** Building networks and engaging other institutes should be incentivized. Some activities (e.g., early career programs) might well be coordinated across all institutes, while other activities that involve research and innovation collaborations carried out among only a smaller number of thematically linked institutes. Networks should be organized and coordinated to communicate both internally amongst themselves and externally. Workshops and other capacity building initiatives are recommended to build community and best practices. Advisory board and external non-academic organizations should be employed to identify opportunities and provide critical feedback.

3.d Cultivation and Development of Human Talent

Cultivating and engaging the human talent that will propel and sustain the institutes will be critical for their success. They will also be one of the most valuable major outcomes of the institutes. Few programs are available to prepare future leaders in translation and innovation and provide individuals with the skills necessary to bridge the gap between use-inspired fundamental research and real-world applications that empower addressing current and future societal challenges. The NNRI vision that

brings together universities, industry, nonprofit, and other community organizations presents an exceptional opportunity to develop the STEM workforce of the future. Inextricably linked with diversity and inclusion and untapped populations, workforce development should not be considered an afterthought but as a central thread throughout the NNRI mission, and a critical component of their success and sustainability.

Findings:

1. **Exposure, experience, and mentorship programs need significant improvements.** While progress has been made in recent years to improve workforce preparation, the focus of most degree programs remains mainly academic, and employers have long lamented the fact that students are insufficiently prepared to join the workforce. In STEM doctoral graduate programs, students are exposed to individuals with a focus on academic research and primarily prepared to continue in academic research. However, even that training may be inadequate, as there is seldom intentional preparation related to critical practical skills such as managing a lab and budgeting for research. If institutes are to be successful at preparing trainees to join the translation and innovation workforce, the approach to training will need to involve intentional changes in their environment, experiences, and mentorship.
2. **Significant tensions that require alignment of incentives**. Developing a translation and innovation workforce will require engaging and incentivizing multiple stakeholders and constituents. Each party brings different and sometimes conflicting priorities, needs, and goals to the table. The typical tenure and promotion process in academia rewards faculty for mentoring trainees in academia, publishing, and bringing grant dollars to the institution. Faculty should also be incentivized and rewarded for their activities related entrepreneurial activities or in attracting people to the STEM workforce.
3. **Diversity and inclusion remain major challenges in STEM workforce development.** Improving diversity and inclusion in the STEM workforce has been discussed for decades. Despite this being a central focus of many programs, progress has been slow. While there have been improvements in the diversity of degree recipients, these have not translated to significant gains in the diversity of the individuals making up the highest levels of academia, industry, and government. A lack of diversity and inclusion is not only a moral and ethical issue, but also vital to robust progress in translation, innovation, and national competitiveness. What problems are solved depends in part on who is identifying and addressing the problems.

Recommendations:

1. **Education and training programs should be designed to overcome major challenges to translation and innovation**. The milieu of the NNRI — bringing together experts from academia, industrial research and commercialization, entrepreneurship, venture capitalism, and different disciplines — may naturally address the need for trainees, and also academic faculty, to be exposed to translational work. However, institutes should ensure not only that the opportunity to be exposed to this type of work exists, but that parties have reason and opportunity to engage in a meaningful way. Institutes should look to successful examples of environments that bring together researchers from academia and industry around access to resources. Non-academic experiential opportunities should be incorporated for trainees at all levels, as they can provide critical and transformational hands-on learning. Addressing the typical academic tenure and promotion incentives will also be important to ensure that faculty are rewarded for participating in these entrepreneurial institutes and that non-academic placement of graduate

trainees is valued. While these institutes would not take on degree-granting roles, they would provide ripe environments for badging, micro-credentialing, and certificate programs.

2. **Institutes should take a holistic approach to workforce development that embeds diversity and inclusion.** While much of the discussion and examples during the workshop focused on the training of individuals pursuing graduate STEM degrees, it should also be emphasized that these approaches and opportunities should be extended to the entire workforce and into the community. Indeed, the recommendation is that these institutes take a holistic view of the workforce and recognize that development of a robust translation and innovation ecosystem will be dependent on considering activities at every stage that will offer accessible opportunities, including those that may be relevant for preK-12, veterans, and displaced workers in the community. These institutes should not only seek the best and brightest individuals from underrepresented groups, but also establish authentic partnerships with local businesses, community colleges, R2 universities, minority-serving institutions, and other relevant community groups and organizations to identify and develop additional tiers of *un-tapped* talent.
3. **Institutes should balance regional and place-based education and training with remote and virtual resource.** While the institutes are necessarily regional and place-based, inclusion of remote and virtual connections as well as short-term on-site training opportunities will significantly enhance impact by increasing important "collisions" between individuals. This includes movement of individuals across institutes with residencies or visiting scientist fellowships that bring new ideas and people that otherwise might be unable to access the institute's resources. Providing options for remote and virtual interactions can help overcome personal and community barriers for physical travel to institute sites, opening up opportunities for a more diverse range of individuals that are encumbered by their unique circumstances. Ideally, these institutes will operate as a truly interactive network and community, fostering collisions and cross-fertilization to identify and share translatable best practices.
4. **The institutes should advance the notion of STEM career pathways as a braided river or pathway, rather than a pipeline**. This model better reflects the reality of today's STEM career trajectories, accommodates life circumstances, and allows for various on-ramps and changes to sectors and disciplines. The model's embrace of diverse experiences and non-traditional paths also helps promote the sense that there is a place for everyone in STEM. The true success of these institutes will be dependent on their willingness to engrain diversity and inclusion in every aspect of the organization and culture. Just as the experiences and pathways of individuals navigating the STEM workforce are unique, each institute's approach to developing the local innovation workforce, particularly those with untapped potential, will also be different and should align with the unique strengths and features of its surrounding community.

3.e Institute and Network Success Metrics

Throughout the workshop, participants emphasized the critical need for a small set of well-defined metrics to measure success, both at the level of individual institutes and at the level of networks. This is a major challenge in the design of the NNRI program.

Findings

1. **One-size does not fit all and *a priori* metrics are difficult to develop.** Participants felt that creating a uniform set of metrics, *a priori*, would be counterproductive. Instead, the participants suggested having an overall purpose, and that local and regional innovation scaling could be one

such purpose. Participants stated that specific metrics may depend on geography, discipline, and sets of stakeholders. Furthermore, participants discussed the potential need for different definitions of intellectual merit and broader impacts for the NNRI as compared to other programs at NSF.

2. **There are concerns about having too many metrics and "metric creep."** Too many metrics could lead to NNRIs treating the metrics as a checklist. This would imperil the success of the networks, particularly if they excel at several metrics, but struggle with one. While pivoting could address a sub-par metric, it could also damage metrics that were successful. Participants were also concerned with metrics creep. They gave examples of NSF ERCs and the Department of Defense acquisition process as situations where the metrics can bog down programs rather than encouraged success.
3. **Metrics need to accommodate and exploit failure as a learning tool.** Metrics should be flexible enough that activities can fail, and failure should become part of the story for future learning and success. Metrics can also be used to help manage risks, to create contingencies from threats, and to measure resilience
4. **The goals of NNRIs include use-inspired research, translational research, and societal benefit.** NSF has historically examined ways to assess exploratory research. Societal benefits of metrics are likely difficult to develop, but translational metrics may serve as a proxy. Translational metrics could be developed around demonstrating pathways to local and domestic scaling.
5. **Metrics for institutes could conflict with metrics for networks.** Suitable care must be exercised to ensure that the success metrics for networks build from institute successes and maximize synergies among institutes.

Recommendations

1. **NSF should focus on NNRI outcomes and a small set of metrics.** NSF should develop an overall purpose for the NNRIs around which metrics can be built. Creating a uniform set of sub-metrics would likely be counterproductive. Ultimately, metrics should be simple to engage, but subtle enough for meaning. Metrics should focus on outcomes to the extent possible. Metrics should be designed to enable speed and agility and not be barriers to them.
2. **NSF needs to pay particular attention to metrics of translational impact.** Measures of scalability may be worth exploring for these metrics. Quantitative and qualitative metrics may both be useful. Qualitative metrics may include case studies.
3. **NSF/NNRIs should balance metrics of innovation and entrepreneurship.** An example of a metric of innovation is the creation of intellectual property. Metrics of entrepreneurship include engagement of industry and transfer of technology. NNRIs may need to define their own balance between these two types of metrics in ways that are unique to each institute.
4. **Proposers should suggest their own set of metrics that are idiosyncratic with the goals of their proposed institutes.** These metrics should be short, ideally one overall goal supported with targeted metrics. The metrics should also be prioritized, so as not to de-focus the NNRIs in too many directions. These metrics may come from the proposers *de novo* or may be drawn from or inspired by a palette of metrics from NSF created for sub-selection. Metrics may also be further defined across different stakeholders, such as universities, industry, and startups. Metrics for institutes and networks should be synergistic.
5. **Metrics should have an outward impact (on the ecosystem) and inward review (how to operationalize).** Metrics of impact may include additional investment (such as from venture capital or industry). There may need to be definitions for what qualifies as a pilot or other metrics of success that account for the ability to adopt and deploy an innovation, as well as its

impact on development in an area. Metrics will also be useful for inward review. Measuring internal processes may assist in NNRI success. Synergy of the network and internal communication may be particularly useful to assess.

4. Summary

The nation is at a crucial moment for the US science and engineering research, innovation, and education enterprise. NNRI is a *once-in-a-generation* opportunity to align this world-leading R&D enterprise against the major challenges ahead in technological competition, sustainable economic growth and shared prosperity, food, energy and environment, health and well-being, as well as national and global security. We hope this report, that is the culmination of input from and exchange among a broad and diverse set of United States thought leaders, will contribute to the development, implementation, and creation of a new collection of institutes and networks whose outcomes and benefits will significantly enhance national competitiveness and global prosperity.

Appendix A – Workshop White Paper

National Science Foundation (NSF) Workshop on
National Networks of Research Institutes (NNRI)
Wednesday-Thursday, May 12-13, 2021

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Contexts and Imperatives

The US faces global challenges in science, engineering, technology and education with important implications for accelerating technological changes, economic and industrial competitiveness and national security. At the same time, we are facing pressing needs in the areas of sustainable economic growth and high-quality jobs, food, energy, water, and environment, personal and population health and well-being, and inequality of opportunity. These challenges are deeply intertwined through interconnected socio-techno-economic systems of climate, environment, knowledge, people, and capital.

Driven in part by these considerations, numerous recent reports and legislation[1-9] have identified the critical need to increase investment in the US science and engineering research aimed at addressing important national priorities via sustained use-inspired convergence research at scale and a translation path for research outcomes into practice. At the same time, it is crucial that both the research and its use-inspired outcomes engage and benefit broad segments of the country. This will maintain US leadership in critical areas of science and technology, and ensure that the Nation continues to reap myriad future benefits of a world-leading R&D enterprise.

NSF has played a leadership role in maintaining US science and technology leadership since its founding. Its deep commitment to both pure and use-inspired fundamental research has helped lay the foundation for remarkable scientific, technological and innovation breakthroughs It has also played a major role in advancing human capital through science and engineering education. It is an opportune time for NSF to play a leadership role in rising to meet the challenges of tomorrow.

NSF Vision 2030: The Challenge

The National Science Board's NSF Vision 2030 report[10] articulates critical three questions that provide a foundation for developing visions and goals that will rise to meet these challenges:

- How can America keep its lead in fundamental research?
- How can American discoveries continue to empower US businesses and entrepreneurs to succeed globally?

- How can the US increase STEM skills and opportunities for all Americans?

A New Research Institute Model

Many of recent reports and legislation noted above have advocated for the establishment of regional innovation/technology "hubs", university technology centers, Industries of the Future Institutes, place-based public-private partnerships, national research centers and mission-driven laboratories. While the terminology and particular implementation specifics may vary, these calls all have a common theme of increased investment in topically-focused, large-scale, long-time-frame research centers – which we refer to as "institutes" – that would collectively drive innovation and provide transformational changes in the health, well-being, security and economic prosperity of the Nation. These institutes would complement existing Federal agency programmatics, and share many common characteristics, including:

- **Long-term research** that can leverage the **virtuous cycle of use-inspired and pure interdisciplinary research.** Solutions to many of the most important societal challenges demand deeply collaborative convergence research that brings together researchers from many different fields of science and engineering – a need that NSF is uniquely well-qualified to meet.
- **Public-private partnerships** that enable synergies among uniquely American strengths: the breadth and pre-eminence of US research universities; the depth, reach, and global leadership of US industry; philanthropic organizations; and strong state and municipal participation.
- **Innovation and technology translation**, in close collaboration with industry partners and with access to the national entrepreneurial ecosystem (e.g., venture capital, incubators) so that research advances can be rapidly transitioned into practice.
- **Scale, with timeframe and investment levels** needed to truly "move the needle" via foundational and use-inspired research advances, innovation, and translation. Longer-term timescales are need for virtuous-cycle research, where researchers and relevant community members may "co-design" in sustained experimental protypes and "living labs" at scale, and that will benefit society broadly in ways that industry cannot rapidly monetize.
- **Education, workforce, and diversity** programmatics that include in-person and virtual multi-disciplinary educational, experience-based, and entrepreneurial earning programs to help build the STEM workforce of the future with opportunities for individuals of all education levels, regardless of prior STEM experience and background.

An individual **Research Institute** would have its own science and technology goals with appropriate public-private partnerships including place-based regional alliances. Each would be funded at $100M or more over 10 years, with substantial additional investment by partnering organizations (including, e.g., support for internships and fellowships). The science and technology goals would be decided through a cooperative process that would be co-designed to leverage time-tested NSF peer review processes in combination with overarching national

strategic goals, and input from the private sector (large and small companies, venture capital, etc.).

National Networks of Research Institutes

We envision **National Networks of Research Institutes** (NNRI), where individual complementary institutes focused on a common major theme, such as clean energy, are networked together to achieve the national impact demanded in that area; NNRIs might also network with existing centers/hubs such as NSF ERCs and STCs, DOE EFRCs, DOD MURIs, and (the National Network of) Manufacturing Innovation Institutes in an area An NNRI may be composed of from one to many individual institutes, corresponding to the scale and scope of the common major theme for the NNRI. The NNRIs will simultaneously focus on the major scientific and technological goals while ensuring broad societal benefits and global leadership, achieving – science and technology advancement and societal enablement.

Workshop

The National Science Foundation (NSF) is sponsoring a workshop on **National Networks of Research Institutes** (NNRI) in May 2021 that will bring together individuals from academia; industry; philanthropy; federal, state and local governments; and non-profit organizations. Participants in the workshop will collectively define a distinctive and compelling vision for a new Institute model and NNRI in the context of NSF's mission with special focus on two key goals: (i) strengthening US leadership in critical areas through fundamental research in those areas; and (ii) fostering the economic and societal impact of federally-funded R&D. With use-inspired fundamental research as the major driver, the workshop will explore innovations in systems, structures, and processes that can deeply interconnect academic, venture capital, technology sectors, small-medium-large industry, and regional, state and federal government agencies. Such innovations will accelerate translation of fundamental advances in critical areas into processes and products that can help achieve national goals related to economic competitiveness, domestic manufacturing, national security, shared prosperity, energy and the environment, health, education and workforce development, and transportation.

The key goal for the workshop is to address the following issues:

1. What are the key defining goals and characteristics of each Research Institute? Beyond funding levels, how can the new Research Institute model be differentiated from existing NSF ERCs and STCs? How can NSF leverage prior experience with large-scale centers to develop processes for establishment of the proposed new Institutes? What are appropriate time and investment levels for such institutes? Are there ramp-up and ramp-down periods? What educational and workforce programs can be established at these institutes? What are the metrics for success? Where along the technology-readiness-level (TRL) spectrum does research within an envisioned institute fall?
2. What are the key defining goals and characteristics for a Network of Research Institutes? How can such Networks be created and managed? How can the "value

added" by the Network be measured and optimized? How does one structure the NNRI so that the geography of innovation is maximized and broad communities across the US may participate and be engaged?

3. What are the key themes (spanning both underlying science and technology areas as well as societal challenges) for formation of such Networks of Research Institutes? What characteristics define a NNRI challenge that can drive the virtuous cycle of foundational-and-use inspired research and transition research results in practice at the scale and timescales envisioned?
4. What are the roles that industry, academia, philanthropy, non-profits, and state and local governments can play in such institutes? What can each partner "bring to the table," and at what scale? How can partnerships with the private sector be created and nurtured for follow-on funding, translation and scaling for large societal impacts?
5. What characteristics align NNRIs with NSF's historic mission of supporting fundamental research, potentially expanded, relative to the R&D missions of other agencies? What proactive approaches to science management can adopted to ensure that both foundational and use-inspired research advances result from the virtuous cycle, and that these advances are effectively transitioned into practice?
6. How do we ensure that the institutes or the NNRI develop the appropriate partnerships, processes and/or ecosystem to accelerate the commercialization of new technologies that are developed by the institutes? How do we ensure that new critical technologies make it safely across the valley of death?

Short (2-page) contributions are welcome (but not required) on these and related challenges and opportunities in advance of the workshop, and will inform the actual workshop program and subsequent report. A public, written report to NSF will document workshop discussions, findings, and recommendations.

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11) The Perils of Complacency: America at a Tipping Point in Science & Engineering, Recommendation 3: a More Robust National Government-University-Industry Research Partnership
12) Engineering Grand Challenges, http://www.engineeringchallenges.org/
13) Department of Energy Hubs, https://www.energy.gov/science-innovation/innovation/hubs

Appendix B: Workshop Participants

Chike	Aguh	Chief Innovation Officer	US Dept. of Labor
Andrew	Alleyne	Ralph M. and Catherine V. Fisher Professor in Engineering, Director NSF ERC on Power Optimization of Electro Thermal Systems	University of Illinois at Urbana–Champaign
Anthony	Annunziata	Director of the IBM Quantum Network	IBM
Errol	Arkilic	Founder	M34 Capital
Tony	Boccanfuso	President, CEO	University Industry Demonstration Partnership (UIDP)
Almesha	Campbell	AVP, Div. Research and Econ. Development	Jackson State U.
Dan	Caruso	Executive Chairman, Interim CEO	Cold Quanta
Vanessa	Chan	Chief Commercialization Officer and Director of the Office of Technology Transitions	DOE
Timothy	Childs	Founder, CEO	TLC Precision Wafer Technology
Parag	Chitnis	Associate Director for Programs	US Department of Agriculture, NIFA
Luis	Cifuentes	Vice President for Research and Dean of the Graduate School	New Mexico State University
Dan	Correa	Director	Day One Project
Deborah	Crawford	Vice Chancellor for Research	U. Tennessee
Matt	Crommett	Director	LH Capital, Inc. / Lyda Hill Philanthropies

Tanya	Das	Chief of Staff, Office of Science	DOE
Simon	Davidson	Executive VP	In-Q-Tel
Tess	deBlanc-Knowles	Policy Advisor for AI, Office of Science and Technology Policy	Executive Office of the President
Juan	DePablo	VP for National Laboratories, Science Strategy, Innovation, and Global Initiatives; Liew Family Professor in Molecular Engineering	U. Chicago
Tejal	Desai	Ernest L. Prien Proessor and Chair of the Department of Bioengineering and Therapeutic Sciences	UCSF
Stephanie	Dorsey	Founding Partner	E^2JDJ
Kirk	Dombrowski	VP Research	U. Vermont
Pat	Falcone	Deputy Director for Science and Technology	Lawrence Livermore National Laboratory
Kathleen	Fisher	Chair, Computer Science	Tufts University
Laura	Frerichs	Executive Director	University of Illinois Research Park
Suresh	Garimella	President, U. Vermont; Member, National Science Board	U. Vermont
Erwin	Gianchandani	Deputy Assistant Director, CISE	National Science Foundation

Dario	Gill	SVP and Director of Research	IBM
Howard	Gobstein	Executive VP	APLU
Dorota	Grejner-Brzezin	Interim Vice President for Knowledge Enterprise	Ohio State University
Ilan	Gur	CEO	Activate
William	Heetderks	Special Senior Advisor to Director	NIH/NIBIB
Brad	Henderson	CEO	P33 Chicago
Barry	Johnson	L.A. Lacy Distinguished Professor	U. Virginia
Lara	Jehi	Chief Research Information Officer	Cleveland Clinic
Bethany	Johns	Director, Research Policy, APLU	
Corey	Jones	Founding Partner	E^2JDJ
Tom	Kalil	Chief Innovation Officer	Schmidt Futures
Randy	Katz	VP Research	UC Berkeley
Pramod	Khargonekar	Vice Chancellor for Research	UC Irvine
Sridhar	Kota	Professor, Mechanical Engineering; Executive Director, MForesight	U. Michigan

Jim	Kurose	Distinguished Professor of Computer Science, Associate Chancellor for Partnership and Innovation	U. Massachusetts
Madhav	Marathe	Distinguished Professor and Division Director, Network Systems Science and Advanced Computing Division, Biocomplexity Institute	U. Virginia
Jalal	Mapar	Sr. Advisor for Future Technologies	Department of Homeland Security
Adam	Marblestone	Schmidt Futures Innovation Fellow	MIT
Cheryl	Martin	Founder	Harwich Partners
Susan	Martinis	Vice Chancellor for Research and Innovation	U. Illinois Urbana-Champaign
Amy	Millman	President, Co-Founder	Springboard Enterprises
Fiona	Murray	Associate Dean For Innovation, Co-Director MIT Innovation Initiative	MIT Sloan Business School
Bindu	Nair	Director of Basic Research	Department of Defense
Graciela	Narcho	Senior Advisor, CISE	National Science Foundation
Aude	Oliva	MIT Director, MIT-IBM Watson AI Lab; Director, MIT Quest Corporate	MIT

Derek	Ozkal	Senior Program Officer – Knowledge Creation and Research, Entrepreneurship	Ewing Marion Kauffman Foundation
Guy	Padbury	Chief Development Office	Scorpion Therapeutics
Lynne	Parker	Deputy United States CTO; OSTP Assistant Director for AI; Director, National AI Initiative Office	Executive Office of the President
Dmitri	Perkins	Professor and Expert/CISE	U. Maryland Baltimore County, National Science Foundation
Albert	Pisano	Dean of Engineering	UC San Diego
Sanjay	Raman	Dean of Engineering	U. Massachusetts
Chris	Ramming	Senior Director of Research and Innovation	VMWare
Dan	Reed	Senior VP for Academic Affairs, member NSB	U. Utah
Chuck	Romine	Acting Chief of Staff, ITL Director	NIST
Aimee	Rose	Managing Director, Boston	Activate
Joan	Rose	Former CEO, advisor	LaunchBio
Tamera	Schneider	Associate Vice Chancellor and University Vice Provost of Research	City University of New York
Paula	Sorrell	Associate Vice President	George Mason University

Carol	Stewart	Associate VP	Arizona Tech Parks
Gabriela	Cruz Thompson	Innovation & Economic Development	Intel
Ajoy	Vase	Consultant - Special Projects	Chan Zuckerberg Initiative
Gilroy	Vandentop	Director, Corporate University Research, Intel Labs; Chair of the Board of Directors, SRC	Intel, SRC
Grace	Wang	Executive VP for Research, Innovation and Knowledge Enterprise	Ohio State University
Grant	Warner	CEA Director of Innovation, HU I-Corps, PI & National Instructor	Howard University
Gerald	Wilson	President, CEO	Autonomic Materials
Michal	Ziv-el	Associate Program Director, CISE	National Science Foundation

Appendix C: Workshop Agenda

Wednesday May 12 (all times EDT)

11:00 am – 12 noon	Welcome, Introductions, Workshop Goals. Workshop co-chairs: Pramod Khargonekar, (UC Irvine), Jim Kurose, (U. Massachusetts), Cheryl Martin (Harwich Partners), Susan Martinis (U. Illinois) NSF Vision and NNRI. Dr. Sethuraman ("Panch") Panchanathan, Director, NSF
12:00 – 12:30	Keynote: a conversation with Fiona Murray, discussion. Moderator: Cheryl Martin.
12:45 – 1:45	Panel: Models for use-inspired, translational research innovation centers. *Panelists: Andrew Alleyne (UIUC), Vanessa Chan (DOE), Dorota A. Grejner-Brzezinska (Ohio State), Adam Marblestone (MIT), Aude Oliva (MIT). Moderator: Jim Kurose.* (slides)
2:00 – 3:00 (3:00 – 3:30 break) 3:30 – 4:30	Breakout sessions. Based on your preferences, you'll be assigned an interdisciplinary breakout session. Session topics will be repeated on day 2, so you will have the opportunity to join a different session. Each session will have a chair, and a scribe. Questions that could be addressed in this session are listed at the bottom of this page. 1. Industry and Venture Engagement. Session Chair: Gabriela Cruz Thompson (Intel). Session scribe: Kelly Monterroso (NSF). Slides 2. Regional and Sites-Based Innovation. Session Chair: Deborah Crawford (U. Tennessee). Session scribe: Michal Ziv-el (NSF). Slides 3. Human Talent Cultivation and Development. Session Chair: A Pisano (UC San Diego). Session scribe: Liz Webber (NSF). Slides 4. Institute and Network Success Metrics. Session Chair: Chris Ramming (VMWare). Session scribe: Nicholas Goldsmith (NSF). Slides 5. Management of Institutes and Networks. Session Chair: Grace Wang (Ohio State). Session scribe: Goli Yamini (NSF). Slides
4:45 – 5:15	Report back from breakout groups (see slides above).
5:15 – 5:30	Wrap up, day 1

Thursday May 13 (all times EDT)

11:00 am – 11:15	Day 2 overview
11:15 – 11:45	Keynote: a "fireside chat" with Dario Gil (IBM), discussion. Moderator: Jim Kurose
11:45 – 12:45	Panel: Partnering for Impact. The NNRIs must engage in strong, collaborative relationships with other government agencies, their labs and facilities as well as the private sector to deliver research that efficiently and effectively leads to important solutions for societal challenges. This panel will share insights on identifying and engaging essential ecosystem partners into long term relationships, including how government agencies can work together to advance translational research towards the market. *Panelists: Parag Chitnis (USDA), Pat Falcone (DOE), Ilan Gur (Activate), Amy Millman (Springboard Enterprises), Chris Ramming (VMWare). Moderator: Cheryl Martin.*
12:45 - 1:15	Break
1:15 – 2:15 (2:15 – 2:30 break) 2:30 – 3:30	Breakout sessions, Day 2. Based on your preferences, you'll be assigned an interdisciplinary breakout session. Each session will have a chair, and a scribe. Questions that could be addressed in this session are listed at the bottom of this page.

1. Industry and Venture Engagement. Session Chair: Anthony Annunziata (IBM). Session scribe: Kelly Monterroso (NSF). Slides
2. Regional and Sites-Based Innovation. Session Chair: Laura Frerich (U. Illinois). Session scribe: Michal Ziv-el (NSF). Slides
3. Human Talent Cultivation and Development. Session Chair: Tony Boccanfuso (UIDP). Session scribe: Liz Webber (NSF). Slides
4. Institute and Network Success Metrics. Session Chair: Barry Johnson (U.Va). Session scribe: Nicholas Goldsmith (NSF). Slides
5. Management of Institutes and Networks. Session Chair: Kathleen. Fisher (Tufts U.). Session scribe: Goli Yamini (NSF). Slides

4:00 – 4:30	Breakout group report back, synthesis (see slides above)

4:30 – 5:15 Workshop wrap up. Wrap up: next steps and dates, closing. Workshop co-organizers, Dr. Sethuraman ("Panch") Panchanathan (NSF), Dr. Erwin Gianchandani (NSF).

Breakout Session Themes and Questions. A short description of this session, and a number of possible questions to be addressed are given below. The questions below are only meant to be suggestive.

1. Industry and Venture Engagement

1. How will industry and VC insights for innovative technologies be leveraged by the NNRI?
2. How will VC insights into large technology and market opportunities to create "pull" be leveraged by the NNRI?
3. How can/will/why industry, VC and others remain engaged in times when there may not be specific projects in which they take an active interest?
4. What is the role of philanthropy, non-profits, and think-tanks for each NNRI?
5. What structures and processes at the Institute level will maximize these connections?
6. What alternatives to traditional membership models (in ERCs, IUCRCs, etc.) should be considered? How can significant investment by industry and VCs be encouraged?
7. How can success in industry and venture engagement be defined?
8. How can industry/VC engagement with other societal benefits of the institutes that are supported be encouraged, i.e., not all the outputs of the institutes will result in new startups or small businesses but could instead give rise to open-source platforms?

2. Regional and Place-Based Innovation

1. How can competitive strengths and historical human, organizational and science/engineering resources in regions be best leveraged for successful Institutes?
2. What are appropriate roles for economic development agencies?
3. What is the role of philanthropy, non-profits, and think-tanks?
4. How can technology parks and other place-based innovation platforms be leveraged by the Institutes?
5. What is the appropriate balance between regional innovation and S&E technical innovation across the portfolio of institutes?

3. Human Talent Cultivation and Development

1. How can Institutes educate a new generation of science and technology leaders to transform innovation for societal benefits?
2. Is there something unique and distinctive for students trained and educated by the Institutes? Can a diversity of careers be encouraged that span expertise in industrial research and commercialization, entrepreneurship, venture capitalist, policy, and academic appointments?
3. How can Institutes support and develop STEM faculty that are positioned to lead successful and networked Institutes, that have broad impact across the country?
4. Can Institutes develop broadly accessible experiential curriculum for translation, innovation, and partnerships? e. How can Institutes and Networked Institutes partner with other educational

institutions (K-12, community colleges, …) to address diversity, inclusion and equity in science and technology workforce at all levels and across all pathways through the educational experiences, including at key entry/transition points?

4. Institute Success Metrics

1. How can the most appropriate and small set of success metrics for Institutes be best defined?
2. How can success metrics for Networks of Institutes be optimally defined? What is the "value added" by Networks?
3. How often should these metrics be measured? On what time scale(s)?
4. If metrics and timelines were specified today, what would these be? How specific/granular?
5. What lessons can be learnt from NSF ERCs, STCs, IUCRCs, EFRCs, etc?
6. What lessons can be learned from competitive translational consortia sponsored by other federal agencies.

5. Management of Institutes and Networks

1. Should Institutes be managed differently from NSF's historical approach towards ERCs and STCs? And if so, why is a different management approach needed? What should be preserved from this historical approach? What is most important to change? What are lessons learned from other agencies?
2. How can NSF cultivate a Network of Institutes? For example, should Institutes come together at the time of proposal formation / submission? Or should NSF try to stitch together a set of Institutes to create a Network among them, either during proposal review or post-award? In short, how can NSF ensure the whole is greater than the sum of the parts?
3. Should NSF hold Institutes accountable primarily for outcomes (and not processes)? At what time points?
4. Should NSF have a new specialized structure for seeking strategic advice from industry, venture, philanthropic foundations, and non-profit organizations? Should NSF support a non-university-based organization for identification of opportunities? At what time scale(s)?
5. How can existing NSF investments (e.g., single-investigator awards, IUCRCs, Expeditions in Computing, ERCs, MRSECs) be aligned with an Institute or Network?
6. How can best processes and practices be shared across Institutes and Networks? How can NSF encourage this sharing?
7. How can NSF best collaborate and partner with other Federal agencies to maximize the value and impacts of Institutes and Networks?
8. How might potential development/seedling activities or programs set the foundation for an institute that would be more fully developed in the future?