

**APPROVED MINUTES
PLENARY OPEN SESSION
477TH MEETING
NATIONAL SCIENCE BOARD**

National Science Foundation (NSF)
Via Videoconference
February 23 – 24, 2022

Members Present:

Ellen Ochoa, *NSB Chair*
Victor McCrary, *NSB Vice Chair*
Sudarsanam Babu
Roger Beachy
Arthur Bienenstock
Maureen Condic
Aaron Dominguez
W. Kent Fuchs
Suresh Garimella
Darío Gil
Melvyn Huff
Steven Leath
W. Carl Lineberger
Matthew Malkan
Emilio Moran
Julia Phillips
Dan Reed
Anneila Sargent
Scott Stanley
S. Alan Stern
Stephen Willard
Heather Wilson

Members Absent:

Sethuraman Panchanathan, *ex officio*

There being a quorum, the National Science Board (NSB, Board) convened in Open Plenary Session at 11:00 a.m. EST on Wednesday, February 23, 2022, via videoconference with NSB Chair, Ellen Ochoa, presiding.

NSB Chair's Opening Remarks

Ochoa welcomed everyone to NSB's 477th meeting. She began the meeting by outlining highlights of the agenda. Ochoa took a moment to acknowledge February as Black History Month, the outstanding Black scientists that have contributed to the science and engineering enterprise and to affirm the Board's commitment to the missing millions in particular the Board's statement on racism from June 2020 and the board's commitment to act intentionally to remove barriers and ensure that the science and engineering(S&E) environment is one in which all are respected and valued. Ochoa concluded her remarks by condemning the recent bomb threats at Historically Black Colleges and Universities (HBCUs). Ochoa then turned the meeting over to NSF Director Sethuraman Panchanathan.

NSF Director's Remarks

NSF Director Sethuraman Panchanathan began his remarks by joining Ochoa in celebrating Black History Month and acknowledging NSF staff accomplishments including facilitating a celebration of Martin Luther King Day and raising \$200,000 for causes important to the D.C., Maryland, and Virginia area through the Combined Federal Campaign. He also noted that for the first time, NSF received an A-plus rating on the Federal Information Technology Acquisition Reform Act or FITARA scorecard.

Through a series of slides, Panchanathan summarized activities since December 2021, including a new national strategy, announced by NSF and the White House Office of Science and Technology Policy (OSTP), to help ensure that U.S. remains a global leader in quantum information science and technology by engaging with youths in the yearly states of quantum education. The Director continued by highlighting examples of the impact of NSF-funded research recently and over the decades and how those investments are anchored to NSF's three major priorities aligned with NSB's *Vison 2030*.

Panchanathan outlined that in 2022, NSF would be looking to expand existing collaborations with partners in industry, academia, and government and specifically highlighted the Resilient and Intelligent NextG System (the RINGS program) and the Platforms for Advanced Wireless Research (PAWR) as examples of NSF's commitment to partnerships with industry. NSF's newest collaboration is with Intel and focuses on supporting research and workforce development to advance semiconductor design and manufacturing involving a \$50 million commitment from Intel and NSF spanning over a 10-year period and is part of Intel's new semiconductor manufacturing investment plan. Through research and education, the initiative will address the immediate semiconductor manufacturing workforce shortages and encourage other professionals to transfer and integrate into the semiconductor workforce. The Intel and NSF collaboration aims to promote diversity among the semiconductor workforce by encouraging access to semiconductor technology opportunities by focusing on minority-serving institutions, community colleges and predominantly undergraduate institutions.

In the spirit of NSF's vision and NSB's *Vision 2030* for expanding the geography of innovation, the Director highlighted NSF's I-Corps program and how over the last decade a network of sites

were established in more than half of U.S. states. He explained that in 2021, NSF awarded regional I-Corps hubs for more compact integration and engagement amongst academic institutions, including minority-serving institutions and R2 installations.

Panchanathan pivoted to the benefits of NSF having shifted to a remote and hybrid work environment over the last two years, one of them being the ability to engage with individuals across institutions, academia, industry, and government quickly. The Director then outlined his engagements since December some of which included meeting with the AAU Council on Federal Relations Conference in early January, the Minister of Information and Technology from South Korea along with other global and U.S. leaders of states, the Alliance of Hispanic Serving Institutions' president and chancellor to talk about ideas for partnership and progress in addressing the missing millions. Along with Victor McCrary, he met with Association of Public and Land-Grant Universities (APLU), Council of Presidents and Chancellors to gather input on how best to make progress in all institutions across the U.S. The Director also participated in a meeting with American Association for the Advancement of Science President Sudip Parikh, the President of Olin College Gilda Barabino and the Vice President of Amazon Babak Parviz to talk about partnerships with academia and industry. Finally, he also spoke with the Association of International Education Administrators about how to build a talent pool in the U.S. and encourage ambassadors of international students that go back to their homes and become partners for future collaborations.

Cool Science

Panchanathan introduced “Cool Science”, a series of presentations by NSF Assistant Directors (ADs) of examples of NSF-funded research and resulting impacts. The examples were presented by NSF ADs of NSF's Engineering Directorate, the Mathematical and Physical Sciences Directorate, and the Directorate of Biological Sciences.

The Equity Ecosystem at NSF

Panchanathan introduced this session as one that was designed to build on August and December 2021 presentations about NSF's DEIA activities and update members on efforts to meet related executive orders and the status of NSF's Racial Equity Task Force (RETF) and recommendations. This presentation would be an overview of NSF's external activities with the scientific community, NSF's internal efforts with its workforce and how research activities are linked together to improve the equity ecosystem external to NSF. Panchanathan introduced the presenting NSF staff including Alicia Knoedler, of the Office of Integrative Activities (OIA), Rhonda Davis and Javier Inclán of the Office of Equity and Civil Rights (OECR), and Wonzie Gardner, of the Office of Information Resource Management (OIRM).

Knoedler began by stating that the objective of the presentation was to promote a better understanding of how NSF organizes activities, measures and mechanisms that used in equity and broadening participation work. Knoedler stated that diversity and inclusion is an NSF core value and is featured in strategic plans. The NSF strives to maintain a staff that is representative of the U.S. population and the STEM community, and that ensuring inclusivity in STEM is one of the three pillars of NSF's vision.

Davis presented some highlights of the history of NSF's equity and broadening participation endeavors including EPSCoR established in 1979, the Committee on Equal Opportunities in Science and Engineering (CEOSE) in the 1980's, NSF INCLUDES in 2017 and most recently the Office of Diversity and Inclusion was reorganized and renamed the Office of Equity and Civil Rights. Davis explained that most of NSF's equity work is driven by presidential executive orders, government-wide regulations, and agency-specific regulations. The Biden Administration (the Administration) issued nine executive orders that have a DEIA component and the responsibility for meeting the requirements is distributed across NSF. Davis provided an update on three of the executive orders focused on program delivery on which OEER is the lead or co-lead. She added that in response to one executive order, NSF recently submitted its equity plan focused on optimizing demographic data collection and equity assessments which was led by NSF OEER, the Office of Budget, Finance and Award Management (BFA), and OIA.

Inclán described NSF's efforts to meet the requirements of a fourth executive order regarding NSF employees and applicants (EO 14035), resulting in a DEIA strategic plan due to the Office of Personnel Management on March 23, 2022. Gardner added the Administration issued one executive order for DEIA which focuses on employees and applicants. In response to, and as a result of surveys and listening sessions, OIRM updated a policy which was perceived to be a barrier to growth opportunities for NSF workforce and a threat to the strength of NSF's competitive pool process.

Knoedler began the next segment of the presentation on NSF's broadening participation portfolio of programs and engagement activities. She took a moment to explain that DEIA activities are not only focused on internal activities such as NSF employee care and service, nor are broadening participation activities only focused on external activities such as delivering NSF's mission to support basic research and people, but that there are points of intersection that require shared knowledge and advocacy.

Gardner turned to an update on NSF's RETF report. Gardner explained that Panchanathan established the RETF before the executive order on Advancing Racial Equity was issued and its charge was to examine the potential for racial barriers and make recommendations to address and extinguish the barriers permanently. The RETF has an internal focus on employees that complements the DEIA executive order and an external focus on program delivery that complements the racial equity executive order. In January, NSF began stakeholder engagement with employees and is beginning to distill feedback as it transitions to the implementation phase. Gardner described some of NSF's accomplishments include developing a civil rights system to receive, track, and adjudicate external civil rights cases at universities and colleges receiving funding from NSF, incorporating a nondiscrimination clause into NSF's Proposal and Award Policies and Procedures Guide, and establishing a working group to address demographic data of staff hired under the Intergovernmental Personnel Act authority for a more inclusive applicant pool.

Knoedler then turned to the subject of broadening participation as a piece of the equity ecosystem related to program delivery. Knoedler described the framework first developed by the former head of OIA Suzie Iacono and how NSF activities are organized within the framework into four conceptual areas; research, education, research infrastructure, and outreach/in-reach and

partnerships. Some examples of activities and programs in the four areas include updating the broadening portfolio of funding programs, improving shared knowledge and awareness, defining accountability activities, developing goals and metrics related to inspiring the Missing Millions, creating new approaches to build institutional research support, and engaging broader populations of experts and innovators stressing the importance of partners.

Board members and the presenting NSF staff then engaged in a question and answer session. Anneila Sargent, Chair of the NSB Committee on Oversight asked whether NSB could review NSF's DEIA strategic plan before it is completed and submitted to OMB to which they agreed. Sargent stated that she was aware that NSF's Directorate for Computer Information Science and Engineering has a diversity, equity and inclusion strategic plan and asked whether other directorates have them. Knoedler responded she believes other directorates are moving in that direction but is unaware of any formal or written plans.

Following and related to Sargent's questions, Suresh Garimella asked how NSF was working to get to a place where everyone at NSF feels responsible for increasing diversity. Knoedler referred to a report issued by CEOSE several years ago on accountability including information to guide investigators, institutions and NSF toward actions and contributions in this area. She agreed that everyone is responsible and noted challenges in the area of knowledge sharing and management and coordination of activities. Davis added that this landscape analysis of NSF's equity footprint was done in part to coordinate the equity components and resulted in a recognition of the need for accountability and metrics across the foundation. Inclán added that this team wants to bring DEIA into the culture of NSF. He emphasized the importance of a DEIA communication strategy and described plans to develop a demographic dashboard so that everyone at NSF can see what the NSF workforce looks like and that all activities are seen through a DEIA lens. Panchanathan rounded out the team's response by describing the components needed to establish the desired culture including valuing diversity and inclusivity, understanding and removing barriers, developing tools to help with accountability and track program progress and training.

Victor McCrary offered that NSF should meet regularly with other agencies such as NASA and the Department of Defense (DoD) on the topic of DEIA and should consider expanding the ecosystem by including university representatives on advisory groups and boards. Panchanathan agreed and noted that near constant engagement with institutions of higher education provides NSF staff with opportunities to listen and adopt ideas toward greater diversity. Panchanathan explained that this thinking is in part, what led to the hiring of this presenting NSF team.

Chair's Activity Summary

Ochoa presented a summary of her activities since the December 2021 meeting. During this time, activities related to the release of the 2022 State of the U.S. Science and Engineering Indicators report on January 18th. Along with the Chair of NSB's Committee of Science and Engineering Policy, Julia Phillips, Ochoa participated in four virtual briefings to the press, to OSTP and OMB staff, to Senate and House Science Committee staff, and then to the general science and engineering community in which over 500 attendees from across the country tuned in, representing universities, science in higher education associations, industry, federal agencies, and

other congressional staff. Ochoa, along with Phillips, also did an *Indicators* rollout-related radio interview in New York State. Ochoa extended her gratitude to Phillips as well as other NSB members who helped disseminate NSB's work, the team at the National Center for Science and Engineering Statistics (NCSES) and NSB office (NSBO) staff.

In February, Ochoa, Sargent and Roger Beachy were invited to the CEOSE board meeting to present and discuss NSB's perspectives on the geography of innovation. NSB members shared the *Vision 2030*, in particular how the board is prioritizing the topic of geography of innovation this year. Ochoa and members shared several maps from the state Indicators report to illustrate variations around the country in college affordability and federal and business investment in research and development.

Session 2 (February 23, 1:00 p.m. – 1:45 p.m.)

NSB Chair/NSF Director Speaker Introduction

Ochoa introduced Dr. Stefanie Tompkins, Director of the Defense Advanced Research Projects Agenda (DARPA) noting that Dr. Tompkins has spent much of her professional life leading scientists and engineers in developing new technologies and has held positions at many levels at DARPA before becoming the Director. Ochoa noted that NSF has long partnered with DARPA in many ways and noted looking forward to learning more about DARPA's approaches to broadening participation, best practices for forging successful partnership, and how NSF and DARPA can most effectively work together to advance common goals in economic development and national security. Ochoa then turned the floor to Panchanathan for an introduction. Panchanathan proceeded with a more in-depth description of Dr. Tompkins' experience highlighting the span across federal government, academia and private sector and putting into motion many translational activities. He also emphasized some common goals of NSF and DARPA as well as the benefits of partnerships in general. Panchanathan then turned to floor to Dr. Tompkins for her presentation.

Director of DARPA, Dr. Tompkins

Tompkins began her presentation with a brief history and mission of DARPA. Tompkins continued her presentation with a slide depicting a timeline of some of DARPA's biggest systems from stealth aircraft, unmanned aerial vehicles to miniaturized GPS receivers, to transformative handheld systems, and on to partnerships with NSF and other science organizations across the research ecosystem which she described as having been particularly fruitful, including Siri and mRNA vaccines. Tompkins then spent some time describing the organization touching specifically on people, processes, and culture.

People

DARPA employs 90 to 100 program managers from military, university, or private sector laboratories for a term of about four years. With a budget of about \$3.5 billion and minimal bureaucracy they are encouraged to use their time at DARPA as effectively as possible.

Processes

DARPA has no in-house labs and with very limited funding going to the maintenance of infrastructure in order to remain nimble. The vast majority of DARPA's budget goes directly to partner institutions and the research performing community. The agency is metrics driven and all programs have end dates and off ramps. Using measurements, DARPA determines whether a program is successful along the way and if its falling short, the program is ended early.

In order for DARPA to begin a project there must be a national security justification but commercialization is considered as it relates to being able to realize national security benefits. She used the development of nucleic acid based vaccines as an example of something developed to protect service members facing potential diseases all over the world and how being able to rapidly produce a vaccine when facing a pandemic would benefit the public as well. She also highlighted that DARPA invented the ARPANET for military purposes and then NSF turned into NSFNET which together with universities grew into a rich research network. Policymakers later wrote legislation that eventually turned NSFNET into something the general public uses today. She referred to this as an ecosystem-level transformation.

Before DARPA starts a program, a program manager must be able to answer briefly a series of questions: What are we trying to do? How is it done today and who does it? What are the limitations to the current approaches? If we succeed what difference do we think it will make? How long do we think it will take and what are our mid-term and final exams? How much will it cost? Once the questions are answered satisfactorily, a budget is allocated and the entire agency supports the work to release a broad agency announcement, to take in and evaluate proposals, get contracts out as quickly as possible, and execute the vision.

Culture

Tompkins described the culture as being about "racing forward and trying to achieve as much as possible in a fairly limited timespan, but at the same time with fairly generous resources". DARPA looks for opportunities to accelerate some particular technology, works on it and then moves on to the next topic. She sees DARPA as an accelerator which is prepared to fail and not failing can be a sign of not taking enough risk. DARPA's role within the ecosystem is to focus on paradigm shifting solutions – the agency tolerates risk and celebrates it. DARPA tends to develop its strategy a little bit after the fact and based on what is happening in the world. Tomkins highlighted an innovation in contracting that allows the agency to rapidly explore new concepts. DARPA might launch a new announcement for a project for 18 months at \$5 million and within 90 days of the announcement staff are under contract and ready to start work. Some of these projects then turn into bigger DARPA programs or might be moved off into another organization for a different kind of development. DARPA focuses on four to five-year out goals which includes achieving a certain end point, but also driving technology during that time. DAPRA is driven to take risks and be as disruptive as possible and that is done in part by keeping employees outside their comfort zone to encourage a steady stream of new ideas. Tompkins offered that she sees NSF and DARPA as complementary and that to have both in the ecosystem is healthy.

Tompkins spent some time describing DARPA's portfolio of projects over the next five years including AI technologies, unmanned vehicles, supply chains, as it relates to raw materials, pharmaceuticals and microelectronics, software and hardware that cannot be hacked and exploring ways to access rare earth elements in the U.S. in a way that is environmentally acceptable and economically. During the COVID pandemic managers at DARPA thought about the interconnectivity between national security and economic security from an individual to national level. DARPA does have some technical offices but they are also very flexible. Some of those offices focus on microsystems and biology and quantum information where there are a lot of cross-disciplinary opportunities. Recent brainstorming amongst DARPA leadership involved exploring something the military calls "gray warfare" which involves economic and information warfare.

Other areas of exploration by DARPA include climate and environment research, methods for developing, testing and evaluating new technologies through modeling and simulation, in part to bring costs down, and transition in business. Tompkins offered that DARPA's interest in "transition in business" might be of particular interest to NSF as it considers how it brings results of research into the real world. DARPA's customer is the DoD which allows the agency to follow military acquisition paths, but is also interested in pursuing commercial pathways. DARPA has some extensive programs to assist startups so certain technologies can be moved into use as quickly as possible. Tompkins concluded her presentation by saying that DARPA has a strong ethos for thinking about ethical, legal, and societal implications of its technologies and are informing policymakers and business models with what some of the potential unintended consequences of new technology might be to prevent surprise by some new capability.

Tompkins took questions from Board Members. In the context of transition to business as an area of growth in activity for DARPA, Gil asked Tompkins for her thoughts on why DoD continues to struggle to bring AI to scale. Tompkins responded that it depends on the technology, the timing of introduction, policy, culture, and possibly because DARPA is looking at the technology differently than the commercial world and it might make sense for other organizations that are better suited to look toward scale. Suresh Babu asked Tompkins how federal agencies could adopt best practices for developing partnerships, contracting and research program execution quickly. Tompkins responded that there is a lot of room for innovation and creativity in federal contracting. She advises program managers not to tell contracting staff what to do, but what the outcomes of the program need to be. This kind of thinking led to "Other Transactional Authorities" which DARPA invented decades ago. In Tompkins experience, contracting staff can be just as creative as technical program managers if given the opportunity. Stephen Willard asked how DARPA handles intellectual property and who gets the patents. Tompkins responded that DARPA follows federal government regulations and the performing institution gets the patents and the intellectual property is theirs. DARPA's position is that the patent should be owned by the inventor and if the invention is not advanced or accelerated by the inventor, DARPA/the federal government retains government purpose rights and thereby the ability to use the technology for other contacts and other projects. Garimella asked Tompkins why so many organizations established after DARPA have failed. In light of NSF's launch of its new Technology, Innovation and Partnerships Directorate, Garimella asked what advice Tompkins had to offer. Although Tompkins responded that not everything DARPA does is essential to its culture, she noted that some of DARPA's organizational tenets are necessary and

most organizations that have failed have refused to accept or adopt some of the pieces necessary for success. She highlighted one practice that NSF already has incorporated which is the rotator which she likened to DARPA's short-term research staff.

Panchanathan asked one last question about the types of metrics DARPA uses to signal progress and success. Tompkins conclude her remarks by offering that too much focus on metrics can mean concentration on the wrong things and too little emphasis could lead to missing important points. Tompkins advised asking and answering two questions; 1) What is it that we want to demonstrate; and 2) How will I know if we've made progress?

Ochoa brought this session to conclusion by thanking Tompkins for her presentation and informed members that the next session would be led by NSB Vice Chair Victor McCrary.

Session 3 (February 23, 2:45 p.m. – 3:45 p.m.)

Committee on Awards and Facilities report

McCrary welcomed everyone back from the break and turned the floor Dan Reed, Chair of the Committee on Awards and Facilities (A&F) for a committee report out. Before providing details about the presentation, Reed informed the Board that over the next couple of meetings, A&F would be considering several context and action items on Operations and Management awards for NoriLab and MagLab and for the inclusion of a Leadership Computing project in a future Major Research Equipment and Facilities Construction (MREFC) budget and the action items following in August. Reed pointed out that the preferred approach is to have the same members serve as lead reviewers for both context and action items, but because several experienced Board Members would be rotating off the Board between May and August, A&F would be reaching out to Members beyond A&F with a request to serve as lead reviewers for these upcoming facilities reviews.

Reed began by reporting that the A&F committee met in an open session on February 22, 2021 to hear a design stage presentation from NSF's Geosciences Directorate on the Antarctic Research Vessel known as ARV. He explained that ARV presentation was part of A&F's work to implement the *Vision 2030* roadmap item of delivering benefits from research and a pilot allowing A&F earlier engagement in the lifecycle of major infrastructure projects, specifically as projects move from development to design stage, in the spirit of more insight and understanding of tradeoffs across projects. Although this project was a bit further along in the design stage, Reed thanked NSF staff Alex Isern and Roberta Marinelli for being active participants in this process and being receptive to committee feedback. Reed reported that the process was useful and it resulted in thoughtful and robust discussion about the ARV.

Reed described the science case as compelling explaining that the current vessel, the Nathaniel Palmer, is 30 years old and is approaching the end of its service life. The ARV, with expanded scientific and icebreaking capabilities, should enable research in critical locations, and in places that were not possible with the current vessel, to answer questions about the changing Antarctic environment and climate change more broadly. The ARV is also a high priority of the advisory committee to the Office of Polar Programs.

Reed explained that for future briefings, the committee asked to hear how NSF is prioritizing projects across the agency because there are a number of potential projects on the horizon and there may not be enough funding to support them. Over the past decade, new MREFC projects have come to the Board at one time, but going forward, projects may come to the board in more of funnel where the Board and NSF will have to collaboratively prioritize projects. There being no questions from members, Reed concluded his report.

Committee on Oversight Report

Sargent reported that since NSB's December 2021 meeting, CO met twice, on January 26 and February 22, 2022. During the committee meeting on January 26, 2022, members reviewed a roadmap for planned CO activities, a schedule for discussing enhancements to future merit review digests and associated and likely data requests. Discussion included possible changes to EPSCoR and progress tracking NSF's implementation of two pilots flowing from NSB 2021 resolutions; the first requiring merit review training for panelist to mitigate bias and improve written reviews and the second recommending inclusion of a broader impacts expert on the NSF's Committee of Visitors (COV). CO was pleased to learn that NSF has created a plan for including a BI expert on all COVs. During and due to the pandemic, only a limited number of COV meetings took place in 2021, but there are still opportunities to collect additional data from the expected 2022 COV meetings in fiscal year (FY) 2022. NSF is still reviewing the data collected on the impact of training for merit review panelists and will continue to update the committee.

At the February 22nd meeting, members of CO received the regular update from the Office of Inspector General (OIG), Allison Lerner and Mark Bell, on the OIG's FY 2022 audit plan which included audits of NSF's oversight of contracts, management of hybrid workforce and potential expansion, awardee compliance with harassment policies and NSF's oversight of public private partnerships. Ongoing audit highlights included the comparison of remote versus in-person merit review approval proposals. The NSF's Chief Financial Officer, Teresa Grancorvitz, updated CO members on awards made under the American Rescue Plan.

Sargent shared her Collaboration with Ochoa and Beachy to present NSB's vision for expanding the geography of innovation at a CEOSE Board meeting on February 17, 2022. At the Meeting there was robust discussion of intersectional approaches to science and engineering geography and the unique roles of minority serving institutions and the possibility of leveraging broader impacts. Sargent found it helpful to hear the discussion of CEOSE's recommendations related to EPSCoR and added that some of the recommendations may be incorporated into CO activities. There being no questions from members, McCrary thanked Sargent for her report.

Committee on External Engagement Report

Suresh Babu, Chair of NSB's Committee on External Engagement (EE) reported that the committee met on February 14, 2022 to review the engagement activities around the release of NSB's Science and Engineering *Indicators* report in January 2022. Activities included five

briefings; one press briefing, one for the White House, one for Senate and House committee staff, one for the Department of State, and one for the Science and Engineering Community. Activities also included feature articles in various media outlets including the Associated Press, the Washington Post and Houston Chronicle to name a few and state radio interviews of members including Phillips, Ochoa, McCrary, Beachy, Wilson and Reed. Babu recognized and thanked NSB's Chair of the Committee on Science and Engineering Policy (SEP) Phillips, Ochoa and the NCSES team, led by program director Amy Burke and NSB SEP and NSF ADs, staff and Panchanathan for his participation in the public Webinar and the White House briefing. Future engagements will include briefings of the National Institute of Science and Technology and the Committee of the National Academies in March 2022. Contact will be made for possible additional briefings to the Department of Energy, Congressional Research Services, Association of Public and Land-grant Universities (APLU) and others. Babu called members' attention to an NSB congressional delegation list in the board book and asked members to review it and send updates to NSBO staff members Nadine Lymn and Reba Bandyopadhyay in order to have a more complete picture of potential opportunities for external engagement by the Board.

At the EE meeting, members also discussed NSB's external panel presentation and discussion on innovation partnerships across the U.S. scheduled for NSB's February meeting. Beachy and Darío Gil organized the panel and Gil will moderate the discussion. Committee members also discussed future panel topics related to expanding the geography of innovation.

Babu concluded his report by sharing the committee has begun to reassess the Board's honorary awards, including elevating the responsibility of managing the awards process to EE, instead of a subcommittee, to ensure opportunities to weigh in earlier on nominations, streamlining the nominations process and eligibility criteria. Babu alerted members that a survey would be sent to all members to gather input on these topics. EE plans to bring recommendations to the full Board at the May meeting. McCrary thanked Babu for his report, McCrary turned the floor back to Ochoa for the remainder of the meeting.

Committee on National Science and Engineering Policy Report

Phillips reported that the SEP committee met on February 11th in open session. At that meeting, the committee announced its vote to approve the one pager on financial barriers to graduate STEM education followed by a discussion of *Indicators 2022* rollout activities. Phillips described the activities of the 2022 Science and Engineering *Indicators* rollout, including the recent Board approval of the *Invention, Knowledge Transfer, and Innovation* report and the *Production and Trade of Knowledge and Technology-Intensive Industries* report. Phillips also reported that as of February 22nd, NSB published the thematic report *Higher Education in Science and Engineering* which highlights the urgent need to expand access to S&E higher education across multiple dimensions and the impact of the COVID pandemic. She thanked both NSB leaders, members and NSF staff for their efforts and asked Board members to look out for the remaining thematic reports for review and approval vote.

In late March the committee will begin planning the next Indicators cycle. Due to the level of interest in the virtual public briefing this year, it will be added to future cycle rollout activities. The Board's 50 state one-pagers were updated with the most recent Indicators state data which she noted is helpful for local radio interviews. Given the demand for the state-level information, the NSB office (NSBO) and NCSES are planning to cohost an informational Webinar for the state Indicators in April to spotlight the availability of tools and resources around state data. Also in late March, SEP plans to hold an Indicators best practices and lessons learned session.

Also at the February 22nd meeting, SEP voted to approve the draft one-pager on financial consideration for doctoral STEM students and Phillips added that it is now final and SEP will send it to all members for a vote. During this report out, NSBO staff member Alexandra Surcel shared that the one-pager discusses the significant barriers faced by both the missing millions and those with low socioeconomic status (SES). Phillips reported that during the February committee meeting, members used the strategy tool to help think about where to focus efforts and coalesced around focusing on graduate education, with the understanding that many of the socioeconomic status-related challenges faced by graduate students would be shared by undergraduate and postdoctoral researchers as well. The committee also highlighted an interest in improving data accessibility and availability, alongside influencing federal policy, and generally raising awareness of the issues faced by students from low SES backgrounds, who are considering advanced STEM education and best practices for addressing the issues. Primary audiences to start with will be White House, Congress, and NSF. Potential activities will include identifying available data, developing policy recommendations, and releasing a policy piece on the topic of barriers faced by those of low economic status. Phillips added that this is just the start of the conversation and the committee is looking forward to assembling a small group to study this question further and identify more targeted points of entry in the near term.

During the committee meeting, Artie Bienenstock shared his views, based on his experience at Stanford, on high rates of student debt, increased financial support for students and the need to increase female and minority faculty to STEM higher education. Bienenstock offered that he is focused on graduate and postdoc because that is the foundation's direct responsibility and can only influence K-12 indirectly. Emilio Moran added that the reports and data discussed should be shared with state-level organizations that work with the private sector and high schools to try to increase the interest in STEM.

Ochoa thanked Phillips for the report and turned the floor to Panchanathan for comment. Panchanathan thanked members for their work and said it was also important that members know that individual educational institutions set parameters for funding and it varies from institution to institution.

Vision 2030 Report

McCrary shared an update on the Board's *Vision 2030* activities. He reminded members that the Vision Implementation Working Group (VIWG) had shared a Vision implementation plan for January-September 2022 at the December NSB meeting. The plan's purpose is four-fold: to commit the Board to specific actions/activities to make progress toward *Vision 2030* goals, to keep NSB and NSF accountable, to coordinate across board committees and subcommittees, and to ensure that the sum of NSB's vision-related activity is greater than the sum of its parts.

McCrary noted that since the December meeting, VIWG in concert with committee chairs, had developed a more-detailed committee-level implementation plan that covers January through early May 2022. He directed members to the plan, found in the Board Book, and noted that details would be shared in the respective committee report outs at the February meeting. He thanked committee chairs in advance for implementing these plans and keeping vision goals front and center on their committees' agendas.

McCrary also provided an update on Vision outreach activities since December. These included a presentation by Reed to the Computing Research Association and a presentation by McCrary to the University of Massachusetts system and MITRE. McCrary also thanked Committee on National Science and Engineering Policy Chair Phillips and Vice Chair Maureen Condic for ensuring that Vision themes were strongly reflected in the *Indicators 2022* rollout materials. McCrary stressed that all members are part of the effort to communicate about *Vision 2030* and encouraged members to keep a copy of *Indicators* in hand since Vision and *Indicators* go hand-in-hand.

Before concluding his remarks, McCrary noted that there will soon be an update to Vision slide deck that integrates messaging from the Board's new Keystone document and *Vision 2030* messaging. As VIWG looks toward the May NSB meeting, it will continue to carry out exploratory work on the geography of innovation and start transition planning, including developing a presentation on the first two years of NSB's vision work and plans to orient a new cohort of NSB members to *Vision 2030*.

K-12 STEM Education Exploratory Group Update

Ochoa introduced Matt Malkan as the lead member of the K-12 STEM Education Exploratory Group for a report of activities since the group was established in December 2021. Malkan began his report by stating that the name of the group would be Explorations in STEM K-12 Education or ESKE. Since December, the group met twice. The first meeting was held on January 26 and focused on drafting a mission statement and approving a work plan. McCrary attended ESKE's first meeting and shared lessons from his work with the Skilled Technical Workforce (STW) working group. The plan outlines hosting a series of listening sessions with stakeholders in NSF, the federal government, educators, and other experts. The plan is modeled largely on NSB's STW work. The second meeting on February 17 was devoted to a discussion with former NSB member Deborah Ball, an expert of the subject of K-12 STEM education. The next ESKE meeting will be with former NSB member Camilla Benbow. The group is currently developing a list of contacts to expand the listening session campaign. Malkan concluded his report by welcoming members to contact him with ideas or contacts in the area of K-12 STEM Education. Ochoa thanked Malkan and adjourned the meeting for the day at 3:40 p.m.

Session 4 (February 24, 1:00 p.m. – 2:15 p.m.)

Innovation Partnerships Across the U.S. - Panel

Ochoa reconvened the plenary open session of the and turned the floor to Beachy who introduced the next session and provided context for the topic explaining that the panel is a continuation of the board's exploration of topics related to NSB's *Vision 2030*, in this case the geography of innovation. Panelists from around the country having accomplished different kinds of milestones in their regions were invited to share what worked and what did not. Beachy turned to floor to Gil to introduce the panelists.

Gil began his introduction by outlining geography as the cornerstone of NSB and NSF goals for an improved domestic S&E ecosystem and saying that Americans in every state must benefit from the progress of S&E and have access to high-quality STEM education and S&E careers. Gil went on to say that the panelists would speak about their knowledge of and experiences with successful innovation partnerships that require STEM talent and introduced the four panelists: Simon Johnson, the Ronald Kurtz Professor of Entrepreneurship at the MIT Sloan School of Management; Doug Gross, the Chairman of the Board of New York CREATES; Hank Webber, most recently the Executive Vice President for Civic Affairs and Strategic Planning at the Washington University in St. Louis; and Barbara Helland, Associate Director of the Office Science's Advanced Scientific Computing Research program at the Department of Energy.

Johnson introduced his book published in 2019, "Jump-Starting America", which he described as being about the overlap between science spending and the creation of new technology and geography. He explained that since the beginning of modern public funding of science in the U.S., in the 1940s, the leading places of innovation have become increasingly concentrated in a few mega hubs on the West and East Coasts. Together with these hubs there is also restricted housing supply which makes it difficult for people new to the workforce and people without a high degree of education and a high income to live in or near these mega hubs which slows innovation and economic growth, by some estimates as high as one third since the 1960s. He offered that one way to address this is to create more hubs and said this approach was written into the Endless Frontier Act and was supported in a June 2021 by 68 senators from 41 states. Johnson offered an interactive tool on the jumpstartingamerica.com website designed to help identify where the next technology hubs could be placed in the future based on factors such as quality of life, cost of living, and education.

Gross, using the semiconductor manufacturing industry as an example, described how programs designed to raise awareness and interest in a particular industry through targeted academic curriculum including through community colleges and internships, and early education and experiences can benefit workforce development, industry and the overall science and engineering ecosystem.

Webber described the development of the Cortex Innovation District, a 203-acre innovation district, which he referred to as a large and successful innovation initiative in a second-tier city consisting of over 200,000 square feet of innovation and start-up lab space. Cortex is a partnership of the city of St. Louis, Washington University in St. Louis, BJC Healthcare System, and the Missouri Botanical Garden featuring biotech, ag-tech, IT and cybersecurity. The Cortex initiative revitalized a mostly abandoned manufacturing site in the center of the city, created thousands of new jobs for the St. Louis region, and generated well over \$75 million in new tax revenue to support essential public services in the city and state. Cortex also made it easier for its university partners to recruit and retain talent and has contributed to its partner universities becoming known for their academic programs and entrepreneurship and innovation. What Cortex has not done as well is contribute to racial equity with next steps to include a new commitment to wealth building among historically marginalized communities.

Webber categorized the reasons for Cortex's success as opportunity, geography, and leadership. On the opportunity side, St. Louis has a strong base in biotech and ag-tech research and the Washington University School of Medicine nearby is one of the largest recipients of National Institutes for Health research funds in the U.S. Cortex took the opportunity to focus on commercializing a base of technology that already existed. On the geography side, Cortex built in an area with almost no residents and a good deal of vacant land posing no relocation issues. Cortex is surrounded by amenities, including a dense and urban neighborhood and close its three partner institutions. The city of St. Louis was supportive, investing \$29 million in the formation of the district and the board of directors always included the most senior leaders of the sponsoring institutions. Cortex also chose the right time to engage with a commercial real estate partner who could help it recruit firms and build space attractive to the private sector. Finally, Cortex committed to a mixed-use community that contained a hotel, restaurants, and green space which is essential to draw in talent.

Helland offered a brief history of the public-private partnership between scientists and the U.S. Army Corp of Engineers that started the Department of Energy (DOE), specifically the Manhattan Project conducted at more than 30 sites across the U.S., many of which are included on Johnson's interactive map shown earlier in this session. This partnership initiated the atomic age with a focus on the use of atomic energy to end World War II, but more importantly, it created legacy DOE's national laboratories. Helland went on to share some examples of where DOE has continued to build on its legacy of partnerships and national capabilities, including the quantum and computing networking initiative deploying scientific high-performance computers and research networks that connect DOE's national laboratories and large scientific-user facilities. Helland explained that the same expertise and resources were called upon many times to provide insight into national and international crises such as the Deepwater Horizon oil spill, the Fukushima nuclear reactor disaster and more recently, DOE's laboratories have pooled their high-performance resources with those from cloud providers, industry and other federal agencies to combat COVID-19 and through this partnership formed the COVID High Performance Computer (HPC) Consortium partnership.

Helland spent the remainder of her presentation highlighting the experiences of the HPC consortium of which there are 43 members. The consortium was established very quickly to coalesce the many ad hoc efforts to fight COVID-19. The agility in part was due to not having a formal agreement and each partner, including the international partners, agreed to provide computer resources, and support the projects on the HPC system. It also used existing resources from NSF's Extreme Science and Engineering Discovery Environment (XSEDE) program to support proposal submission and review. Through the consortium, programs have been accelerated and a basic understanding of the virus and its host interactions in early-stage drug development was built, namely by university groups and small companies although to a more limited extent. More recently, consortium board members have recognized the power of what the consortium created and envision a National Strategic Computing Reserve where there is a standing public-private partnership ready to provide high-performance computing resources, software tools, and data as an integral part of any solution to respond to future crises.

The NSB Members engaged in a question and answer session with the panelists. Matt Malkan asked about the different factors considered in the Jumpstartingamerica.com interactive map. Johnson responded that the map was built using factors including college educated populations, open land that can be developed, proximity to urban areas and research universities, and quality of life factors such as commuting time. Ochoa asked Gross and Webber how the partnerships they highlighted got started, specifically the critical factors that allows to start and grow. Webber responded that there is no clear formula, but that in the case of Cortex it was the combination of leadership, the investment of funds, influential non-profits and land that could be developed. Gross agreed that there is no clear path, but that in the case of the semiconductor industry in New York, it had a lot to do with leadership, starting with Governor Pataki's focus on major urban areas around certain core technology themes followed by IBM who chose to partner with New York state which later became a draw for the university system answered the call for engineers and technician. Gross emphasized how important capital is for this particular type of industry. He also noted that because the industry is constantly innovating, experience and upgrading skills is also necessary which leads to further growth in the region.

Babu and Phillips asked questions related to how to best to include rural communities, community colleges and about lessons learned from the pandemic that might help bring more people in. John offered that Americans could be connected within a reasonable commute to the 104 hubs identified in his book *Jump-starting America* and Helland and Johnson both agreed that improved broadband was needed. Webber offered that a key for smaller and more rural areas is to identify the assets they have and what they can build on and to assess the educational system and whether there are strengths in a particular research area. He added that successful innovation districts do a checklist of things well. They have venture capital available, basic research, talent both in terms of doing the work and experienced entrepreneurs who know how to grow businesses. Every region has to conduct its own assessment and then develop an appropriate strategy. Gross added that the community college system in New York was well developed which then pointed them to curriculum development for example. With respect to difficulties recruiting tech graduate into the semiconductor industry, Gross offered they needed to do a better job at explaining or demonstrating the benefits of the semiconductor industry.

Panchanathan offered that some geography locations might have an advantage which would help guide the types of innovation there, for example the best place for an agricultural laboratory might be for example, Iowa, Nebraska, Kansas, and Indiana. Panchanathan also inquired about Johnson's thoughts on start-ups gravitating toward where venture capital is. Johnson agreed that localities need to have something such as land, water and other resources, and then governments should provide a catalyst in the form of matching funds. Currently, state and local governments provide over \$50 billion a year to businesses, 90 percent of whom end up investing in the same places they would have anyway. Johnson was not sure yet whether remote work over the last two years has changed ideas about the proximity of venture capitalists to start ups. If not, he suggested getting creative and finding new venture capitalists.

Carl Lineberger offered that another way to bring talented people into less populated areas is to locate federal government agencies into the middle of the country. He used the example of the federal government opening up office in Colorado which was then followed by IBM and then an improved university system and a technology hub to serve the defense industry. That was 50 years ago and it made a big difference.

Johnson pointed out that a hot question in science policy in Washington DC right now is how to bring the research or science together with commercialization and which federal or state agencies should do it. Gil raised the difficulty of bringing together public investments and risk. Heather Wilson asked whether Gross and Johnson's experiences involved international collaboration with Canada. Neither one had.

The session concluded with each panelist offering a take-home message. Helland offered that we need a strong community college system and adequate broadband and then let the rural communities be part of the solution. Webber asked how can we empower states to think about empowering people to prioritize developing innovation districts? How can states incentivize local governments to take action? Gross stated that after spending billions of dollars on infrastructure and equipment to strengthen the U.S. semi-conductor industry for example, it would be a tragedy if we did not have the intellectual assets to innovate and continue to operate these facilities efficiently. Finally, Johnson added that we need to get everyone everywhere connected to science, not because everyone should have a PhD, but because there are a lot of great jobs that can be created. He commended NSB for taking on this topic and particularly for the focus on community colleges.

Ochoa thanked the panelists and concluded the session by saying that hearing these different experiences makes it clear that there are multiple ways to think about success and innovation.

Session 5 (February 24, 5:40 p.m. – 6:05 p.m.)

NSB Chair's Remarks

Ochoa began her remarks by recognizing NSBO staff member Reba Bandyopadhyay as having been elected to the AAAS Fellows Class of 2021. She then expressed thanks to Theresa Good who served as an executive secretary for the Board's Committee on Strategy from February 2020 until February 2022. She also announced plans for an in-person May NSF/NSB Awards ceremony and added that it would be a smaller event than it had been historically but hoped that it would be back to a bigger and more formal event next year. Next, Ochoa offered that Dr. Eric Lander stepped down from his position as Director of the Office of Science and Technology and Policy (OSTP) and that Dr. Alondra Nelson would perform the duties of the Director of OSTP and Dr. Frances Collins the duties of Science Advisor to the President and Co-chair of the President's Council of Advisors on Science and Technology (PCAST) until permanent leadership is nominated and confirmed. She concluded her remarks by saying that this change served to reinforce NSB's responsibilities as leaders to create a welcoming and inclusive culture in science and engineering. She also remarked on what a wonderful example the NSF Director sets every day in this role as leader of the broad science and engineering community.

Approval of Prior Minutes

Ochoa presented the minutes of the December 2021 Open Plenary for approval. Those minutes were approved as presented.

NSF Director's Remarks

Panchanathan began by thanking the Chair for her leadership. He then recognized Theresa Good for having served as an Executive Secretary for NSB's Committee on Strategy as she rotates off the assignment. Panchanathan then pivoted to welcoming a new cohort of senior executives including Dr. David Manderscheid, Director of the Division of Mathematical Sciences; Dr. Casonya Johnson, Deputy Division Director in the Division of Molecular and Cellular Biology in the Biological Sciences Division; Charisse Carney-Nunes, Deputy Director of the Division of Graduate Education; and Dr. Sandra Richardson as the Section Head of EPSCoR. He also recognized two individuals that were reassigned to new positions including Dr. Timothy Patten, Deputy Assistant Director for GEO, formerly the Deputy Division Director in the Engineering Directors, and Dr. Linda Blevins, OIA, formerly the Deputy Assistant Director of Engineering. The Director concluded his remarks by drawing NSB members' attention to the activities report of the Office of Legislative and Public Affairs (OLPA).

NSB Chair's Closing Remarks

Ochoa concluded the meeting by thanking everyone for their attendance and participation with a special thanks to the guest speakers. She also acknowledged and thanked the NSBO staff for

their work to execute the virtual meeting. She added that she looked forward to the possibility of a hybrid meeting in May with the opportunity for members to attend in person or virtually. She invited members to send her or John Veysey feedback about the meeting.

There being no further business, the meeting was adjourned at 6:03 p.m.

5/9/2022

X Andrea Rambow

Andrea Rambow

Signed by: ANDREA I RAMBOW

Andrea Rambow
Executive Secretary to the National Science Board