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**Submitted to the Committee on Commerce, Science and Transportation  
United States Senate  
for the  
Legislative Hearing on the Endless Frontier Act**

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I extend my deep appreciation to Chair Cantwell, Ranking Member Wicker, and Members of the Committee for the privilege of testifying on the Endless Frontier Act. My name is Kelvin K. Droegemeier, and I am Regents' Professor of Meteorology at the University of Oklahoma. I also am a former member of the National Science Board (2004-2016), serving the last four years as Vice Chairman. I served as Secretary of Science and Technology in the Cabinet of former Oklahoma Governor Mary Fallin (2017-2019), and most recently served for two years as Director of The White House Office of Science and Technology Policy (OSTP) and Science Advisor to the President (2019-2021). During the latter appointment, I also served for two and a half months as Acting Director of the National Science Foundation (NSF). Before going to The White House in early 2019, I served for nine years as Vice President for Research at the University of Oklahoma (2009-2018), where I have been for nearly 36 years. I am testifying today in my roles as an academic researcher, administrator, teacher, and advisor on matters of science and technology policy.

I also wish to thank the Members of this Committee for their longstanding commitment to fostering national prosperity, economic security, quality education, and international competitiveness through support for fundamental/discovery research and related activities. Not to be overlooked are staff for both the majority and minority, all of whom work exceptionally hard and in a collaborative manner on behalf of our Nation. I am especially grateful for assistance provided to me in this hearing by Gabrielle Slais, Richard-Duane Chambers, and Mary Guenther of Chair Cantwell's office, and by Cherilyn Pascoe, James Mazol, and MaryAsa England of Ranking Member Wicker's office.

The topic of this hearing is especially important in light of increasing challenges faced by the United States, both from within and externally, as well as extraordinary opportunities now before us to build upon – in bold and transformative ways – the exceptional foundation of American leadership in science and technology developed since World War II. That foundation was laid, in large part, in response to Dr. Vannevar Bush's visionary treatise, *Science: The Endless Frontier*.<sup>1</sup> The bold vision put forth by Dr. Bush led to the creation, in 1950, of the National Science Foundation (NSF), which is unique among Federal agencies in two important ways.

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<sup>1</sup> <https://www.nsf.gov/od/lpa/nsf50/vbush1945.htm>

First, NSF funds the bulk of non-medical/clinical foundational/discovery/curiosity-based<sup>2</sup> research in the United States.<sup>3</sup> Second, its governing body, the National Science Board (NSB),<sup>4</sup> also serves as an independent source of advice to the President and Congress on matters of science and technology research and education. It therefore is especially appropriate the Endless Frontier Act (EFA) seeks to continue Dr. Bush's bold, transformative thinking by providing substantial increases in funding for NSF, along with creating a new directorate and taking other actions to accelerate the movement of research outcomes to products and services that benefit society.

**Such a transformation will come about not only by virtue of additional funding, but also by thoughtfully implementing structural changes that are essential if the additional funding is to achieve its intended purpose.** Specifically, success will require creating more effective linkages and partnerships among all sectors of our innovation ecosystem; co-investing and leveraging funding, facilities and talent across academia, industry, Federal agencies, and non-profit organizations; eliminating regulations that unnecessarily tie our hands, impede our progress, and arguably provide little or no practical benefit; and securing our research assets in a manner balanced with an appropriately open system of sharing and collaboration.

Despite the terrible consequences of the global COVID-19 pandemic, it offered us a powerful glimpse of what is possible in America when the aforementioned issues are addressed, albeit temporarily. Although we do not wish to continue operating within a pandemic, we should desire to continue operating with the urgency it brought forth. We should not wish to go back to where we were in our science and technology research and education enterprise, but rather use the lessons learned from the pandemic to go to a much better place. A place of greater efficiency, better coordination, stronger leveraging and partnering, and emphasis on whole-of-Nation goals. The EFA provides one mechanism to do so and will help ensure that science continues to inspire, unite, and guide America.

I offer with this testimony several comments and suggestions regarding the EFA. We should not be comfortable as a Nation to simply compete, but rather our goal should be global collaborative leadership in science and technology research, education and innovation. Underpinned by our national values, which comport with values of the research process itself, America can remain a beacon to the world of freedom, integrity, mutual respect, progress, and principled collaboration.

## **1. Why Increased Funding for the National Science Foundation (NSF) is a National Imperative**

Created more than 70 years ago with a powerfully elegant statutory mandate and organizational structure, NSF has become the envy of the world among government funding agencies. The research it supports has unlocked the secrets of nature – from sub-atomic particles to the vastness of the universe – spurring major technological innovations, creating entirely new research disciplines, and producing generation upon generation of scientists and engineers who help ensure America's global strength in science and technology. Since 1950, over 230 Nobel

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<sup>2</sup> I prefer these terms to "basic" research because to some, the word basic connotes "simple."

<sup>3</sup> <https://www.nsf.gov/about/>

<sup>4</sup> <https://www.nsf.gov/nsb/about/index.jsp>

Laureates have received funding from NSF at some point in their career.<sup>5</sup> NSF's merit review process is the global gold standard, and only a small portion of NSF's yearly budget goes toward supporting organizational overhead.

Despite these and numerous other extraordinary attributes, NSF has been woefully underfunded for many years. The reasons are many, including difficulty by some of conceptually linking fundamental research outcomes with products and services, even though the latter are all around us (e.g., the Internet, search engines, smartphones, medical diagnostic equipment, global positioning system-based maps, on-demand commercial programming); the long time required for some fundamental research outcomes to bear fruit; and the view by some that funding curiosity-based research, without a clear practical outcome, is a waste of money.

The 2007 America COMPETES Act<sup>6</sup> sought to double, over a five-year period, the budgets of NSF, the National Institute of Standards and Technology (NIST), and the U.S. Department of Energy Office of Science (SC). Despite best intentions, this doubling did not occur then, or during the 2010 reauthorization<sup>7</sup>. In 2016, COMPETES became the American Innovation and Competitiveness Act (AICA)<sup>8</sup>, which did not include authorization levels. Yet during this same overall period, the budgets of other agencies supporting fundamental research did in fact increase, in some cases substantially,<sup>9</sup> while that of NSF grew more modestly. Today, NSF is forced to decline several billions of dollars in proposals judged to be as meritorious as those it does support, simply due to the lack of funding.

**I believe the EFA can help redress years of failed attempts to increase the NSF budget. In light of increasing global competition and threats from nations that do not share our values, an infusion of funds at NSF, along with other actions, truly are national imperatives. NSF already is moving forward on several organizational innovations, and as a major driver of change in the research enterprise, especially academia, NSF is well suited to continue its established leadership role by executing the EFA.**

## 2. The Endless Frontier Act (EFA) in Context

Each sector of America's science and technology research, education and innovation ecosystem – Federal agencies, colleges and universities, for-profit corporations, and non-profit organizations – has its own reasons for existing, its own structures and operating philosophies, and its own measures of success. Although differing from one another – in some aspects dramatically – these sectors are highly interdependent and mutually reinforcing. When brought together in tight collaboration toward common goals, each contributes what the other cannot or will not – both culturally and in other ways – yielding a whole that is far greater than the sum of the parts.

<sup>5</sup> [https://www.nsf.gov/news/news\\_summ.jsp?cntn\\_id=100683](https://www.nsf.gov/news/news_summ.jsp?cntn_id=100683)

<sup>6</sup> <https://www.congress.gov/110/plaws/publ69/PLAW-110publ69.pdf>

<sup>7</sup> <https://www.congress.gov/111/plaws/publ358/PLAW-111publ358.pdf>

<sup>8</sup> <https://www.congress.gov/114/plaws/publ329/PLAW-114publ329.pdf>

<sup>9</sup> The NIH budget increased by \$12.5 billion between FY 2007 and FY 2020, an increase of 43%. The Department of Energy Office of Science budget increased by 3.2 billion between FY 2007 and FY 2020, an increase of 84% and thus nearly doubling. The NSF budget increased by \$2.4 billion between FY2007 and FY2020, an increase of 41%.

Within this framework, it is well understood that fundamental research is funded primarily by the Federal Government<sup>10</sup> owing to the lack of certainty in producing outcomes having practical value, though value indisputably exists in the creation of knowledge itself. The national appetite for increased Government investment in such research generally has been limited, apart from health-related topics as evidenced by substantial increases to the National Institutes of Health (NIH) budget over the past several years. However, the COVID-19 pandemic has illuminated brightly the numerous other areas of science and technology that have proved essential to our Nation's response.<sup>11</sup> These include but are not limited to molecular and structural biology, *in situ* and remote sensing, advanced manufacturing, artificial intelligence, microelectronics, atmospheric science, and social and behavioral science. Each of these areas and more are core components of NSF, and indeed, NSF's "fingerprints" can be found in virtually every area of capability used to fight the pandemic. And each of these areas yielded basic research outcomes from which innovation led to practical, implementable solutions.

The EFA seeks not only to provide an unprecedented increase in funds to NSF to support use-inspired fundamental research, but also establish a new directorate for technology and innovation,<sup>12</sup> create new research test beds, centers, technology hubs, and fabrication facilities; expand engagement in research of various types of institutions; and substantially increase postdoctoral awards, graduate fellowships and traineeships, and undergraduate scholarships. Understandable fear exists among some in the community about the potential for changing NSF's foundational mission from one of curiosity-based research to one that is driven mainly by practical needs, and these concerns are not without merit.

**However, if implemented thoughtfully, the EFA can in fact enhance the capabilities of NSF, strengthening its core purpose while greatly improving the efficiency by which research outcomes are innovated for the benefit of society.** Indeed, America needs to supplement the current "handoff and hope" model of research-to-products and services transition with one that more effectively integrates all four sectors of our research enterprise without forsaking the features of any, and without placing itself on the slippery slope of use-inspired technology research becoming the tail that wags the curiosity-based research dog. The EFA can, in my view, serve as one mechanism for achieving those ends.

### 3. Comments on the Endless Frontier Act Specific to NSF

**Point #1. The Potential Risk of Displacing Fundamental Research.** As noted previously, virtually all technology innovation owes its existence to fundamental research. That America now has trillion-dollar technology companies, and numerous other high-wealth companies that depend upon technology, is a testament to the virtue of Government investment in fundamental

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<sup>10</sup> The private sector, and non-profit organizations, also fund discovery research, with the former funding nearly three-quarters of total research and development in the United States.

<sup>11</sup> Droegemeier, K., 2020. *Harnessing the power of science to fight the coronavirus*. Op-ed, *Washington Times*, August 19. Available at <https://www.washingtonexaminer.com/opinion/op-eds/harnessing-the-power-of-science-to-fight-the-coronavirus>

<sup>12</sup> NSF is structured around seven directorates: Biology (BIO), Computer Information Science and Engineering (CISE), Engineering (ENG), Geosciences (GEO), Education and Human Resources (EHR), Mathematics and Physical Sciences (MPS), and Social, Behavioral and Economic Sciences (SBE). Three other programs support cross-cutting activities: Office of Integrative Activities (OIA), Office of International Science and Engineering (OISE), and Environmental Research and Education (ERE).

research and our ability as a Nation to transition research outcomes into products and services for the benefit of society. However, **the very size and reach of our technology enterprise suggests care needs to be taken in creating a technology directorate at NSF (see below), lest technology become the focal point for new resources and ironically end up harming the very thing upon which it depends for continued success – fundamental research.**

A good example of this risk is illustrated in the field of meteorology. Both research and operations are critical for protecting life and property, and operational forecasting and warning capabilities depend upon advances in research. However, at the end of the day when money is appropriated, operations always take priority for obvious reasons. This approach led, in part,<sup>13</sup> to the United States being overtaken by Europe in computer weather prediction capabilities, though fortunately, recent investments are reversing that trend. **Fundamental or curiosity-based research therefore must remain the strong philosophical and practical foundation upon which NSF continues to be funded and operate, augmented by, but not replaced with, new mechanisms for engaging use-inspired research in technology domains that enhance America's competitiveness.**

**Point #2. Creating a New Directorate.** Although NSF indeed was founded to support fundamental or discovery research, a portion of its portfolio appropriately consists of use-inspired research. This is especially true in the Engineering, Computer Information Science and Engineering, Geosciences, and Social/Behavioral/Economic Sciences directorates, and likewise is true in research university departments. Consequently, such work is not foreign to NSF's operating framework or culture, and in fact creating a technology-focused directorate can enhance support for curiosity-based research, as noted below.

The EFA speaks to the importance of bringing DARPA-like capabilities to the new directorate, and I interpret that in at least two ways. The first includes funding more use-inspired research, issuing solicitations that seek to address specific problems, applying DARPA hiring authorities, and engaging industry directly as programs are being structured. The second emphasizes autonomy of program officers to make funding decisions that run counter to prevailing wisdom or reviewer input.

To the first point above, NSF already issues solicitations to address specific challenges and is changing the way it engages industry (see below). To the second point, although NSF program officers do have considerable latitude in making decisions, panel review, community pressure, and budget realities often lead to understandable aversion to intellectual risk-taking. This behavior is not unique to NSF but is prevalent in many if not most funding agencies. **America needs to be willing to make big bets on big ideas that could fail.**

**Consequently, if the EFA seeks to bring more of a DARPA-like culture to NSF, it should not confine those attributes to the new directorate, but rather use that directorate to help infuse positive change throughout the Foundation.** In so doing, NSF program officers would become more empowered to go against the flow and make big bets on big ideas, with some failure not only an expectation, but rather a desired outcome. **The absence of failure indicates an absence of boldness, and America will not become more competitive by being timid.**

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<sup>13</sup> Another major contributor was insufficient investment in computing resources.

Another important way in which NSF differs from DARPA is the breadth of disciplines and topic areas represented in the NSF portfolio. The new NSF technology directorate can do what other directorates already do, namely, create substantial horizontal connective tissue across directorates and thus a wide array of disciplines. However, **the new technology directorate can play an *additional and unique role*, by virtue of its special partnerships with industry and other collaborators, in linking curiosity-based research with use-inspired research and subsequent applied development and scale-up (see Point #3).**

The following specific suggestions are offered regarding a new technology directorate to address some of the issues raised above.

- a. **A new directorate should not duplicate activities** being undertaken by other Federal agencies (though in some cases competition is warranted), nor should it fund activities likely to be supported by private industry or non-profit organizations. Instead, **the directorate should partner with other components of the research enterprise, including regional, state and municipal entities, to fill gaps and leverage all available resources to achieve a force multiplier effect that accelerates innovation and greatly enhances competitiveness.**
- b. Although a new technology directorate should receive sufficient funding to pursue certain activities of its own design, such as issuing solicitations for use-inspired research, developing partnerships with industry, and managing grant and contract programs in a DARPA-like manner, **the structure and level of funding should be designed such that the directorate cannot succeed in achieving its goals in the absence of working in close partnership** with other NSF directorates and other sectors of the research enterprise, including other Federal agencies. **In other words, the directorate should inherently be designed to fail if it works only in isolation.**
- c. Changes of the nature and magnitude proposed in the EFA require a time of transition to accommodate institutional cultural adjustment (both within NSF and the external research community), the creation of required or the modification of existing administrative frameworks, and the development of implementation strategies. Yet the length of this adjustment period needs to be balanced with some urgency in light of aforementioned competition and threats. **NSF should be provided the flexibility, working closely with Congress and other stakeholders, to determine the appropriate rate at which programs are ramped up in time and funding, particularly a new technology directorate.** NSF has extensive experience doing so by virtue of the numerous new centers, institutes, and major research facilities it creates on a regular basis.

**Point #3. Engaging Private Industry and Non-Profit Organizations.** Although, as discussed earlier, the Federal Government funds the majority of non-medical/clinical fundamental research in the U.S., the vast majority of funding for applied research and development, and the transition of research outcomes to products and services, is principally the domain of the private sector (note that some private sector organizations also fund a considerable amount of use-inspired fundamental research on topics related to their business priorities). Yet the intertwined and circuitous pathway from fundamental research, say as performed in academia, to scaled prototype product or service, within industry, is fraught with inefficiency owing to factors such as numerous cultural differences among the sectors involved, the many handoff points present within the overall process, and complex legal issues, particularly those involving intellectual property, that often vary among organizations.

**Bringing all four sectors of the ecosystem together for specific activities, with each playing its unique role, creates an extraordinarily powerful framework that will truly transform American competitiveness without forsaking the value or place of fundamental research. Indeed, industry, academia, and non-profits must be at the table with the Federal Government, *from the very beginning as programs are being contemplated, so they all can truly be active participants in the entire process from fundamental research to scaled prototype.***

This point was underscored during several meetings and a national summit<sup>14</sup> coordinated by OSTP and collaborators during the past two years on multi-sector partnerships. One recurring message, delivered by private industry, was its dismay at typically being brought into discussions of partnering only as programs were being executed, and only at the tactical rather than the strategic level.

The NSF Director already has begun meeting with counterpart institutional leaders in the private for-profit and non-profit sectors to frame partnerships and programs at a strategic level, which will set the stage for, and greatly accelerate progress in, tactical execution. **Such efforts should continue in order that these sectors may co-invest with the Government as active, participatory research and development partners in executing the EFA – including in hubs, fabrication facilities, and centers.**

This co-investment should involve not only funding at the strategic institutional level, but also corporate-sponsored facilities, industry researchers, internships, apprenticeships, enhancements to I-CORPS, fellowships, test beds, and joint activities to engage traditionally underserved and marginalized populations. Indeed, the EFA seeks to create 1000 new post-doctoral awards, at least 2000 graduate fellowships and traineeships, and at least 1000 undergraduate fellowships. Industry partners could co-fund such activities and perhaps triple the number of recipients by creating prestigious NSF industry scholars and fellows, also thereby contributing substantially to increased participation by underserved populations.

**A new directorate can serve as the *organizing framework* by which to achieve the aforementioned multi-sector collaboration in technology and thus provide a means for more effectively moving research outcomes across the “valley of death” to become de-risked and tested at scale – the next step being a final prototype for production.** In this approach, NSF would not be responsible for funding all de-risking and testing at scale, but rather, by virtue of its partnerships with industry, would principally provide the organizing framework by which such activities would take place in a seamless and efficient manner – all the while preserving the cultural elements of NSF so critical to its past and future success.

Such a concept was proposed in a January, 2021 report<sup>15</sup> issued by the previous President’s Council of Advisors on Science and Technology (PCAST) and may be useful here. Specifically, PCAST recommended creating a new type of organizational framework that brings together multiple technology areas (e.g., artificial intelligence, advanced manufacturing, and

<sup>14</sup> <https://uidp.org/new-report-from-ostp-uidp-symposium-broadening-university-and-industry-engagement/>

<sup>15</sup> [https://science.osti.gov/-/media/\\_/pdf/about/pcast/202012/PCAST---IOTFI-FINAL-Report.pdf?la=en&hash=0196EF02F8D3D49E1ACF221DA8E6B41F0D193F17](https://science.osti.gov/-/media/_/pdf/about/pcast/202012/PCAST---IOTFI-FINAL-Report.pdf?la=en&hash=0196EF02F8D3D49E1ACF221DA8E6B41F0D193F17)

biotechnology) to address compelling practical problems at the intersection of such areas as a complement to recently created centers and institutes.<sup>16</sup> The organizations envisioned by PCAST would conjoin all four sectors of the research enterprise, as equal partners from the outset, and span the entire spectrum from fundamental research to prototype de-risking and scale up – all within the same administrative framework. They also would be structured with streamlined administrative compliance environments, in some cases via Federal waivers of certain requirements that unnecessarily inhibit progress, flexible personnel policies that allow researchers from all four sectors to move across organizational boundaries with ease, and intellectual property frameworks that accelerate the transfer of technology to industry.

**By following a strategic, all-sector true partnership model for certain activities, America more broadly will reap greater benefits from the EFA, and the momentum and collective partnership resources thus established will provide a mechanism to help ensure long-term sustainability.**

**Point #4. More Innovative and Efficient Models for Centers and Hubs.** NSF and other agencies have been funding university-based research centers, institutes and facilities for several decades. Although this mode of funding has proven successful, the increasingly prescriptive nature of such efforts, driven in large part by today’s burdensome and complicated compliance environment and general aversion to intellectual risk-taking, suggest that modified structures should be pursued. This issue was addressed in the aforementioned PCAST report, which identified a number of significant limitations with current research organizational models and suggested a new multi-sector framework that would stimulate new ideas, simplify collaboration among types of institutions, and accelerate the movement of fundamental research outcomes to products and services at scale, all within the same general framework.

**The centers and other entities proposed by the EFA, as well as programs such as EPSCoR (Established Program to Stimulate Competitive Research), could serve as experimental proving grounds for new organizational approaches, including accelerated approvals and waivers of certain compliance requirements and new personnel structures.** One need look no further than the COVID-19 pandemic for a compelling example of such an experiment. In *one week*, several organizations joined forces to establish and begin executing a consortium that made huge amounts of both public and private computing time available to researchers, free of charge and with rapid proposal review, to understand the virus and begin developing vaccines and therapeutics. Under normal circumstances, this effort would have taken months to establish.

**Point #5. Broadening Engagement.** A particularly significant component of the EFA involves programs which seek to engage a larger segment of America’s academic research and education enterprise, especially emerging research institutions, emerging institutions of higher education, Historically Black Colleges and Universities (HBCUs), Minority Serving Institutions (MSIs), and Tribal Colleges and Universities (TCUs). I can well attest that extraordinary research accomplishments and talent can be found in all parts of our great Nation, especially in rural and underserved areas, and in institutions which are not research powerhouses but are becoming more engaged in research with a great deal to offer. I also am quite aware that a great number of capable individuals never have an opportunity to develop their talent or achieve their goals and

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<sup>16</sup> For example, the U.S. Department of Energy Quantum Information Science Research Centers and NSF National Artificial Intelligence Research Institutes.

dreams, whether by virtue of their race, ethnicity, socioeconomic status, or other circumstances. **Taking firm action to address these and other issues is essential, and in doing so, two important factors need to be considered.**

**The first concerns institutional culture.** Many emerging research institutions have well established and highly regarded reputations for instruction, with faculty incentive and reward systems likewise structured. Enhancing research in substantial ways most likely will require faculty to reallocate their time, thus reducing their formal teaching activities so they can spend more time writing grant proposals, managing awards and facilities, and mentoring student and post-doctoral researchers. All of these are positive activities and foundational to research in academia. However, because notable increases in such activities can impact both institutional culture as well as existing personnel policies, these and other impacts need to be fully understood by the highest level of institutional leadership. Consequently, **leaders of emerging and other types of research institutions named in the EFA should be engaged as soon as possible to understand how their institutional cultures and policies might need to change, if such change is desired, for them to accommodate greater research funding.**

The second issue concerns the **administrative frameworks needed to support research grants or contracts and associated compliance requirements**, such as financial and other management activities, intellectual property management, legal review, space allocation and tracking, reporting to state and Federal organizations, and research security. Many emerging research institutions have relatively small research offices that are not presently equipped to handle significantly larger numbers of, or more complex research grants and contracts. Nor do they likely have the funding to create or enhance them. Consequently, **some of the funding from the EFA should be used to create new or enhance existing institutional research administration capabilities.** This funding could be provided for a limited period, until such time the institution can absorb the costs by virtue of increased research revenues.

**Point #6. Discovering Emerging Intellectual Property.** Despite the fact that America invests nearly \$600 billion per year in research and development, only limited mechanisms exist, to my knowledge, with which one can identify and then explore emerging research outcomes to determine whether a particular activity holds sufficient promise for possible corporate investment. Some funding agencies have powerful databases with which the public can use keyword searches to obtain plain-language summaries of current and past research projects. Yet, if a small company, for example, is interested in research on a particular topic and wishes to determine which Federally funded projects on that topic are nearing completion – and explore their results to date and contact the investigators – existing databases are not designed to readily provide such information

If the technology goals of the EFA are to be met, **America needs a more effective mechanism for linking progress and outcomes in research to those who wish to innovate with them.** Yet doing so in an open manner creates obvious vulnerabilities at a time when theft of ideas, proposals, and intellectual property by certain foreign governments is a real and significant threat to America's competitiveness. If a new NSF technology directorate is established, it should coordinate with NSF and other organizations to consider ways for addressing these competing needs.

**Point #7. Test Beds and Fabrication Facilities.** The EFA suggests test beds and fabrication facilities would be located at universities or consortia of academic institutions, which indeed would be valuable for enhancing education and research. However, the private sector already operates substantial facilities that could function as test beds and be used for fabrication through creative partnerships with academia. In particular, use of such facilities could be linked with internships and apprenticeships as a mutual value proposition, which would be particularly important for emerging institutions. Additionally, a partnership strategy would enhance the likelihood of sustainability as some academic institutions, especially emerging institutions, may not be positioned to absorb out-year costs of facility maintenance, staff support and upgrades.

**Point #8. Timing and Allocation of Funds.** NSF is a highly sophisticated and effective Federal agency that operates with great efficiency and transparency, and works closely and successfully with both the Executive and Legislative branches of Government. It also has extraordinary leadership in its Director and governing board. **Consequently, NSF and the NSB should be provided maximum flexibility and freedom, with obvious continuous oversight from Congress, to execute the EFA as it deems most appropriate for achieving the stated goals.**

#### **4. Comments on the Remainder of the Endless Frontier Act**

In addition to changes associated with NSF, which include creating a new directorate, establishing several University Technology Centers, creating test beds and fabrication facilities, directing funds to STEM education, enhancing existing research programs, and broadening engagement in research and technology commercialization, the EFA seeks to establish several Regional Technology Hubs. Consideration also is being given in Washington, DC to substantially expanding the current Manufacturing USA Institutes (MUI) and Hollings Manufacturing Extension Partnerships (MEP). Collectively, this represents an extraordinarily large and complex endeavor which underscores the well know adage that it is far easier to create than coordinate. Thus, several important issues need to be addressed if the proposed infusion of significant funds, and the associated creation of large and complex activities in America's research and technology enterprise, are to work as needed.

First, as noted previously, America's innovation engine suffers from a number of inefficiencies, including the lack of a seamless national framework by which multiple sectors of the enterprise can seamlessly transition fundamental research outcomes to scaled prototype products and services. It is unclear how investments in the Department of Commerce will avoid reinforcing challenges with existing handoff points and address the "valley of death" problem?

Second, although the EFA speaks to the importance of coordination with the MUI and MEP programs, it does not address the many ways in which a new NSF directorate, or increased NSF activities in technology-driven fundamental research more broadly, could contribute to enhancing both the MUI and MEP programs or lead to new, innovative approaches for executing the MUI and MEP missions. Nor does it address how MUI and MEP might coordinate with and enhance NSF activities, especially corporate engagement, which is foundational to both MUI and MEP. This interaction is especially important in light of ways in which MUI and MEP can enhance engagement with emerging institutions, which is a significant aspect of NSF's focus in the draft bill.

Third, the proposed Department of Commerce Regional Technology Hubs appear designed to create confederations of stakeholders within multiple sectors of a region with the goal of enhancing technology development, creating jobs, and transforming local and regional economies. Although this is an important and valuable idea, such top-down approaches often fail to align stakeholders with common goals because they lack a “grass roots” push. Once again, coordination is one of the many challenges needing to be addressed. If the Hubs are scaled as described in the bill, at roughly \$1B per award, additional clarity is needed regarding how the confederations would be structured and managed to “create the conditions” for economic development and education enhancement. Additionally, how would such large funding complement new investments made within NSF as well as programs such as MUI and MEP – all of which are candidate components of a confederation?

Fourth, throughout the EFA, coordination and collaboration among multiple Federal agencies is rightly cited as critical to success of the programs described. Such coordination historically has proved extremely difficult, particularly for the scale and complexity of programs envisioned in the EFA and in light of the multiple stakeholder sectors involved. One possible coordination mechanism would be to create a special, select or joint committee within the National Science and Technology Council (NSTC), co-chaired by OSTP and the Office of Management and Budget (OMB) and involving NSF, the Department of Commerce, and other departments and agencies as deemed appropriate. Based upon my experience with major multi-agency Government programs, front-line OMB involvement is essential for ensuring inter-agency coordination.

Finally, multiple undertakings as large as those proposed in the EFA will create extraordinary challenges in accountability, especially with regard to evaluating how the collective of the activities are achieving more than the sum of their individual parts. To be effective, the various elements need to work together in ways different from and more effective than previously, which creates complex interdependencies. This is a feature and not a limitation, but will require careful thought in how success is defined and measured, and how the various EFA elements contribute to success individually and collectively.

## 5. Final Thoughts

America today boasts the greatest research, education, and innovation ecosystem in the world. Although we do not lead in every area, the collective of our four-sector enterprise, underpinned by our values, is unmatched. Yet we face unprecedented threats and competition. **By bolstering and weaving together all elements of our research enterprise in powerful new ways, without compromising the identity, culture and value of each, and by appropriately resourcing NSF, we will help ensure not only that America becomes more competitive and broadly engaging, but also that it continues as the global leader in scientific and technological research, education and innovation.**