

**APPROVED¹ MINUTES
OPEN SESSION
440TH MEETING
NATIONAL SCIENCE BOARD**

National Science Foundation
Arlington, Virginia
May 5-6, 2015

Members Present:

Dan E. Arvizu, Chairman
Kelvin K. Droegemeier, Vice Chairman
John L. Anderson
Deborah Ball
Roger N. Beachy
Arthur Bienenstock
Vinton G. Cerf
Vicki L. Chandler
Ruth David
Inez Fung
Robert M. Groves
James S. Jackson
G. Peter Lepage
Alan I. Leshner
W. Carl Lineberger
Stephen Mayo
Sethuraman Panchanathan
G.P. "Bud" Peterson
Geraldine Richmond
Anneila I. Sargent
Diane L. Souvaine

France A. Córdova, *ex officio*

Members Absent:

Bonnie L. Bassler
Robert J. Zimmer
Maria Zuber

The National Science Board (Board, NSB) convened in Open Session on Tuesday, May 5, 2015 at 11:15 a.m. with Dr. Arvizu, Chairman, presiding. In accordance with the Government in the Sunshine Act, this portion of the meeting was open to the public.

¹ The minutes of the 440th meeting, plenary open session, were approved by the Board at the August 2015 meeting.

Dr. Arvizu explained that since 1998, the National Science Board Public Service Award has recognized individuals and groups that have made substantial contributions to increase the public understanding of science and engineering in the United States. This year's Public Service Award recipients are today's honored guest speakers.

AGENDA ITEM 1: Presentation by 2015 Public Service Award Recipient

Dr. Arvizu then introduced Ms. Ellen Futter, President of the American Museum of Natural History. She oversees the Museum's educational resources and scientific assets that include more than 33 million specimens and artifacts, 200 scientific staff, and interdisciplinary research (e.g., in genomics, computational biology and astrophysics). The American Museum of Natural History in New York City was founded in 1869. Its mission is to discover, interpret and disseminate through scientific and research education, knowledge about human cultures, the natural world and the universe.

Ms. Ellen Futter presented an overview of three innovative programs.

First, the Museum developed and leads a pioneering collaboration, "Urban Advantage" with eight institutions—botanical gardens, the zoos, aquarium science center, and the New York City Department of Education. Urban Advantage was designed to assist eighth graders in completing their exit project; combining rigor with equity and access. These resources include professional development for teachers, classroom resources and equipment for schools, family engagement through educational outreach, capacity building with lead teachers, school leadership and demonstration schools, national and local standards built into the design and formal assessment of program goals, student learning and systems of delivery. After 10 years, this program has served 1,148 teachers and more than 185,000 students in 323 public schools.

In 2006, the Museum was authorized to grant a PhD degree; the only museum in the western hemisphere and the second in the world to do so. A ground-breaking program was launched in comparative biology in the newly established Richard Gilder Graduate School, which builds on the museums' many decades of experience in training doctoral students in partnership with leading universities such as Columbia, Cornell, City University of New York and New York University. In 2012, the Museum focused its sights on the critical shortage of effective science teachers and welcomed its first class of teacher candidates into a new and equally innovative master's program in teaching earth science and space science. All of the 36 MAT graduates are now teaching in high-need schools in New York State.

In addition, technology is enabling the Museum to enhance the museum-going experience through augmented reality in the galleries and through augmented visitor directed content delivered through a hand held device. Students are learning 21st century skills such as scientific visualization, 3-D modeling and coding all of which will help prepare and empower them to join the 21st century workforce. The Museum is now offering massive open online courses (MOOC), through a partnership with Coursera, building on its long-standing online courses for teachers.

To date, over 75,000 people from around the world have enrolled in the MOOCs in genetics, evolution, and earth science.

AGENDA ITEM 2: Presentation by 2015 Public Service Award Recipient

Dr. Arvizu explained that the second 2015 public service award recipient is the Museum of Science's National Center for Technological Literacy (NCTL). Dr. Arvizu then introduced Ioannis Miaoulis, president and director of the Museum of Science in Boston. He oversees one of the largest science centers with 1.4 million visitors per year; the first in the U.S. with a strategy and infrastructure to integrate engineering into schools and museums nationwide. The NCTL was launched in 2004 to exhibit and teach visitors about science and engineering. The center also pioneered engineering education curricula for K through 12 schools nationwide through a unique curriculum that integrates engineering and technology with science, language arts, social studies and math via storybooks and hands-on design challenges.

Dr. Ioannis Miaoulis presented an overview of the Museum's program.

About 12 years ago, the Museum created a strategy to introduce engineering in the lives of people through the museum world and through schools. As a result, the Museum undertook a number of major projects.

The Museum partnered with Lucas Films and created the Star Wars exhibit, their first engineering exhibit. Star Wars was a fun exhibit that attracted millions of people; at the same time, the exhibit was engineering-education in action. The Museum also partnered with 200 science centers and several universities to inform the general public about the importance of modern technology, reaching over 30 million people. Pixar is the next scheduled exhibit—the Museum's first computer science actual exhibit.

Based on this success, the Museum designed a system to do three things:

- Advocacy: for the introduction of engineering at the state and federal levels; working with universities, school systems and industry to create energy and excitement for introducing engineering in the science standards.
- Curriculum development: the Museum is the largest curriculum development producer in the world for engineering for young children. For example, the "Engineering is Elementary" curriculum has an international flavor that introduces engineering through story telling—it has reached millions of children throughout the world.
- Professional development of teachers. The Museum has established networks throughout the United States to provide professional development for teachers. Within the last 10 years, the Museum has trained over 86,000 teachers.

Note: the Plenary open session recessed for lunch and other NSB business.

The Board reconvened in Open Session on Wednesday, May 6, 2015 at 10:45 a.m. with Dr. Arvizu, Chairman, presiding. In accordance with the Government in the Sunshine Act, this portion of the meeting was open to the public.

Dr. Arvizu explained that the next two presenters are recipients of the 2015 Vannevar Bush and Alan T. Waterman awards. He then turned over the meeting Dr. France Córdova, director of NSF.

AGENDA ITEM 12: Presentation by 2015 Alan T. Waterman Award Recipient

Dr. Córdova explained the Alan T. Waterman award recognizes young researchers in any field of science or engineering, supported by the National Science Foundation, who shows exceptional promise for significant future achievements demonstrated through personal accomplishments. The Waterman award was established in 1975 to mark the 25th anniversary of the National Science Foundation and to honor its first director.

The winner of the 2015 Alan T. Waterman award is Dr. Andrea Alù. Dr. Alù is an engineering professor at the University of Texas at Austin and a leading innovator in metamaterials, artificial materials with properties and wave interactions not found in nature and plasmonics (the study of how light interacts with the surface of nano-scale objects). Cloaking technologies are among Dr. Alù and his team's accomplishments—technologies capable of bending electromagnetic waves around objects with the overall effect of rendering those objects invisible to sensors.

Dr. Andrea Alù presented a summary of his team's work.

Over the past 10 years, a goal was to cover certain objects with a metamaterial shell with the right properties in order to scatter a different type of light; essentially a negative light, cancelled by destructive interference the scattering of the object at all angles. Then, light can only go through the object. If the whole scattering of an object is cancelled, the object becomes transparent—one does not see it.

This team works with radio waves with several applications in mind; for example, building sensors that can receive the impinging wave but are not visible. Such invisible sensors are important for camouflaging as well as improving measurements.

A cloaked antenna for a broad bandwidth for radio communications can now transmit and receive without interfering with other antennas. Other antennas can be placed nearby, even on the back of the cloaked antenna, which will improve the way in which crowded communication systems are designed and operate.

Additionally, Dr. Alù's team is interested in trying to get rid of magnetic effects. Magnets are bulky, difficult to integrate in a circuit, and typically mined outside the U.S. This interest led to the idea of building a metamolecule that would look like a magnetized ferromagnetic molecule. Instead of spinning electrons in a hollow cavity, they mechanically spin a fluid. Based on this

approach, they built a circulator for acoustic waves. It was the first time that a circulator was built for airborne sound waves.

The team is also working to use metamaterials with near-field optical microscopes to overcome limitations of conventional microscopes. The problem with conventional microscopes is that they disturb the measurement at very close proximities. The coating can avoid this problem. The team is working on experiments to coat the tips of microscopes to pick up the signal without perturbing the measurement. In this way, we will obtain far more accurate and precise measurements at the nanometer level.

AGENDA ITEM 13: Presentation by 2015 Vannevar Bush Award Recipient

Dr. Arvizu stated that the recipient of the Vannevar Bush Award, Dr. James Duderstadt, is the final presenter. The NSB Vannevar Bush Award honors exceptional lifelong leaders in science and technology; individuals who have made substantial contributions to the welfare of the nation through public service activities in science, technology, and public policy. The award was established in 1980, in memory of Dr. Vannevar Bush, who served as a science advisor to President Franklin Roosevelt, and helped create the National Science Foundation.

Dr. Arvizu then introduced Dr. James Duderstadt. He is president emeritus of the University of Michigan and professor of science and engineering. Over the past four decades, Dr. Duderstadt contributed significantly to the national interest as a leader in American higher education. As an engineering dean, he created a new modern engineering campus by combining public and private funding sources and stimulated the introduction of digital and online technologies in research and education, including the creating of NSFNET, a precursor to the internet.

As provost and president of the University of Michigan, Dr. Duderstadt fostered UM's leadership in research and spearheaded industry, university-government collaborations. One of his most important legacies was the development of effective strategies for diversifying the student body, faculty, and leadership of Americans' higher education.

He has chaired numerous studies concerning America's science, technology, and education policy; served as a member and chairman of the National Science Board, playing an influential role in setting strategic directions for the National Science Foundation.

Dr. James Duderstadt gave a presentation to the Board.

The National Science Foundation Act established both the National Science Foundation and the National Science Board in 1950. This important development created a cross-sector partnership in science and engineering between government, university, and industry.

The strength of American research today encompasses federal support of competitive, peer-reviewed grants and the support of investigators to engage in research of their choosing,

In 1992, a special commission was established, co-chaired by Bill Danforth, Chancellor of Washington University, and Bob Galvin, former chief executive officer of Motorola. The commission examined the mission of both the National Science Foundation and the National Science Board.

The commission called for a stronger, more coherent policy. Their report noted a number of important factors. For example, the expectation that NSF and scientific research would generate new knowledge is the basis for NSF support; investigator-initiative proposals and merit-based review are also important contributors to NSF's support. The commission encouraged the support of fields not covered by traditional disciplines and the evolution of NSF activities. The commission also called for greater involvement of the private sector

The National Academy completed a subsequent study in 1993 on the allocation of funds for science and technology. This study introduced the idea that only part of what is termed the federal R&D budget (of about \$150 billion p.a.) really generates new knowledge. It also articulated a new concept—the federal science and technology budget, which generates new knowledge and was about \$60 billion of the \$150 billion. Research agencies, like the National Science Foundation, and the National Institutes of Health, became a priority.

Lessons learned for science policy include persistence and consistency. At the same time, adaptability is important; look for unexpected opportunities; re-engage with the public and listen to them. Coming in and saying, "I'm a scientist, and let me tell you why climate change is going to happen," just doesn't work. This reengagement is essential, to make the case for enlightened federal science policies and strong support.

Essentially, we are learning to once again return to the spirit of the U.S. frontier; to recognize the changing environment; and, to rededicate ourselves to the NSF mission.

AGENDA ITEM 14: Approval of Open Session Minutes, February 2015

With no objections, the February 2015 open plenary session minutes were approved as written.

AGENDA ITEM 15: Chairman's Report

Dr. Arvizu, Chairman of the National Science Board, thanked the NSB and NSF staff for their efforts in contributing to a successful awards dinner. He announced that Drs. Diane Souvaine and G.P. Bud Peterson were elected to the Executive Committee for two-year terms. Dr. Arvizu congratulated Dr. Arthur Bienenstock on the creation of an endowed professorship in his name at Stanford University.

Dr. Arvizu extended a thank you on behalf of the Board to all of the staff at NSF, who provide needed services with efficiency and integrity every day. He also thanked NSF management and staff for ensuring that the nation's science, engineering, and educational communities are well served.

AGENDA ITEM 16: Resolution Votes, National Interest

Dr. Arvizu introduced the national interest resolution. The Board has held a number of discussions on this resolution. Dr. Arvizu indicated that in summary the resolution recognizes and supports the NSF's efforts in developing procedures and policies, which emphasize transparency and accountability.

It was moved and seconded to adopt this resolution. The Board voted and approved the resolution; Dr. France Córdova abstained.

AGENDA ITEM 17: Director's Report

Dr. Córdova provided an overview of NSF support of graduate students through research grants, graduate research fellowships, and the new NSF research traineeship program. She also noted NSF support for young career principal investigators. Dr. Córdova then turned to Dr. Roger Wakimoto, Assistant Director of the Geosciences Directorate, to provide an update about the Ocean Observatories Initiative (OOI).

Dr. Wakimoto explained that OOI will be commissioned this summer. Although an underwater volcano recently erupted before the commissioning, scientists not only expected the eruption but collected data (after the eruption) using GPS sensors. After OOI is commissioned, real-time data flows will be available for such oceanic events.

Dr. Córdova introduced new staff members Rebecca Keiser, Office Head of the International Science and Engineering Office; Dr. Barry Johnson, Division Director for Industrial Innovation and Partnerships in the Engineering Directorate; and Christina Sarris, senior policy advisor in the Office of the General Counsel. Dr. Córdova also announced that Dana Topousis, acting head of the Office of Legislative and Public Affairs, and Joanne Rom, Deputy Director in Budget, Finance and Award Management, would be leaving the agency.

Dr. Córdova noted that the agency has released its Office of Science and Technology Policy (OSTP) approved public access plan. The plan requires dispositive journals and juried conference papers be submitted to an NSF public access repository within twelve months following initial publication. Dr. Córdova acknowledged and thanked the individual NSF staff members, who worked so hard on the public access plan.

Dr. Córdova reported that she and Dr. Arvizu testified on the NSF budget before the House Science, Space and Technology Subcommittee on Research in February. Dr. James Olds, Assistant Director for the Biological Sciences Directorate, testified in March before the same subcommittee about NSF's activities in neuroscience and neurotechnology. Dr. Córdova also noted that the House Science, Space and Technology Committee marked up the 2015 America COMPETES legislation on April 22.

AGENDA ITEM 18: Open Committee Reports

Dr. Ruth David, Chair of the Audit and Oversight Committee, presented an action item to the Board for transmittal of the March 2015 OIG semi-annual report to Congress, the accompanying management tables, and the transmittal letter. The Committee voted to recommend approval of the materials to the full Board for action (see Appendix A).

It was moved and seconded to concur with the transmittal of these documents to Congress as required by statute. The Board voted and approved the motion.

Dr. Anneila Sargent, Chair of the Committee on Programs and Plans, noted that Board members Drs. Lepage, Richmond, Fung and Lineberger volunteered to work with her and GEO on planning for regular discussions of polar issues (see Appendix B).

Dr. Alan Leshner, Chair of the Committee on Strategy and Budget, noted that the committee met the previous day. Dr. Leshner submitted a summary report for inclusion in the plenary minutes (see Appendix C).

Dr. Arvizu noted that Committee on Science and Economic Indicators (SEI) was scheduled to meet after the plenary open session. He requested the SEI Chair, Dr. Droegemeier, to submit a summary report for the record (see Appendix D).

Dr. Vint Cerf, Chair of the ad hoc discussion group on Communications and Outreach, noted that Alan Alda would be here in late July. He invited any interested Board member to join the discussion—improving communication with the general public about the importance of science and technology. Dr. Cerf also asked Board members to develop stories about the products and services we enjoy, in order to connect the role of science and the NSF in the creation of these products and services.

AGENDA ITEM 19: Chairman's Remarks

There being no further business, Dr. Arvizu adjourned the plenary meeting at 1:20 p.m.

[signed]
J. Ronald Campbell
Executive Secretary
National Science Board

Appendices:

Appendix A: A&O Committee Summary Report Submitted for the Record

Appendix B: CPP Summary Report Submitted for the Record

Appendix C: CSB Summary Report Submitted for the Record

Appendix D: SEI Summary Report Submitted for the Record

COMMITTEE ON AUDIT AND OVERSIGHT (A&O)
Meeting Summary Submitted for the Record
Open Session

Dr. Ruth David, A&O Chair, notified the committee that the National Science Foundation (NSF) and the Board commissioned the National Academy of Public Administration to conduct a study of the Agency's use of cooperative agreements. A final report is expected by the end of this year.

Inspector General Allison Lerner delivered the March 2015 Office of Inspector General (OIG) Semiannual Report to Congress. Dr. Joan Frye, Senior Staff Associate, presented the transmittal letter and management tables that accompany the report. The committee expressed no concerns with the report, transmittal letter or tables, and voted to recommend to the full Board that it authorize the Chairman to send them to Congress as required by statute.

Drs. Wanda Ward, Office Head, and Stephen Meacham, Senior Staff Associate, provided a brief overview of the structure of the annual report on NSF's merit review process. The report highlighted the low success rate for proposals to NSF, particularly for new and early-career investigators.

Inspector General (IG) Allison Lerner briefed the committee on an OIG investigation that resulted in 15 felony count convictions against two SBIR (Small Business Innovation Research) grantees that improperly received \$10.5 million in federal funds from NSF and other agencies.

The IG introduced Sal Ercolano, NSF's financial statement auditor, who discussed the planning for the fiscal year 2015 financial statement audit and how the audit process will unfold.

Ms. Martha Rubenstein, Chief Financial Officer, updated the committee on the successes and challenges that NSF is having with iTRAK's operation and maintenance. The Office of Budget, Finance and Award Management is addressing system issues and supporting the agency through a "super user" group, providing additional training and creating job aids, targeted communications, and additional desk-side user support.

**Committee on Programs and Plans (CPP)
Meeting Summary Submitted for the Record
Open Session**

Chair's Remarks

Following approval of the minutes from the open session of the February 2015 CPP meeting and the February 2015 joint CPP-CSB meeting, Dr. Anneila Sargent, CPP Chair, drew attention to the updated CY 2015 schedule of action and information items for NSB review. She noted that there are no updates from February, and that there is only one additional action item for the remainder of this calendar year, anticipated to come before CPP in November 2015.

She also raised the issue of CPP's oversight of Polar Programs. She noted that since the Subcommittee on Polar Issues had been folded into CPP, the Board had heard from Polar a number of times, but a structure or calendar for reporting had not been established. She asked the committee to think about whether it might be useful to both NSF and the Board to lay out a plan, which would not preclude the presentation as appropriate of Polar-related items at other, unscheduled times. Drs. Peter Lepage, Geri Richmond, Inez Fung, and Carl Lineberger volunteered to participate in an upcoming telecom with GEO leadership to develop the plan.

Information Item: Cornell High Energy Synchrotron Source (CHESS)

Next, CPP heard an information item on the status of CHESS. Dr. Fleming Crim, Assistant Director for the Directorate for Mathematical and Physical Sciences (MPS), and Dr. Thomas Rieker, Program Director for CHESS, gave the presentation. Dr. Rieker informed the Board that the MPS Advisory Committee, Subcommittee on Materials Instrumentation had felt that CHESS did not articulate a unique science case, and was unconvinced by the upgrade plan proposed by CHESS, particularly budget and timelines. He also provided the Board-requested annual update on CHESS, noting that the facility was developing unique science on their engineering beam line. Dr. Rieker described improvements to the proposal system and reviewer pool that had helped broaden the user base, though he noted that one third of beam time continues to go to Cornell and CHESS-specific principal investigators. He characterized CHESS as taking NSF's concerns seriously and is engaging external advisor committee and users.

Dr. France Córdova, NSF Director, inquired whether the committee would benefit from an assessment that was more quantitative. Dr. Sargent agreed that this would be helpful, and requested that the next CHESS update incorporate such elements.

Information Item: Advanced LIGO

Dr. Fleming Crim, Assistant Director for the Directorate for Mathematical and Physical Sciences (MPS), briefly introduced Dr. Mark Coles, senior advisor in the Division of Physics (PHY) within MPS. Dr. Coles provided an update on the Laser Interferometer Gravitational-wave

Observatory (LIGO) and Advanced LIGO facility. He described the 2014 computing review that was held in partnership with experts from the Directorate for Computing and Information Science & Engineering (CISE) in 2014 and noted that currently everything except computing is complete. He noted that NSF had granted a no-cost extension to allow later purchase of computing equipment.

The committee raised a number of issues and wondered what is considered the biggest LIGO accomplishment to date. Dr. Coles explained that the LIGO upgrade should allow it to detect certain inspiral events within 68 megaparsecs, a significant improvement over the prior range of 14 megaparsecs. In Dr. Crim's opinion, the LIGO/Advanced LIGO is a success story because of the cooperative agreement, which has allowed interaction between NSF and the project that significantly increased the overall return on investment.

COMMITTEE ON STRATEGY AND BUDGET
Meeting Summary Submitted for the Record
Open Session

Mr. Michael Sieverts, Division Director, Budget Division/BFA, updated the Board on the FY 2016 Budget. He noted that it is impossible to talk about the FY 2016 budget process without discussing discretionary caps (sometimes known as “sequestration”), which have been the focus of Congressional efforts to reduce spending over the last several years. The President has proposed a 7% increase to the caps for FY 2016 and noted that if the House and the Senate pass appropriations that fall within the original, lower caps, he will veto those bills. In addition, the reauthorization process will impact the NSF account. The FY 2016 House Reauthorization has both Education and Human Resources (EHR) and Agency Operations and Award Management (AOAM) accounts lower than requested. This would not enable NSF to go forward with certain EHR initiatives or the relocation to Alexandria. The House Reauthorization breakdown by directorate realigns the Research and Related Activities Account, although the total equals the amount requested. These changes would necessitate some major reductions in ongoing activities within Social, Behavioral, and Economic Sciences (SBE). SBE’s National Center for Science and Engineering Statistics would take a small cut in budget, but the rest of SBE would be subject to a 58% reduction. The interplay between the authorization and appropriations process will be important to watch going forward. This is all under the umbrella of the appropriations process and will be overshadowed by the President’s commitment to veto all bills that are under caps.

**Committee on Science and Engineering Indicators (SEI)
Meeting Summary Submitted for the Record
Open Session**

The Committee on Science and Engineering Indicators (SEI) met from 1:15 p.m. to 2:50 p.m. on Wednesday, May 6, 2015.

The committee was briefed on the release of the NSB companion report to *2014 Indicators, “Revisiting the STEM Workforce.”* This report was widely circulated and presented, including the following. Dr. Arvizu briefed Congress, OSTP and OMB on April 15, 2015. Drs. Arvizu and Droegemeier held a media teleconference on April 21, 2015. NSB sent out an e-mail alert to over 1,000 stakeholders. Finally, Dr. Droegemeier moderated an expert panel at the AAAS Science and Technology Forum on April 30, 2015 and hosted a breakfast roundtable discussion on May 1st at the same meeting.

The committee made an artwork selection for the *Indicators 2016 Digest*. The image is a 180-degree fisheye view of the Gemini North Telescope in Mauna Kea, Hawaii. The image will be featured on the *Digest*, and the artwork will be incorporated into the new *Indicators 2016* digital website.

The remainder of the meeting was spent discussing the expert and NSB reviews of the draft chapters for *Science and Engineering Indicators 2016*. For each chapter, an author presented the major themes and issues identified in the reviews and their proposed response. The NSB reviewers then provided additional comments, suggestions for revisions, or raised additional issues for discussion.

Due to time constraints, discussion of the *Indicators 2016* “state indicators” follow-up activities to the most recent companion report, and of the *2016 Digest* and Overview will take place via teleconference following the May 6 meeting.