Robert Dickey, President, National Association of Marine Laboratories

Dave Carlon, Chair, Public Policy Committee, National Association of Marine Laboratories

NATIONAL ASSOCIATION OF MARINE LABORATORIES

Annual Public Policy Meeting

March 22-23, 2021

Prepared by Joel Widder and Meg Thompson Federal Science Partners

Briefing Book for NAML Meeting

March 22-23, 2021

Washington, D.C.

- ✓ **Meeting Schedule**
- ✓ **Background Information on Speakers and Suggested Questions**
- ✓ **NAML FY 2021 Public Policy Agenda**
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- ✓ **STEM Education for the Future**
- ✓ **Membership of Key Congressional Committees for Ocean, Coastal, and Great Lakes Issues**

National Association of Marine Laboratories
Public Policy Meeting Agenda
March 22-23, 2021
(Registration Required)

Monday, March 22 (all times Eastern Daylight-Savings Time = EDT)

10:30AM: **Opening Remarks: Robert Dickey (NAML President) and Dave Carlon (Chair, NAML Public Policy Committee)**

11:00AM: **Ocean Policy in a Biden Administration – Deerin Babb-Brott, Principal Assistant Director, Office of Science and Technology Policy (OSTP)**

12:00PM: **Education and Training – Karen Marrongelle, Assistant Director for Education and Human Resources, National Science Foundation (NSF)**

1:00PM: **NOAA -- Climate, Oceans, and Resilience – Nicole LeBoeuf, Acting Assistant Secretary of Commerce for Oceans and Atmosphere and Acting Assistant Administrator, NOAA National Ocean Service**

2:00PM: **NSF – A View from the Office of the Director – Amanda Greenwell, Head, NSF Office of Legislative and Public Affairs**

3:00PM: **Diversity and Opportunities at Marine and Freshwater Laboratories: Broader Impacts Moving From the Back Pages – Moderator: Dr. Sue Ebanks, Savannah State University; Panelists: Dr. Mona Behl, Associate Director of Georgia Sea Grant; Dr. Brandon Jones, NSF Program Director for Education, Geosciences; Dr. Matt Gilligan, Retired, NAML Member Emeritus, Savannah State University**

4:30PM: **Public Policy Environment for the Ocean, Coastal, and Great Lakes Enterprise - Kolo Rathburn, former Professional Staff, Senate Appropriations Committee**

5:00PM: **Day One Ends**

Tuesday, March 23 (all times Eastern Daylight-Savings Time = EDT)

11:00AM: **Discussion: NAML – Moving Ahead with its Public Policy Agenda – Robert Dickey (NAML President), Dave Carlon (NAML President-Elect and Chair of the Public Policy Committee), Joel Widder (Federal Science Partners), and Meg Thompson (Federal Science Partners)**

12:00PM: **Funding Environment for Science in the 117th Congress – Mr. Matt Womble and Mr. Blaise Sheridan, Professional Staff, Senate Appropriations Subcommittee for Commerce, Justice, and Science**

1:00PM: **Public Policy Meeting Ends**

1:30PM: **NAML Membership Business and Regional Meetings (Zoom Meeting - link will be emailed to members)**

3:30PM: **Meeting Ends**

Biographical Information on and Possible Questions for Speakers
NAML Public Policy Meeting
March 22-23, 2021

Mr. Deerin Babb-Brott is the Principal Assistant Director for Oceans and Environment at the White House Office of Science and Technology Policy. He has served as the Executive Director of the Ocean Policy Committee, established by Executive Order 13840 to coordinate Federal agency engagement in ocean policy matters. Deerin previously served as the first Director of the National Ocean Council and led development of the final U.S. National Ocean Policy Implementation Plan. Between terms at the White House, he was a senior partner at SeaPlan, where he provided technical and policy support for public and private sector ocean and coastal management initiatives. Previously, Deerin was Assistant Secretary for Ocean and Coastal Zone Management in Massachusetts, where he directed the state coastal program and led teams that developed the Massachusetts Ocean Management Plan and Federal Wind Energy Areas. He also served as Assistant Secretary for Environmental Impact Review in Massachusetts, where he managed the review of development projects, including joint state-Federal review of major marine infrastructure such as Cape Wind and offshore LNG terminals. Deerin received a B.A. in Government and Environmental Studies from Bowdoin College.

Possible Questions

- How does this Administration's priorities for ocean science and technology differ from the previous Administration?
- What advice can you provide NAML labs that would assist them in getting their message about the importance of research and education across more effectively with Members and Administration officials.
- What areas should we expect the National Ocean Policy committee focus on in this Administration?
- What does the reauthorization of the National Ocean Partnership Program mean for the future of NOPP in ONR, NOAA and other agencies?
- What role could NAML or its members play in the NOPP program – membership on advisory committees, for example?
- To what extent will ocean and coastal issues be reflected in the Administration's emphasis on climate, including the forthcoming infrastructure proposal?
- The prior Administration consistently proposed to eliminate or drastically reduce support for the various external competitive ocean and coastal programs at NOAA, NSF, EPA and other agencies. What can NAML expect under this new Administration?
- Each year – usually in the early spring – NAML issues its public policy agenda and priorities that we believe enable marine labs to contribute significantly the health of our ocean, coastal, and Great Lakes enterprise. NAML's priorities for FY 2021 call for strengthened support for aquaculture; understanding the factors and impacts of shifting environmental regimes, ocean research and technology to advance national security and economic competitiveness; support for data, observations, marine infrastructure, new technologies, research and education. Would you comment on NAML's priorities and how they compare to the Administration's emerging priorities as they relate to our ocean, coasts, and Great Lakes?

Dr. Karen Marrongelle, Assistant Director, Education and Human Resources, National Science Foundation – Since 2018, Dr. Marrongelle has served as Assistant Director for Education and Human Resources at the National Science Foundation. Marrongelle's career as a leader in the research community has been marked by a deep commitment to diversity, equity and inclusion. As an

administrator, she has focused on understanding the causes of disparities in educational opportunities and establishing strategic visions for addressing those issues. Prior to coming to NSF, Marrongelle served as dean of the College of Liberal Arts and Sciences at Portland State University, overseeing 24 departments and programs and 2,000 employees. During her tenure as dean, she has worked to implement student inclusivity measures, establish public-private partnerships to support research, and optimize the school's use of grants from NSF and other funding organizations. In addition to her work as dean, Marrongelle, has served as a professor of mathematics and statistics at Portland State University since 2001. Prior to her appointment as dean, she held positions as the vice chancellor for academic strategies and assistant vice chancellor for academic standards and collaboration with the Oregon University System. Marrongelle has a bachelor's degree in mathematics and philosophy from Albright College, a master's degree in mathematics from Lehigh University and a doctorate in mathematics education from the University of New Hampshire.

Possible Questions

- Can you highlight some of the new key directions NSF will be going particularly as it relates to undergraduate STEM education and the REU program, diversity, and broadening participation?
- The NSF Director has been talking about the "missing millions"—and calling for a rapid increase in the number women and minorities not currently well represented in science and engineering. How is the agency responding to that challenge? What programmatic changes are we likely to see and how would you advise our labs and campuses to participate in these efforts?
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Dr. Nicole LeBoeuf, Acting Assistant Secretary of Commerce for Oceans and Atmosphere and Acting Assistant Administrator, NOAA National Ocean Service -- Nicole R. LeBoeuf is the Acting Assistant Administrator, and the permanent Deputy Assistant Administrator, for the National Oceanic and Atmospheric Administration's (NOAA's) National Ocean Service, an organization of 1,800 staff in more than 50 locations around the country. As the Acting Assistant Administrator for Ocean Services and Coastal Zone Management at NOAA, Ms. LeBoeuf oversees all strategic and operational aspects of America's premiere coastal and ocean agency. She provides the strategic vision needed to lead the implementation of activities that support NOS's priorities of safe and efficient transportation and commerce; preparedness and risk reduction; and stewardship, tourism and recreation. She serves as the focal point for conveying the value of NOS products and services within NOAA and to the Department of Commerce, the Office of Management and Budget, and Congress. Ms. LeBoeuf actively establishes and grows partnerships with other federal agencies, non-governmental organizations, and industry.
Ms. LeBoeuf has over 20 years of scientific and program management experience, with emphasis on the connections between science and policy. Previously, Ms. LeBoeuf served as the NOS Deputy Assistant Administrator. In this role, she oversaw the financial, administrative, and performance activities across NOS to address the evolving economic, environmental, and social pressures on our ocean, coasts, and coastal communities. Prior to joining NOS, Ms. LeBoeuf served as Acting Deputy Director of the Office of Protected Resources in NOAA Fisheries, and Chief of the Marine Mammal and Sea Turtle Conservation

Division in the Office of Protected Resources, where she maintained oversight of a diverse portfolio of protected species conservation and management activities. Ms. LeBoeuf has also worked in NOAA headquarters, in the NOAA Budget Office and as NOAA's finance lead during the Deepwater Horizon oil spill, in NOAA Fisheries' Office of International Affairs as NOAA's Lead for the Convention on the Conservation of Antarctic Marine Living Resources, and as the Special Assistant to NOAA Fisheries Science Director, during which time she represented NOAA at the U.N. General Assembly and the World Conservation Union.

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- The prior Administration consistently proposed to eliminate or drastically reduce support for the various external competitive ocean and coastal programs at NOAA, NSF, EPA and other agencies. What can NAML expect under this new Administration?
- Can you discuss how you intend to make use of the coastal roundtable given the new Administration's interest is climate and coastal resilience?
- What role do you see for NAML to support the NOS mission and related programs?
- There is a lot of emphasis in the new Administration on climate, clean energy, de-carbonizing our environment, etc. The Climate 21 report has reportedly help ramp up the Administration's plans in area. What role do you expect NOAA to play in the revitalized climate change activities of the U.S. Government?
- What does the expiration of the statutory spending caps on defense and non-defense spending mean for NOAA in the FY 22 appropriations process? What advice can you provide NAML labs that would assist them in getting their message about the importance of research and education across more effectively with Members and Administration officials.

Ms. Amanda Greenwell, Head, Office of Legislative and Public Affairs, National Science Foundation – Ms. Greenwell has served as the Head of the NSF Office of Legislative and Public Affairs since 2015. In that capacity she is responsible for developing and executing the Foundation's communications with decision makers and the public. Prior to joining NSF, Ms. Greenwell served as director of the National Oceanic and Atmospheric Administration's (NOAA) Office of Legislative and Intergovernmental Affairs. She was responsible for advising the NOAA Administrator, senior leadership and the Department of Commerce on Congressional activities and for developing legislative strategies. Prior to her current position, Greenwell served as deputy director of the office for nearly four years. Before joining NOAA, Greenwell served as professional staff for the U.S. Senate Committee on Commerce, Science and Transportation for the Subcommittee on Oceans, Atmosphere, Fisheries and the Coast Guard. In that role she had oversight of NOAA and the U.S. Coast Guard. Greenwell advised Congressional members on a variety of issues including domestic and international fisheries, marine mammals, coral reefs, aquaculture, seafood safety and the U.S. Coast Guard. Greenwell also served as staff for the Committee's Subcommittee on Trade, Tourism and Economic Development and the Subcommittee of Consumer Affairs, Product Safety and Insurance. She assisted the senior counsel for the subcommittees that oversee the Federal Trade Commission (FTC), the Consumer Product Safety Commission (CPSC), the

National Highway Traffic Safety Administration (NHTSA), and the Department of Commerce. Greenwell earned a Bachelor of Science degree in marine biology from Hawaii Pacific University.

Possible Questions

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- What does the expiration of the statutory spending caps on defense and non-defense spending mean for NSF in the FY 22 appropriations process? What advice can you provide NAML labs that would assist them in getting their message about the importance of research and education across more effectively with Members and Administration officials.

Dr. Sue Ebanks, Associate Professor of marine and environmental sciences at Savannah State University. Dr. Ebanks' area of scientific research is the study of aquatic physiology and toxicology with particular focus on macroinvertebrates. She studies the effects of physically weathered and chemically dispersed crude oil on development and physiological processes in brine shrimp and marsh shrimp species. She is active in engaging students and underrepresented community youth in the exploration and monitoring of the Lower Ogeechee River Estuary. She actively advises the Savannah State Environmental Science Club. Dr. Ebanks is the incoming President of the Southern Association of Marine Laboratories. She also serves on the public policy committee of the National Association of Marine Laboratories. She has a B.S. and an M.S. from Savannah State University and a Ph.D. from the University of Miami.

Dr. Brandon Jones, Program Director for Education, Directorate for Geosciences, National Science Foundation – Brandon Jones is the Program Director for the education and diversity programs in NSF's Geosciences Directorate. Brandon joins NSF after serving almost 13 years as a grants and fellowships Program Manager at EPA where he was also the former EPA representative for the National Science and Technology Policy Office's Federal Committee on STEM working group (the strategic planning committee under the COSTEM effort). At NSF, Brandon's portfolio includes undergraduate and graduate education programs as they pertain to geoscience disciplines as well as diversity, inclusion and belonging efforts as they relate to the geosciences and STEM overall. Brandon received a BA in biology from The Lincoln University (PA) and his both his graduate degrees in Marine Biology and Biochemistry from the University of Delaware's College of Earth, Ocean and Environment. He taught five years of high school science in the interim between his postgraduate degrees. Brandon has been an adjunct professor of Environmental Science at Trinity University in Washington DC. He is also an active mentor in several programs that focus on support and professional development for under-represented students interested in STEM. And he serves as a board member for the Environmental Leadership Program as well as a Dean's advisory member for the College of Earth, Ocean and Environment at the University of Delaware.

Dr. Mona Behl, Associate Director, Georgia Sea Grant, University of Georgia -- Dr. Mona Behl serves as associate director of NOAA's Sea Grant program at the University of Georgia, where she holds public service and academic appointments. In her current role, she provides administrative and financial

oversight to Georgia Sea Grant, directs its research and fellowship portfolios, and ensures the quality, relevance and impact of Sea Grant activities in Georgia. She is also a non-residential policy fellow with the American Meteorological Society (AMS). Dr Behl is passionate about improving access, engagement and leadership development of people from marginalized groups in geosciences. She co-led the development of Sea Grant's 10-year diversity; equity and inclusion vision plan, Sea Grant's community-engaged internship program, and AMS' Early Career Leadership Academy. She serves on the leadership board of Earth Science Women's Network, an international non-profit for women in Earth sciences; and on the executive committee of NOAA's Grays Reef National Marine Sanctuary. Dr. Behl is a national award-winning educator who believes in the scientific underpinning of decisions and is committed to instill love for problem-solving through scientific research and public service. She earned her bachelors and master's in Physics (Honors) from Panjab University (India), and doctorate in Physical Oceanography from Florida State University.

Dr. Matt Gilligan, Professor Emeritus, Marine Science, Savannah State University -- After completing a doctoral degree at the University of Arizona studying fishes in the Sea of Cortez, Mexico, Dr. Gilligan was hired by Savannah State College (a Historically Black College and University founded in 1890) in 1979 where he has taught and mentored scores of students and faculty for more than 30 years. There, he helped implement a ground-breaking baccalaureate program in Marine Biology through which both minority and majority students enrolled and graduated in nearly equal numbers. In 1998, Dr. Gilligan and Dr. Sue Cook at the Harbor Branch Oceanographic Institution developed a special Bridge to Research in Marine Sciences program for early undergraduates designed to retain minority students in the Ocean Sciences. By 2011—as an instructor, academic advisor, and mentor—he had touched the lives of 194 graduates in Marine Sciences (159 B.S. degree recipients and 35 M.S. degree recipients). Ninety-two of the graduates were African American and 94 were white, non-Hispanic. Most if not all of the $9 million in externally funded projects that he was involved with at SSU included internships and fellowships for students. In 2002, Dr. Gilligan testified on ocean education and diversity before the U.S. Commission on Ocean Policy in Charleston, South Carolina and, in 2006, he moderated a panel on the future ocean workforce and diversity at the Conference on Ocean Literacy in Washington, D.C. On October 1, 2011, after 31 years of service, Dr. Gilligan retired from Savannah State University and received an appointment as Professor Emeritus in the Department of Marine and Environmental Sciences. Since he retired in late 2011 and as a professor emeritus, direct mentoring has given way to consulting and community activities. He serves on the Board of Wilderness Southeast Inc., a 40-year-old ecotourism non-profit that has shifted its focus to providing STEM education supplement programs for middle schools that include classroom, laboratory and field trips to explore and learn about water/habitat quality and its relation to human health and well-being.

Possible Questions for Brandon Jones, Mona Behl and/or Matt Gilligan

- What actions would recommend NAML take to demonstrate a real commitment to addressing under-representation issues in our fields of science?
- Would you suggest some milestones or quantifiable objectives NAML might adopt in its efforts to address DEI issues?
- If NAML establishes a new committee on these diversity issues, could you recommend two or three key action items this committee should consider undertaking?

Mr. Kolo Rathburn, Associate, Hogan Lovells, former Professional Staff Member, Senate Appropriations Committee -- Prior to joining Hogan Lovells, Mr. Rathburn spent nearly a decade in government service. He served as top policy advisor to U.S. Senator Roger Wicker for issues covered by the Senate Commerce Committee. He then joined the Senate Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies as a professional staff member under Chairman Richard Shelby. With six annual appropriations bills under his belt – each amounting to roughly US$65 billion in funding – Kolo understands the nuances of the federal appropriations process. He also served as a senior political appointee in the U.S. Department of Commerce before joining Hogan Lovells. Kolo attended law school as an evening student while working full-time as a congressional staffer. He was a member of the *American University Law Review* and graduated number one in his class, among both full-time and evening students. He has a strong science background, including an undergraduate degree in biology and a Master of Science degree in marine biology. He has published four peer-reviewed papers in the field of marine biology.

Possible Questions

- What does the expiration of the statutory spending caps on defense and non-defense spending mean for the FY 22 appropriations process?
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- Can you give us a sense of the FY 2022 budget constraints the Congress will be confronting and how those pressures may impact the research and education programs important to NAML?
- Which ocean and coastal issues seem to be at the top of the "To Do" list of your Members, at least as it relates to the appropriations process? Are there ways NAML might better serve the information needs of your committee or Members in general?
- How can we go about increasing bipartisan support for the ocean, coastal and Great Lakes enterprise and what can NAML members do to expand awareness of and support for ocean research and education?

Mr. Matt Womble, Professional Staff, Senate Commerce, Justice, Science and Related Agencies Appropriations Subcommittee -- Mr. Matthew (Matt) Womble is a professional staff member of the U.S. Senate Appropriations Committee, where he works on the Subcommittee on Commerce, Justice, Science, and Related Agencies. In this role, Mr. Womble oversees funding for agencies at the Department of Commerce, including the National Oceanic and Atmospheric Administration (NOAA) and the National Institute of Standards and Technology, among others. Mr. Womble was a 2016 John H. Knauss Sea Grant Fellow, during which he worked in the office of the NOAA Chief Scientist and spearheaded efforts to evaluate and improve NOAA's Research and Development portfolio. Following the fellowship, Mr. Womble remained at NOAA and worked in the Office of the NOAA Administrator and at the National Water Center in Tuscaloosa, Alabama. Mr. Womble is originally from Ocean Springs, Mississippi. He earned his BSc in Wildlife, Fisheries, and Aquaculture Science from Mississippi State University in 2012, and an MSc in Parasitology from Auburn University School of Fisheries, Aquaculture, and Aquatic Sciences in 2015.

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Mr. Blaise Sheridan, Professional Staff, Senate Commerce, Justice, Science and Related Agencies Appropriations Subcommittee -- Mr. Blaise Sheridan is a Professional Staff Member on the Senate Appropriations Subcommittee on Commerce, Justice, and Science under the leadership of Senator Jeanne Shaheen. His portfolio includes the National Science Foundation and the Department of Commerce and the related trade agencies, including the National Oceanic and Atmospheric Administration. Previously he served as a Legislative Assistant in the Offices of U.S. Senators Tina Smith (D-MN) and Al Franken (D-MN), where his portfolio included the Great Lakes, climate change, energy, agriculture, and innovation issues. He also served as the lead advisor to the Senators on the Committee on Energy and Natural Resources. Prior to this position, he served as Legislative Aide for Senator Chris Coons (D-DE), where he covered ocean, energy, environment, and transportation issues. Before his Senate tenure, he worked at the Environmental and Energy Study Institute (EESI) as a Climate and Energy Policy Associate. He has a Master's Degree in Marine Policy from University of Delaware and a B.S. in Engineering from Swarthmore College.

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NATIONAL ASSOCIATION OF MARINE LABORATORIES

FY 2021 PUBLIC POLICY AGENDA

April 2020

The National Association of Marine Laboratories (NAML) was established in 1989 to support the vital role of Marine and Great Lakes Laboratories in the Nation's Ocean and Coastal Enterprise -- This network of place-based marine and Great Lakes laboratories is a unique and valuable national asset. The geographic reach of this network includes estuaries, the coastal zone, the Great Lakes and inland watersheds, the global ocean including polar regions, and the sea floor. NAML labs connect scientists, students, public and civic leaders with leading edge science, environmental and coastal intelligence and professional training that contributes to the understanding, management, and stewardship of our ocean, coastal zones and Great Lakes.

The intersection of ocean, coastal zone and Great Lakes natural resources and U.S. economic activity is complex and highly interdependent. The U.S. depends on healthy marine and freshwater resources, yet many human activities and natural events impact these resources, thereby jeopardizing jobs, wages, our gross domestic product, human health, and well-being. NAML labs operate on the frontline of a rapidly changing environment providing coastal intelligence, comprised of both human socioeconomics and the natural aquatic world to better manage and sustain the full spectrum of marine and Great Lakes resources.

Marine and Great Lakes science laboratories play pivotal roles in the national priorities identified in the ***Memorandum on Ocean Mapping of the United States Exclusive Economic Zone and the Shoreline and Nearshore of Alaska***, and in national assessments on ***Science and Technology for America's Oceans: A Decadal Vision***; ***Sea Change: 2015-2025 Decadal Survey of Ocean Sciences***, and ***Enhancing the Value and Sustainability of Field Stations and Marine Laboratories in the 21st Century***. These documents emphasize the need to understand the ocean in the earth system, promote the blue economy, advance monitoring and predictive modeling capabilities. NAML laboratories bring a high degree of relevance to these critical efforts at lower cost, higher return on investment and with the important benefit of training future generations of the marine science and policy workforce.

The Importance of Oceans, Coasts, and Great Lakes to National, Economic, and Environmental Security -- The ocean, our coasts, and the Great Lakes are among the United States' most treasured resources. They are an integral part of our national identity and our Nation's future. The ocean covers 71% of the Earth's surface and hundreds of millions of people rely on a viable ocean. A healthy, productive, and resilient ocean is inextricably linked to Earth's climate and weather patterns and contributes significantly to our quality of life. The ocean provides and creates jobs, gives mobility to our national commerce and Armed Forces, helps feed our Nation, secures our borders, fuels our economy, and provides places for recreation and solace. Understanding the physical, chemical, biological, and geological changes in the ocean is vital to the survival and prosperity of humanity.

In the United States, the ocean and its wealth of natural resources have played a critical role in fueling American prosperity and energy independence, protecting our country, generating over 3 million jobs, sustaining industries, and contributing to 2% of the nation's gross domestic product. Our coastal ports and ocean transport systems are the engines of world trade, facilitating a thriving U.S. economy through the maritime enterprise. The biological diversity and productivity of the ocean sustains the health of coastal communities and promotes a vibrant national economy. At the same time, coastal communities that drive the ocean economy are also vulnerable to events such as hurricanes, tsunami's, sea level rise, floods, over-development and surging coastal population growth. Many of these stressors to our oceans and coastal zones, and by extension the services they provide, are evidenced by human observations of changing coastlines and ecosystems, navigation routes, water quality, species diversity, the timing and occurrence of pathogen outbreaks, the rising burden of marine debris, and flat-lined or declining populations of commercially and ecologically important marine species.

The ocean science and technology (S&T) enterprise -- through its use and support of marine and Great Lakes laboratories -- can provide the knowledge and the education and training needed to address these and other important and complex challenges while also providing fact-based information for decision makers that will ultimately strengthen our Nation and its communities.

NAML Research and Education Priorities for FY 2021 -- To support the vital role of marine and Great Lakes laboratories in the ocean S&T enterprise, NAML requests that our Nation's Leaders fully fund the Federal Government's investment in extramural, merit-based, competitive research, infrastructure, observing and education programs at NSF, NOAA, NASA, EPA, DOI, USGS, and other ocean, coastal and Great Lakes related agencies. Investments through these agencies are essential for the development of knowledge, a diverse workforce, an ocean-literate society, and the technological innovations needed to power the Nation's economy, improve human health, and sustain a strong national defense and vibrant society. NAML urges expanded support for these extramural programs that support research, infrastructure, observations, and education. Examples of what they address include:

- The U.S currently imports 90% of its seafood - U.S.-based aquaculture is needed to address this imbalance, to advance seafood security and to expand opportunities for economic growth;
- The ocean is changing – we must understand the impacts and causative factors of shifting environmental regimes such as sea level rise, harmful algal blooms, hypoxia, and ocean acidification to improve coastal resilience and inform risk management of critical defense, transportation, civic and business infrastructure along U.S. coastlines;
- The ocean holds vast renewable and nonrenewable resources - ocean exploration, research, and technology development are needed to advance national security, commerce and domestic energy independence;
- Technology is the great enabler – big data, sustained ocean observations, predictive ecosystem models, "omics" are all needed for comprehensive understanding of ecosystems fueling adaptive management strategies to sustain the social-economic productivity of U.S. exclusive economic zones;
- Marine infrastructure is vital - ships, autonomous vehicles, laboratory refurbishment, data analysis, observational capabilities, and instrumentation development combine to understand the complex four-dimensional ocean; and
- STEM is the foundation – biological, chemical, geological and physical marine sciences, ocean engineering and marine policy education and training is key to long-term advancement of human and environment health and social-economic objectives.

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Testimony for the Record
Dr. Robert W. Dickey, Ph.D.
President, National Association of Marine Laboratories
for the
Subcommittee on Commerce, Justice, and Science, and Related Agencies
Committee on Appropriations
United States Senate
Washington, D.C.
April 2020

The National Association of Marine Laboratories (NAML) is submitting testimony that considers the impact of the COVID-19 pandemic that has gripped the country. The pandemic has fundamentally and dramatically changed our way of life for the foreseeable future. In less than four months, we have seen nearly every person, business, government, educational enterprise, health care system, and societal institution adversely impacted in previously unimaginable ways. Since the pandemic was detected in this country in January of this year, the interconnectedness of the world in which we live has been clearly demonstrated. This nation has been challenged before and has proven its resilience and ability to rise to the occasion. We must do so again while also learning from this pandemic to be better prepared for such challenges in the future.

As most NAML laboratories are housed at academic institutions we are acutely aware of the impacts of this pandemic upon our research and educational enterprise. NAML requests supplemental funding for federal research agencies to support emergency paid leave for grant personnel – including students, post docs, technicians, and other support staff. Federal Agencies have provided some flexibility to continue to pay the salaries of grant personnel, but without supplemental support, grant funding will be depleted long before sponsored projects can be resumed and completed. Marine and freshwater laboratories at institutions of higher education face significant challenges in continuing to meet payroll obligations for graduate students, postdocs, and other research grant funded personnel where work has necessarily been suspended. We urge the Subcommittee to ensure that research agencies have the financial resources to help our institutions and principal investigators address the issues below as well as the ability to provide the grantees and their institutions with maximum flexibility in addressing these difficult circumstances. We strongly recommend funding in the next COVID-19 stimulus bill to alleviate the impact on our facilities and personnel and in so doing sustain the nation's current and future research workforce and capabilities.

Issues of Concern/Areas for Investment

- The education and training of, and loss of support for our students. Our laboratories play an important part of their education in that they provide unique, place-based experiential learning opportunities. At the same time many students are supported, in whole or in part, via the research grants our principal investigators are awarded. Many of these opportunities have been suspended for the foreseeable future with the consequence being the loss of support we typically provide our students. This creates additional hardships for the students.

- Salaries for graduate students, post-doctoral researchers, other research personnel, and laboratory technicians are often fully funded by federal grants. Campuses are responding to

COVID-19 public health recommendations and working diligently to ensure the safety of their employees and to accommodate work from home scenarios for researchers who can work remotely. However, many research projects not related to COVID-19 are suspended due to campus closures.

- Expenses to ramp-down and suspend federally sponsored work and eventual ramp-up costs to resume research activities include: loss or necessary destruction of cell cultures and biological samples, disposal of hazardous materials and other environmental safety costs, care for live specimens, and in some cases replacement of specimens, and restarting experiments that could not be completed due to the closure of research facilities, inability of personnel to conduct fieldwork, or missed seasonal opportunities;

- Recovery costs for federally funded services that researchers, students and staff perform for data acquisition, computational analysis, interpretation and deposition in national databases that inform national management strategies and policy.

Federal agencies are working with our institutions to minimize the pandemic's impact and the enactment by Congress of the CARES Act is a helpful step in terms of supporting our first responders, those who are now unemployed, small businesses, hospitals and healthcare providers, and industries hit hardest by this pandemic. However, the impacts and consequences of this pandemic run deep and additional relief and economic stimulation will be needed in additional legislation.

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Economic Stimulus - The Blue Economy Initiative

Once the immediate outbreak is partially contained and officials deem it is time to begin to restore our lives and livelihoods, there will undoubtedly be a need for additional assistance to re-start the economy and all the societal elements that contribute to our quality of life.

As marine and freshwater laboratories, we see the role our ocean, coasts, and Great Lakes can play in helping to revitalize our overall economy through a specific focus on the ocean or blue economy. There are some estimates that put the value of the ocean to the world's economy at an estimated $24 trillion, making it the world's seventh largest economy. According to the Organization for Economic Cooperation and Development, by 2030 the blue economy could outperform the growth of the global economy as a whole. In the U.S. NOAA estimates that the ocean economy has been growing at twice the rate of the rest of the U.S. economy, employing 3.2 million people and contributing $320 billion.

We find ourselves in some of the most challenging times our nation has ever faced. Government at all levels is being called upon to respond, as is nearly every other facet of our society. Challenging times require bold and impactful actions. NAML believes this Subcommittee could significantly impact the blue economy by enacting, as part of a larger economic stimulus package, a strategic investment in the ocean, coastal, and Great Lakes enterprise through investments in research and related infrastructure; next generation observation platforms; advanced marine technology development; and the development of the "blue" workforce.

Given the importance and impact we believe the blue economy can make to the improved health and well-being of our citizens, NAML proposes a billion-dollar ***Blue Economy Initiative*** to aid the nation in recovering from the damage brought on by the COVID-19 pandemic. We recognize that a considerable number of Federal agencies are involved in the federal ocean science and technology enterprise with distinct roles and responsibilities. We will focus on the two agencies that are within the jurisdiction of this Subcommittee and have particularly significant roles in supporting the science and technology that underlies the foundation of our blue economy.

National Science Foundation

Ocean Science Research for Human Health – The ocean, covering 75% of the planet, is full of potential human-health assets. In recent decades, scientists have discovered whole new ecological communities in the ocean with unique biochemical systems, such as those associated with thermal vents and hydrocarbon seeps. These communities hold huge possibilities for development of products to improve human health and well-being. Prior discoveries that now have practical applications include anti-cancer drugs, diagnostics, molecular probes, and nutrients.

Ocean Science Research for the Blue Economy – Increase merit-based research related to "omics; sustained coastal and ocean data collection; comprehensive understanding of ecosystems; and adaptive management strategies to increase productivity and sustainability of marine fisheries and the social-economic productivity of U.S. exclusive economic zones; harmful algal blooms, ocean acidification and hypoxia, sea level rise and extramural research and education activities related to restoration of the Great Lakes. Support for NSF Big Idea – Navigating the New Arctic. Research should also be focused on the key challenges laid out in *Sea Change* – the National Academies' report on ocean science priorities.

Academic Research Fleet – Support to re-start and continue operations for all vessels within the UNOLS Academic Research Fleet with sufficient operational support for the fleet to be fully utilized to its capacity for the next three years; expanded efforts to modernize the UNOLS fleet with the next generation research vessels, observing platforms, unmanned surface and subsurface vehicles, artificial intelligence, quantum computing, advanced computing and data analysis, etc.; funding sufficient for the acquisition of a next generation global class research vessel for the UNOLS fleet with state-of-the-art seabed and sub-seabed imaging capabilities, and on board educational and outreach capabilities.

Next Generation Ocean Research Infrastructure – Infrastructure support for ocean, coastal, and Great Lakes marine and freshwater labs, aquariums, and other related facilities through NSF's Field Stations and Marine Laboratories Program, Major Research Instrumentation, and Mid-Scale Infrastructure initiatives; Ocean Observatories Initiative; and the International Ocean Discovery Program.

Blue Workforce Development – Support for graduate and undergraduate students, instructional resources, and public-facing programing that elevate ocean literacy and inspire careers in the ocean sciences.

Presidential Ocean Exploration/Mapping Initiative – This interagency effort is designed to develop and execute and strategic plan to map the U.S. Exclusive Economic Zone, explore and

characterize priority areas, partner with other entities, and integrate new and emerging technologies.

National Oceanic and Atmospheric Administration

Oceans for Human Health – NOAA should partner with NSF, NIEHS, EPA and FDA given NOAA's past Oceans and Human Health program. NOAA's experience and assets combined with access to experts in marine science and other related fields across these agencies and within the nation's marine and Great Lakes laboratories, could yield important advancements in pharmaceuticals, treatments, food security, and the interdependency of human and environmental health.

Fisheries Assistance – Additional assistance to tribal, subsistence, commercial, and charter fishery participants impacted by COVID-19, including assistance to fishing communities, aquaculture, young commercial fisherman professional development including fisheries extension and outreach via relevant current NOAA programs, such as Sea Grant.

Coastal Communities Resilience - Through the existing Title IX program and the National Sea Grant College Program to help coastal communities establish economic and environmental resilience actions that will spur economic growth while planning strategically to adapt to changing environmental conditions.

Next Generation Marine Technology Development and Research Infrastructure – Including modernizing research vessels, observing platforms, unmanned surface and subsurface vehicles artificial intelligence and quantum computing deployment, and commercial engagement through ocean technology.

Research Centers and Management Support -For the personnel and activities at NOAA Cooperative Institutes, labs, and centers; extramural ocean, coastal, and Great Lakes laboratories, Sea Grant College programs, integrated ocean observing systems, national estuarine research reserve system sites, national marine sanctuaries operations.

Blue Workforce Development – Support for NOAA education programs focused on the undergraduate level; graduate training; the Jose Serrano Educational Partnership Program; and public science education activities at museums, aquaria and zoos.

Presidential Ocean Exploration/Mapping Initiative – This interagency effort is designed to develop and execute and strategic plan to map the U.S. Exclusive Economic Zone, explore and characterize priority areas, partner with other entities, and integrate new and emerging technologies.

Conclusion

Our nation has faced great adversity in the past and has always proven resilient and risen to any challenge. We will do so again with strategic investments for a robust recovery that includes our Ocean Research, Education and Economic Enterprise.

On behalf of the members of NAML listed below, thank you for the opportunity to submit this statement.

Host Institution	Laboratory/Facility
Alabama's Marine Science Institution	Dauphin Island Sea Laboratory
Bermuda Institute of Ocean Sciences	Bermuda Institute of Ocean Sciences
Bigelow Laboratory for Ocean Sciences	Bigelow Laboratory for Ocean Sciences
Bowdoin College	Schiller Coastal Studies Center
California State University	Moss Landing Marine Laboratories
Central Michigan University	CMU Institute for Great Lakes Research
College of Charleston	Grice Marine Laboratory
Cornell University, University of New Hampshire	Shoals Marine Laboratory
Duke University	Duke University Marine Lab
East Carolina University	Coastal Studies Institute, Integrated Coastal Programs
Eckerd College	Galbraith Marine Science Center
Florida Atlantic University	Harbor Branch Oceanographic Institute
Florida Fish and Wildlife Conservation Commission	FWC Fish and Wildlife
Florida Institute of Oceanography	Keys Marine Laboratory
Florida State University	Florida State University Coastal and Marine Laboratory
Grand Valley State University	Annis Water Resources Institute
Hubbs Sea World Research Institute	Hubbs Sea World Research Institute
Humboldt State University	Telonicher Marine Laboratory
Jacksonville University	Marine Science Research Institute
Louisiana Universities Marine Consortium	Louisiana Universities Marine Consortium
Marine Biological Laboratory	Marine Biological Laboratory
Michigan Technological University	Great Lakes Research Center
Monterey Bay Aquarium Research Institute	Monterey Bay Aquarium Research Institute
Morgan State University	Patuxent Environmental and Aquatic Research Center
Mote Marine Laboratory	Mote Marine Laboratory
Natural History Museum of Los Angeles County	Research & Collections Branch
New College of Florida	Pritzker Marine Laboratory
North Carolina State University	Center for Marine Sciences and Technology
Northeastern University	Northeastern University Marine Science Center
Ohio State University	Stone Laboratory on Lake Erie
Old Dominion University	Dept. of Ocean, Earth and Atmospheric Sciences
Oregon State University	Hatfield Marine Science Center
Prince William Sound Science Center	Prince William Sound Science Center

Host Institution	Laboratory/Facility
Roger Williams University	Marine Laboratory
Rutgers University	Institute of Marine and Coastal Sciences
San Francisco State University	Estuary & Ocean Science Center
San Luis Obispo University	Center for Coastal Marine Sciences
Sanibel-Captiva Conservation Foundation	Sanibel-Captiva Conservation Foundation
Savannah State University	Marine Science
Seattle Pacific University	Blakely Island Field Station
Sitka Sound Science Center	Sitka Sound Science Center
Smithsonian Institution	Smithsonian Marine Station at Fort Pierce
South Carolina Aquarium	South Carolina Aquarium
Southern California Coastal Water Research Project	Southern California Coastal Water Research Project
Stanford University	Hopkins Marine Station
State University of New York	School of Marine & Atmospheric Sciences (SoMAS)
Stockton University	Marine Field Station
Texas A&M University	Geochemical and Environmental Research Group
Texas A&M University, Corpus Christi	Conrad Blucher Institute
Texas A&M University, Corpus Christi	Harte Research Institute
Texas A&M University, Galveston	Dept. of Marine Biology
University of Alaska, Fairbanks	Kasitsna Bay Marine Laboratory
University of California, Berkeley	Richard B. Gump South Pacific Research Station
University of California, Davis	Bodega Marine Laboratory
University of California, San Diego	Scripps Institution of Oceanography, UCSD
University of California, Santa Cruz	Institute of Marine Sciences/Long Marine Lab
University of Connecticut	Marine Sciences/CT SeaGrant
University of Delaware	School of Marine Science and Policy
University of Florida	Nature Coast Biological Station
University of Florida	Whitney Laboratory for Marine Bioscience
University of Georgia	Marine Institute at Sapelo Island
University of Georgia	Skidaway Institute of Oceanography
University of Guam	University of Guam Marine Laboratory
University of Hawaii	Hawaii Institute of Marine Biology
University of Hawai'i at Manoa	Kewalo Marine Laboratory
University of Maine	Darling Marine Center
University of Maryland	Chesapeake Biological Laboratory
University of Maryland	Horn Point Laboratory

Host Institution	Laboratory/Facility
University of Massachusetts, Boston	Nantucket Field Station
University of Miami	Rosenstiel School of Marine and Atmospheric Sciences
University of Mississippi	National Center for Natural Products Research
University of New England	Marine Science Center
University of New Hampshire	Jackson Estuarine Laboratory
University of North Carolina, Chapel Hill	Institute of Marine Sciences
University of North Carolina, Wilmington	Center for Marine Science
University of North Florida	Coastal and Marine Biology Flagship Program
University of Oregon	Oregon Institute of Marine Biology
University of Rhode Island	Graduate School of Oceanography
University of South Carolina	Belle W. Baruch Institute
University of South Florida	College of Marine Science
University of Southern California	Wrigley Marine Science Center
University of Southern Mississippi	Gulf Coast Research Laboratory
University of Texas	Marine Science Institute
University of Texas Rio Grand Valley	Coastal Studies Lab
University of Washington	Friday Harbor Laboratories
University of Wisconsin, Milwaukee	School of Freshwater Sciences
Virginia Institute of Marine Science	Virginia Institute of Marine Science
Walla Walla University	Rosario Beach Marine Laboratory
Williams College at Mystic Seaport	The Maritime Program
Woods Hole Oceanographic Institution	Woods Hole Oceanographic Institution

Memorandum to the Biden-Harris Administration

Date: January 2021

From: Robert W. Dickey, Ph.D.
President, National Association of Marine Laboratories

Subject: Nation's Recovery Tied to Resilience of Ocean, Coastal, and Great Lakes

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The National Association of Marine Laboratories (NAML) is a network of place-based marine and Great Lakes laboratories. The research and education activities we carry out contribute to your Administration's priorities and the increased resiliency of our coastal communities. We recommend major investments in research infrastructure, innovation, research and development, education, and clean energy to generate the knowledge, new technologies, and people that will enhance the resilience of our coastal communities and economy.

NAML labs operate on the frontline of a rapidly changing environment. The ocean, coasts, and the Great Lakes are vital resources and an integral part of our national identity and our nation's future. The ocean and our Great Lakes fuel our economy with an estimated 3 million jobs, give mobility to our commerce and Armed Forces, feed our nation, secure our borders, and provide places for recreation. Understanding the physical, chemical, biological, and geological changes in the ocean and our Great Lakes is vital to the survival and prosperity of our country. The U.S. depends on our healthy marine and freshwater resources, yet many human activities and natural events impact coastal community resilience, thereby jeopardizing jobs, wages, our gross domestic product, human health, and well-being.

At the same time, deadly and expensive weather- and climate- related hazards have increased at an alarming rate. Since 1980, the Nation experienced 285 weather and climate disasters where overall damages reached or exceeded $1 billion. The total cost of these 285 events exceeds $1.875 trillion. Over the last five years (2016-2020), the Nation was subjected to 81 events that resulted in nearly 4000 deaths and damages that exceed $600 billion. Weather and climate hazards challenge the resilience of coastal communities via damage to critical infrastructure, disrupt water and food supplies, and cause social instability, unemployment, and governance challenges.

The ocean science and technology enterprise -- through its use and support of NAML laboratories – provides the knowledge and training for decision makers concerned about the economic and environmental resilience of our coastal communities. To support the vital role of marine and Great Lakes laboratories in the ocean enterprise, we recommend prioritizing the Federal Government's investment in extramural, merit-based, competitive programs at NSF, NOAA, NASA, EPA, DOI, USGS, and other ocean, coastal, and Great Lakes related agencies. Investments in federally funded extramural research, education and infrastructure (physical, cyber-related, data management, etc.) of our ocean and Great Lakes are essential for new knowledge, a diverse workforce, an ocean-literate society, and technological innovations needed to power the nation's economy, improve human health, and sustain a strong national defense and vibrant society. Suggestions for increased support include:

- Investigate shifting environmental regimes such as sea level rise, harmful algal blooms, hypoxia, and ocean acidification to improve coastal resilience and inform risk management of critical defense, transportation, civic and business infrastructure along U.S. coastlines.
- Ocean exploration, research, and technology development to advance national security, commerce, and domestic energy independence.
- Supporting U.S. aquaculture will reduce our dependence on imported seafood, advance seafood security, and expand opportunities for economic growth.
- Big data, sustained ocean observations, predictive ecosystem models, next-generation DNA sequencing technology ("omics"), are all needed for comprehensive understanding of ecosystems fueling adaptive management strategies to sustain the social-economic productivity of U.S. exclusive economic zones.
- Marine infrastructure - ships, autonomous vehicles, laboratory refurbishment, data analysis, observational capabilities, and instrumentation – is vital to understand the complex four-dimensional ocean; and
- STEM is the foundation – biological, chemical, geological and physical marine sciences, ocean engineering and marine policy education and training - of a diverse constituency is key to long-term advancement of human and environment health and social-economic objectives.

The NAML network of place-based marine and Great Lakes laboratories is a world renowned valuable national asset. The labs' geographic network includes estuaries, the coastal zone, the Great Lakes and inland watersheds, the global ocean including polar regions, and the sea floor. NAML labs provide scientists, students, public and civic leaders with leading edge science, environmental and coastal intelligence, and professional training that contributes to the understanding, management, and stewardship of our ocean, coastal zones and Great Lakes. The NAML network stands ready to assist the new Administration by offering ocean and Great Lakes research and solutions that strengthen economic and environmental resilience.

Thank you for the opportunity to provide these views.

EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON, D.C.

August 14, 2020

M-20-29

MEMORANDUM FOR THE HEADS OF EXECUTIVE DEPARTMENTS AND AGENCIES

FROM: RUSSELL T. VOUGHT
DIRECTOR, OFFICE OF MANAGEMENT AND BUDGET

DR. KELVIN K. DROEGEMEIER
DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY

SUBJECT: Fiscal Year (FY) 2022 Administration Research and Development Budget Priorities and Cross-cutting Actions

"We look at tomorrow and see unlimited frontiers just waiting to be explored. Our brightest discoveries are not yet known. Our most thrilling stories are not yet told. Our grandest journeys are not yet made..."

President Donald J. Trump, 2020 State of the Union Address

Over the past 75 years, the United States has emerged as the unquestioned global leader in science and technology (S&T) research and innovation. The importance of this leadership has never been clearer than in our whole-of-Nation response to the COVID-19 pandemic. The sum total of decades of public and private investment in research and development (R&D) has served as the foundation for rapidly characterizing the SARS-CoV-2 virus and developing life-saving diagnostics and medical interventions. The Trump Administration's focus on the Industries of the Future (IotF) and, in particular, artificial intelligence (AI) has equipped researchers with new and better tools to fight the disease. Likewise, investments in advanced communications, networking, and broadband access have ensured that millions of Americans can continue to work and access education and medical services remotely.

A foundation of the Nation's ability to respond to COVID-19 is the capacity of government, the private sector, academia, and nonprofits to make substantial and complementary investments in R&D and effectively partner to create the discoveries and innovations. This same partnership fuels the economic prosperity, health, and security of all Americans. The Federal Government, in particular, serves as a catalyst for innovation by investing in early stage research, supporting workforce education and training, and optimizing research environments by streamlining administrative barriers and adhering to bedrock American values, such as free inquiry, competition, honesty, and inclusion.

OVERVIEW OF THE FY2022 MEMORANDUM

For FY2022, the ***five R&D budgetary priorities*** in this memorandum ensure that America remains at the global forefront of S&T discovery and innovation. The IotF—AI, quantum information sciences (QIS), advanced communication networks/5G, advanced manufacturing, and biotechnology—remain the Administration's top R&D priority. This includes fulfilling President Trump's commitment to double non-defense AI and QIS funding by FY2022.

In light of the significant health and economic disruption caused by the COVID-19 pandemic, the FY2022 memorandum includes a new R&D priority aimed at ***American Public Health Security and Innovation***. This priority brings under a single, comprehensive umbrella biomedical and biotechnology R&D aimed at responding to the pandemic and ensuring the U.S. S&T enterprise is maximally prepared for any health-related threats.

Lastly, this memorandum also describes ***four high-priority crosscutting actions***. These actions include research and related strategies that underpin the five R&D priorities and ensure departments and agencies deliver maximum return on investment to the American people.

R&D BUDGETARY PRIORITIES

1. American Public Health Security and Innovation

R&D to strengthen and safeguard the health and quality of life of individuals, families, and communities is a top priority for the Trump Administration. COVID-19 has highlighted the extent to which public health threats and challenges can impact economic and national security. The Administration is committed to focusing on R&D initiatives that improve health while ensuring a retooled economy that optimizes innovation.

Diagnostic, Vaccine, and Therapeutic R&D: As has been demonstrated with COVID-19, the importance of detection, prevention, response, and control to protect all Americans against infectious diseases or other bio-threats is paramount and requires the coordinated effort of all relevant departments and agencies. Departments and agencies should continue to support R&D that will contribute to timely development of modernized devices and equipment, diagnostics, therapeutics, and vaccines within the medical countermeasures enterprise.

Infectious Disease Modeling, Prediction, and Forecasting: The United States must improve epidemiological modeling R&D, as well as use such models on a continuous basis rather than employing them only in times of crisis. Relevant departments and agencies should enhance their ability to predict future pandemics by continuing to advance data and forecasting science to inform a more streamlined, better coordinated, and continual whole-of-society approach to addressing future infectious disease outbreaks.

Biomedicine and Biotechnology: Departments and agencies should prioritize accelerated identification and selection of R&D investments including the rapid detection, containment, and treatment of infectious diseases. Topics include pharmaceutical and non-pharmaceutical interventions, personalized medicine, neuroscience, and opioids, and advancing other IotF areas such as AI and advanced manufacturing—technologies that have been critical in ensuring rapid R&D of vaccines and therapeutics for pathogens such as COVID-19.

Bioeconomy: The American Bioeconomy represents a convergence of science, infrastructure, innovation and technology, health, and national security that drive economic growth, promote health, and increase public benefit across the human, plant, and animal spectrums. In response to the unprecedented number of lives lost and resources consumed to combat COVID-19, departments and agencies should prioritize evidence-based standards and research to rapidly and strategically continue improving biotechnology infrastructure that support human, plant, and animal safety. In addition, departments and agencies should focus on R&D that enables forecasting and analyses from comprehensive collections of epidemiological, clinical, and genomic data capable of driving supply chain resilience and economic growth across sectors such as healthcare and pharmaceuticals, engineering biology, nanobiotechnology, agriculture, and IotF including advanced manufacturing.

2. American Leadership in the Industries of the Future and Related Technologies

The Trump Administration continues to prioritize the science and technologies that power IotF—AI, QIS, advanced communications networks/5G, advanced manufacturing, and biotechnology[1]—as well as the future computing ecosystem that underpins advances in IotF, and the autonomous and remotely piloted vehicles that are enabled by IotF. These industries promise to fuel American prosperity, improve quality of life and national security, and create high-paying jobs for American workers. Some of the industries are also key enablers in our response to and recovery from COVID-19 and its impacts. Sustained, strategic R&D investment in these emerging technologies and the supporting future computing ecosystem will better position the Nation for handling future crises and catalyzing discoveries and innovations that will shape the global S&T landscape for the decades ahead.[2] Additionally, research at the convergence of these industries with pathfinders such as advanced air mobility that integrates AI, autonomy, advanced manufacturing, and next-generation communications, will accelerate new discoveries that fuel future breakthroughs and yield a near-term economic and national security advantage.

Artificial Intelligence: Departments and agencies should prioritize research investments consistent with the *Executive Order on Maintaining American Leadership in Artificial Intelligence*[3] and the 2019 update of the *National Artificial Intelligence Research and Development Strategic Plan*.[4] Transformative basic research priorities include research on ethical issues of AI, data-efficient and high performance machine learning (ML) techniques, cognitive AI, secure and trustworthy AI, scalable and robust AI, integrated and interactive AI, and novel AI hardware. The current pandemic highlights the importance of use-inspired AI research for healthcare, including AI for discovery of therapeutics and vaccines; AI-based search of publications and patents for scientific insights; and AI for improved imaging, diagnosis, and data analysis. Beyond healthcare, use-inspired AI research for scientific and engineering discovery across many domains can help the Nation address future crises. AI infrastructure investments are prioritized, including national institutes and testbeds for AI development, testing, and evaluation; data and model resources for AI R&D; and open knowledge networks. Research is also prioritized for the development of AI measures, evaluation methodologies, and standards, including quantification of trustworthy AI in dimensions of accuracy, fairness, robustness, explainability, and transparency.

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[1] See Priority 1, "Public Health Security and Innovation," for discussion of the IotF biotechnology priority areas.
[2] President's Council of Advisors on Science and Technology, "Recommendations for Strengthening American Leadership in Industries of the Future," https://science.osti.gov/-/media/_/pdf/about/pcast/202006/PCAST_June_2020_Report.pdf.
[3] Exec. Order No. 13859, "Maintaining American Leadership in Artificial Intelligence," 84 Fed. Reg. 3967 (Feb. 11, 2019).
[4] National Science and Technology Council (NSTC), "The National Artificial Intelligence Research and Development Strategic Plan: 2019 Update." https://www.nitrd.gov/pubs/National-AI-RD-Strategy-2019.pdf.

Quantum Information Science: Consistent with the 2018 *National Quantum Initiative Act*[5] and the 2018 *National Defense Authorization Act*,[6] departments and agencies should pursue quantum frontiers by prioritizing approaches for enabling and invigorating the nascent QIS ecosystem while deepening focused efforts, such as centers, core programs, and novel quantum networking collaborations. Opportunities to encourage collaboration between efforts and agencies should be prioritized, as should support for pre-competitive R&D through mechanisms such as consortia and other technology translation efforts, investment in critical infrastructure and testbeds in concert with work on future computing paradigms and advanced manufacturing to enable next-generation quantum devices, and expansion of efforts exploring and piloting uses of quantum technology to help support agency missions.

Advanced Communications Networks: Departments and agencies, in close coordination with the private sector, should strengthen basic research in advanced communications technologies, including furthering America's leadership in 5G and beyond wireless networks, in order to spur innovation and growth. As outlined in the report *Research and Development Priorities for American Leadership in Wireless Communications*,[7] this includes research on AI/ML techniques optimized for wireless systems, as well as applying AI/ML to communications and cyber security in general, toward the goal of secure and trusted applications. Departments and agencies should encourage the development of applications that leverage 5G and advanced networks that incorporate security and privacy as fundamental values. Departments and agencies should support growth in American manufacturing of wireless network equipment through R&D of open, interoperable, secure-by-design, modularized network architectures.[8]

Advanced Manufacturing: Department and agency R&D investments should support the goals in the report *Strategies for American Leadership in Advanced Manufacturing*.[9] Priorities include smart and digital manufacturing and advanced industrial robotics, especially systems enabled by the industrial internet of things. Departments and agencies should focus on methods for low-cost distributed manufacturing and continuous manufacturing, including investments in bio-based manufacturing to ensure domestic access to needed medicines. An area of particular importance is the development of nano and advanced materials and processes in the biomedical arena to support the Nation's response to COVID-19, such as the development of effective antimicrobial materials and polymers for additive manufacturing and prototyping of critical medical devices.

IotF-Related Technology – Future Computing Ecosystem: To accelerate IotF, departments and agencies should prioritize the implementation of a national strategic computing ecosystem as outlined in the report *National Strategic Computing Initiative Update: Pioneering the Future of*

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[5] Pub. L. No. 115-368.
[6] Pub. L. No. 115-91.
[7] OSTP, "Research and Development Priorities for American Leadership in Wireless Communications," https://www.whitehouse.gov/wp-content/uploads/2019/05/Research-and-Development-Priorities-for-American-Leadership-in-Wireless-Communications-Report-May-2019.pdf.
[8] Exec. Order No. 13873, "Securing the Information and Communications Technology and Services Supply Chain," 84 Fed. Reg. 65316 (May 15, 2019).
[9] NSTC, "Strategy for American Leadership in Advanced Manufacturing," https://www.manufacturing.gov/news/announcements/2018/10/strategy-american-leadership-advanced-manufacturing.

Computing,[10] integrating advanced computing, software, and data resources from extreme scales to the edge towards enabling end-to-end application workflows, while supporting innovations in and translation of future technologies. This includes prioritizing investments in fundamental R&D in future computing technologies and paradigms including testbeds, experimental systems, and prototypes. To amplify the transformative impact of a strategic computing ecosystem as demonstrated by the successes of the COVID-19 HPC Consortium,[11] departments and agencies should explore innovative models for resource aggregation and sharing and for public-private partnerships.[12] Priorities include translational efforts such as consortia or centers of excellence that leverage such partnerships towards the development and sustainability of software and data solutions.

IotF-Related Technology – Autonomous and Remotely Piloted Vehicles: Leveraging emerging IotF technologies, departments and agencies should prioritize R&D that enables surface, air, and maritime autonomous and remotely piloted vehicles, and optionally piloted electric vertical-takeoff-and-landing aircraft. They should prioritize R&D to lower barriers to the deployment of surface, air, and maritime autonomous vehicles with a focus on developing operating standards including sense and avoid technologies, integration approaches, traffic management systems, and defense/security operations including technology to aid law enforcement policing of autonomous and remotely piloted transportation systems. This includes technology to aid regulators in quickly and effectively validating the safety and security of advanced transportation technologies. Departments and agencies should also prioritize civil supersonic aircraft, including for type certification, the creation of over-land supersonic flight noise standards, and low-sonic-boom aircraft research.

3. American Security

The 2017 National Security Strategy[13] states "[a]n America that is safe, prosperous, and free at home is an America with the strength, confidence, and will to lead abroad. It is an America that can preserve peace, uphold liberty, and create enduring advantages for the American people." Preserving and protecting American security requires targeted Federal Government investments in R&D leading to robust and flexible capabilities for preventing and responding to evolving challenges posed by strategic competitors and adversaries, as well as those that arise from the natural world.

Resilience: Departments and agencies should invest in R&D that improves the safety and resilience of American individuals, businesses, communities, government, and society. This should include R&D to enhance capabilities for anticipating, preventing, responding to, and/or recovering from physical threats and natural disasters, including compound and cascading incidents. Such R&D should encompass and, as appropriate, integrate across threat and hazard domains, including infectious diseases and other biological threats, extreme terrestrial and space weather events, geophysical hazards, cyber and electromagnetic pulse attacks on critical infrastructure, and exploitation of supply chain vulnerabilities.

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[10] Fast Track Action Committee on Strategic Computing, "National Strategic Computing Initiative Update: Pioneering the Future of Computing," November 2019. https://www.whitehouse.gov/wp-content/uploads/2019/11/National-Strategic-Computing-Initiative-Update-2019.pdf.

[11] "COVID-10 High Performance Computing Consortium," https://www.whitehouse.gov/briefings-statements/white-house-announces-new-partnership-unleash-u-s-supercomputing-resources-fight-covid-19/.

[12] See cross-cutting actions 2 and 4, for additional actions to support partnerships and data sharing, respectively.

[13] https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf.

Advanced Military Capabilities: Relevant departments and agencies should invest in R&D to deliver the advanced military capabilities necessary for meeting emerging threats and protecting American security into the future, including offensive and defensive hypersonic weapons capabilities, resilient national security space systems, and modernized and flexible strategic and nonstrategic nuclear deterrent capabilities. Departments and agencies should seek to develop technology approaches that can shorten defense acquisition cycles and increase our responsiveness to emerging military threats in all domains, including space and cyber.

Semiconductors: Departments and agencies, working together and in collaboration with industry and academic partners where appropriate, should prioritize investments to ensure government access to trusted and assured microelectronics and continued American leadership in semiconductor technologies, including the underlying materials, devices, designs, and software; and the fabrication and characterization tools and facilities required for advanced microelectronics.

4. American Energy and Environmental Leadership

Advancing energy technologies to assure a secure and abundant energy supply, understanding our unexplored ocean and expanding use of ocean data, improving our Earth system prediction capabilities, and the Arctic are Administration priorities that will enhance the Nation's economic vitality, national security, and environmental quality and are critical to the well-being and prosperity of all Americans.

Energy: Departments and agencies should invest in early-stage, innovative R&D into technologies that show promise for harnessing American energy resources safely and efficiently, inclusive of nuclear, renewable, and fossil energy. Federally-funded energy R&D should continue to reflect an increased reliance on the private sector to fund later-stage research, development, and commercialization of energy production, storage, and consumption technologies, while also supporting user facilities that can improve multisector collaboration. Department and agencies should invest in nuclear energy R&D, including further development of advanced reactor technologies.

Earth System Predictability and Meteorological Services: The United States aspires to lead the world in meteorological services via an Earth system approach that encompasses weather, climate, hydrologic, ocean, and related environmental topics—providing societal benefits with information spanning highly local to global impacts. Departments and agencies should prioritize, coordinate, and collaborate to implement a national strategy to accelerate progress in improving the theoretical understanding and practical utilization of predictability, reducing gaps in the observation of crucial processes, and exploring advanced modeling capabilities using non-traditional approaches such as AI. Departments and agencies should prioritize the availability of adequate computing and data infrastructure and technology to enable this research; they also should collaborate closely on the most effective use of research resources via coordination and partnerships.

Oceans: To advance implementation of the Presidential Memorandum on ocean mapping,[14] departments and agencies should continue to prioritize new and emerging technologies and collaborative approaches to efficiently map, explore, and characterize the resources of the U.S. exclusive economic zone. Departments and agencies should also focus on increasing their capacity to effectively and efficiently manage large volumes of ocean observation and research data, and make it available to the Federal government and stakeholders.[15] Departments and agencies should continue to prioritize R&D that improves understanding of and supports effective responses to changes in the ocean system, such as ocean chemistry.

Arctic: The United States is an Arctic nation, and the rapidly changing conditions in the Arctic have national security, commerce, and transportation implications that other nations are already addressing. Departments and agencies should prioritize research investments that enhance our ability to observe, understand, and predict the physical, biological, and socio-economic processes of the Arctic to protect and advance American interests.

5. American Space Leadership

R&D investments should continue to leverage efforts underway at American universities and in the private sector and focus on ensuring American leadership in space by supporting the Trump Administration's call for a return of Americans to the Moon's surface by 2024 for long-term exploration and utilization, and as a proving ground for future human missions to Mars. Microgravity research in biological and physical science on new platforms in Low Earth Orbit is important to enabling longer duration human missions in space and may have practical benefits to life on Earth.

Departments and agencies should prioritize in-situ resource utilization on the Moon and Mars, cryogenic fuel storage and management, in-space manufacturing and assembly, advanced space-related power and propulsion capabilities, and orbital debris management. Departments and agencies should also prioritize activities that ensure an industrial base for commercial activity in space and that will broadly speed private-sector progress in meeting stated Government goals and furthering the space economy. Finally, departments and agencies should seek opportunities to work with advanced materials, additive manufacturing, and machine learning capabilities that have broad potential applications in space and on Earth.

PRIORITY CROSSCUTTING ACTIONS

1. Build the S&T Workforce of the Future

Harmonized investments in R&D and S&T workforce advance the Nation's economic prosperity and national security. The foundation of these investments is the STEM ecosystem—a cross-sector collaborative effort that provides all Americans with access to high-quality STEM education and advanced workforce pathways throughout their lifetimes. Consistent with the Federal strategic plan for STEM education, *Charting a Course for Success: America's Strategy for STEM Education* (STEM Strategic Plan),[16] departments and agencies should prioritize investments in

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[14] Memorandum on Ocean Mapping of the United States Exclusive Economic Zone and the Shoreline and Nearshore of Alaska, https://www.whitehouse.gov/presidential-actions/memorandum-ocean-mapping-united-states-exclusive-economic-zone-shoreline-nearshore-alaska/.

[15] See Cross-cutting Action 4, "Leverage the Power of Data," for additional actions to facilitate safe and effective use of data.

[16] https://www.whitehouse.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf.

research programs and other related activities that advance innovation in STEM education and increase diversity, equity, and inclusion in STEM.

To further these goals, departments and agencies should prioritize education investments that: (1) support learning through the development of infrastructure and tools for delivery of both remote and in-person learning; (2) develop mechanisms to attract, prepare and support all Americans to pursue STEM pathways, especially for underrepresented and underserved populations; (3) create effective experiential and work-based learning opportunities to engage students in STEM; (4) develop the next generation of teachers and faculty prepared to advance STEM education; (5) expand broadband access and improve teaching and learning modalities for remote learners; and (6) ensure a robust pipeline of American students capable of pursuing graduate degrees in STEM. Research advances and best practices in STEM teaching and learning should be disseminated throughout the STEM ecosystem to ensure high levels of STEM literacy for all Americans.

2. Optimize Research Environments and Results

To advance S&T progress and ensure maximum return on taxpayer investment in R&D, any setting where R&D is performed must welcome all individuals without prejudice. Consistent with American values, investigators, students, postdoctoral scholars, and technicians should be able to work safely, efficiently, and ethically, and be treated with respect. In addition, in accordance with the President's Management Agenda (PMA) CAP Goal 8, "Results-Oriented Accountability for Grants," departments and agencies should enhance efficiencies, reduce unnecessary burdens, and improve successful results for the American taxpayer.

Four high-priority areas related to research environments require significant attention:

- Strengthening the security of U.S. research enterprise;

- Reducing administrative burdens on federally-funded research; continue efforts to streamline and coordinate Federal grant policies and processes consistent with PMA CAP Goal 8,[17] including use of shared profile systems and persistent identifiers; identify opportunities to institutionalize effective practices for accelerating research and innovation developed in response to COVID-19;

- Improving rigor and integrity in research; prioritize research on training and resources that promotes rigor, transparency, and integrity. Coordinate efforts with academic institutions, philanthropic organizations, publishers, and other stakeholders to foster rigorous practices; and

- Creating safe, diverse, inclusive, and equitable research environments for all members of the research enterprise, paying particular attention to the burdens COVID-19 has placed on the S&T workforce.

[17] PMA CAP Goal 8 is working to streamline administrative burdens associated with all Federal grant programs and maximize the value of grant funding by applying a risk-based, data-driven framework that balances compliance requirements with demonstrating successful improve efficiencies, reduce unnecessary burdens, and improve successful results for the American taxpayer.

Departments and agencies should ensure that their R&D investments improve intramural and extramural research environments that address these four action areas, and actively coordinate and collaborate with other R&D departments and agencies, via the National Science and Technology Council Joint Committee on the Research Environment, to ensure that R&D investments and policies are aligned with the four priority areas.[18]

3. Facilitate Multisector Partnerships and Technology Transfer

America's continued economic growth and recovery from the COVID-19 pandemic is strongly rooted in securing and reinforcing multisector partnerships in S&T. The commercialization of federally-funded research and outcomes of lab to market strategies are substantially increased through partnership agreements, licensing, and successful startups. Departments and agencies should develop the skills and prioritize the resources to "Improve Transfer of Federally-Funded Technologies from Lab-to-Market" by further advancing this objective of the President's Management Agenda (PMA) Cross-Agency Priority (CAP) Goal 14.[19]

Departments and agencies should consider initiatives to ease administrative and regulatory burdens for Federal technology transfer to increase private sector investment in R&D and innovative processes and services to support IotF. Additionally, effective partnering tools, resources and technology transfer mechanisms for departments and agencies should be developed, clarified, and released for public consumption to stakeholders. Departments and agencies should prioritize funding for cooperative projects that align organizational incentives and advance new external partnership opportunities through multisector engagement.

Departments and agencies should facilitate increased interagency collaboration and transparency to strengthen coordination on existing and new partnerships that improve place-based and national-level collaboration for innovation economies, such as those in Opportunity Zones, underrepresented populations, and Historically Black Colleges and Universities (HBCUs) and minority serving institutions (MSIs) through multisector engagement that accelerates entrepreneurship and innovation to support the next generation of industry leaders.

4. Leverage the Power of Data

Data is increasingly critical for research and innovation, accountability and transparency, and evidence-based policymaking. The PMA CAP Goal 2, "Leveraging Data as a Strategic Asset,"[20] describes three objectives: develop a long-term, enterprise-wide Federal Data Strategy to better govern and leverage the Federal Government's data; enable Government data to be accessible and useful for the American public, businesses, and researchers; and improve the use of data for decision-making and accountability for the U.S. Government, including for policy-making, innovation, oversight, and learning.

Department and agency investments should reflect and support the objectives of CAP Goal 2 and the Federal Data Strategy framework, especially the *2020 Action Plan*.[21] Departments and agencies should also prioritize R&D aimed at improving data accessibility and security, including

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[18] Agencies should also actively participate on the PMA CAP Goal 8 workgroups to help build shared solutions that would contribute to reducing administrative burden and improving results.

[19] https://www.performance.gov/CAP/lab-to-market/

[20] The Federal Data Strategy, http://strategy.data.gov, (2020).

[21] https://strategy.data.gov/action-plan/

fundamental research into efficient privacy and security preserving techniques and building and/or strengthening infrastructure, platforms, and tools that facilitate responsible data use. Departments and agencies should coordinate and collaborate with each other and non-Federal stakeholders to drive discovery and innovation in high priority areas, such as biomedicine and biotechnology, by leveraging AI/ML and other technologies, tools, platforms, and protocols. Departments and agencies should also make their data discoverable, accessible and useable, consistent with all applicable laws, regulations, and policies governing data use, disclosure, and sharing.

BRIEFING ROOM

Executive Order on Tackling the Climate Crisis at Home and Abroad

JANUARY 27, 2021 • PRESIDENTIAL ACTIONS

The United States and the world face a profound climate crisis. We have a narrow moment to pursue action at home and abroad in order to avoid the most catastrophic impacts of that crisis and to seize the opportunity that tackling climate change presents. Domestic action must go hand in hand with United States international leadership, aimed at significantly enhancing global action. Together, we must listen to science and meet the moment.

By the authority vested in me as President by the Constitution and the laws of the United States of America, it is hereby ordered as follows:

PART I — PUTTING THE CLIMATE CRISIS AT THE CENTER OF UNITED STATES FOREIGN POLICY AND NATIONAL SECURITY

Section 101. Policy. United States international engagement to address climate change — which has become a climate crisis — is more necessary and urgent than ever. The scientific community has made clear that the scale and speed of necessary action is greater than previously believed. There is little time left to avoid setting the world on a dangerous, potentially catastrophic, climate trajectory. Responding to the climate crisis will require both significant short-term global reductions in greenhouse gas emissions and net-zero global emissions by mid-century or before.

It is the policy of my Administration that climate considerations shall be an essential element of United States foreign policy and national security. The United States will work with other countries and partners, both bilaterally and multilaterally, to put the world on a sustainable climate pathway. The United States will also move quickly to build resilience, both at home and

abroad, against the impacts of climate change that are already manifest and will continue to intensify according to current trajectories.

Sec. 102. Purpose. This order builds on and reaffirms actions my Administration has already taken to place the climate crisis at the forefront of this Nation's foreign policy and national security planning, including submitting the United States instrument of acceptance to rejoin the Paris Agreement. In implementing — and building upon — the Paris Agreement's three overarching objectives (a safe global temperature, increased climate resilience, and financial flows aligned with a pathway toward low greenhouse gas emissions and climate-resilient development), the United States will exercise its leadership to promote a significant increase in global climate ambition to meet the climate challenge. In this regard:

(a) I will host an early Leaders' Climate Summit aimed at raising climate ambition and making a positive contribution to the 26th United Nations Climate Change Conference of the Parties (COP26) and beyond.

(b) The United States will reconvene the Major Economies Forum on Energy and Climate, beginning with the Leaders' Climate Summit. In cooperation with the members of that Forum, as well as with other partners as appropriate, the United States will pursue green recovery efforts, initiatives to advance the clean energy transition, sectoral decarbonization, and alignment of financial flows with the objectives of the Paris Agreement, including with respect to coal financing, nature-based solutions, and solutions to other climate-related challenges.

(c) I have created a new Presidentially appointed position, the Special Presidential Envoy for Climate, to elevate the issue of climate change and underscore the commitment my Administration will make toward addressing it.

(d) Recognizing that climate change affects a wide range of subjects, it will be a United States priority to press for enhanced climate ambition and integration of climate considerations across a wide range of international fora, including the Group of Seven (G7), the Group of Twenty (G20), and fora that address clean energy, aviation, shipping, the Arctic, the ocean, sustainable development, migration, and other relevant topics. The Special

Presidential Envoy for Climate and others, as appropriate, are encouraged to promote innovative approaches, including international multi-stakeholder initiatives. In addition, my Administration will work in partnership with States, localities, Tribes, territories, and other United States stakeholders to advance United States climate diplomacy.

(e) The United States will immediately begin the process of developing its nationally determined contribution under the Paris Agreement. The process will include analysis and input from relevant executive departments and agencies (agencies), as well as appropriate outreach to domestic stakeholders. The United States will aim to submit its nationally determined contribution in advance of the Leaders' Climate Summit.

(f) The United States will also immediately begin to develop a climate finance plan, making strategic use of multilateral and bilateral channels and institutions, to assist developing countries in implementing ambitious emissions reduction measures, protecting critical ecosystems, building resilience against the impacts of climate change, and promoting the flow of capital toward climate-aligned investments and away from high-carbon investments. The Secretary of State and the Secretary of the Treasury, in coordination with the Special Presidential Envoy for Climate, shall lead a process to develop this plan, with the participation of the Administrator of the United States Agency for International Development (USAID), the Chief Executive Officer of the United States International Development Finance Corporation (DFC), the Chief Executive Officer of the Millennium Challenge Corporation, the Director of the United States Trade and Development Agency, the Director of the Office of Management and Budget, and the head of any other agency providing foreign assistance and development financing, as appropriate. The Secretary of State and the Secretary of the Treasury shall submit the plan to the President, through the Assistant to the President for National Security Affairs and the Assistant to the President for Economic Policy, within 90 days of the date of this order.

(g) The Secretary of the Treasury shall:

(i) ensure that the United States is present and engaged in relevant international fora and institutions that are working on the management of climate-related financial risks;

(ii) develop a strategy for how the voice and vote of the United States can be used in international financial institutions, including the World Bank Group and the International Monetary Fund, to promote financing programs, economic stimulus packages, and debt relief initiatives that are aligned with and support the goals of the Paris Agreement; and

(iii) develop, in collaboration with the Secretary of State, the Administrator of USAID, and the Chief Executive Officer of the DFC, a plan for promoting the protection of the Amazon rainforest and other critical ecosystems that serve as global carbon sinks, including through market-based mechanisms.

(h) The Secretary of State, the Secretary of the Treasury, and the Secretary of Energy shall work together and with the Export–Import Bank of the United States, the Chief Executive Officer of the DFC, and the heads of other agencies and partners, as appropriate, to identify steps through which the United States can promote ending international financing of carbon-intensive fossil fuel-based energy while simultaneously advancing sustainable development and a green recovery, in consultation with the Assistant to the President for National Security Affairs.

(i) The Secretary of Energy, in cooperation with the Secretary of State and the heads of other agencies, as appropriate, shall identify steps through which the United States can intensify international collaborations to drive innovation and deployment of clean energy technologies, which are critical for climate protection.

(j) The Secretary of State shall prepare, within 60 days of the date of this order, a transmittal package seeking the Senate's advice and consent to ratification of the Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, regarding the phasedown of the production and consumption of hydrofluorocarbons.

Sec. 103. Prioritizing Climate in Foreign Policy and National Security. To ensure that climate change considerations are central to United States foreign policy and national security:

(a) Agencies that engage in extensive international work shall develop, in coordination with the Special Presidential Envoy for Climate, and submit to

the President, through the Assistant to the President for National Security Affairs, within 90 days of the date of this order, strategies and implementation plans for integrating climate considerations into their international work, as appropriate and consistent with applicable law. These strategies and plans should include an assessment of:

(i) climate impacts relevant to broad agency strategies in particular countries or regions;

(ii) climate impacts on their agency-managed infrastructure abroad (e.g., embassies, military installations), without prejudice to existing requirements regarding assessment of such infrastructure;

(iii) how the agency intends to manage such impacts or incorporate risk mitigation into its installation master plans; and

(iv) how the agency's international work, including partner engagement, can contribute to addressing the climate crisis.

(b) The Director of National Intelligence shall prepare, within 120 days of the date of this order, a National Intelligence Estimate on the national and economic security impacts of climate change.

(c) The Secretary of Defense, in coordination with the Secretary of Commerce, through the Administrator of the National Oceanic and Atmospheric Administration, the Chair of the Council on Environmental Quality, the Administrator of the Environmental Protection Agency, the Director of National Intelligence, the Director of the Office of Science and Technology Policy, the Administrator of the National Aeronautics and Space Administration, and the heads of other agencies as appropriate, shall develop and submit to the President, within 120 days of the date of this order, an analysis of the security implications of climate change (Climate Risk Analysis) that can be incorporated into modeling, simulation, war-gaming, and other analyses.

(d) The Secretary of Defense and the Chairman of the Joint Chiefs of Staff shall consider the security implications of climate change, including any relevant information from the Climate Risk Analysis described in subsection (c) of this section, in developing the National Defense Strategy, Defense

Planning Guidance, Chairman's Risk Assessment, and other relevant strategy, planning, and programming documents and processes. Starting in January 2022, the Secretary of Defense and the Chairman of the Joint Chiefs of Staff shall provide an annual update, through the National Security Council, on the progress made in incorporating the security implications of climate change into these documents and processes.

(e) The Secretary of Homeland Security shall consider the implications of climate change in the Arctic, along our Nation's borders, and to National Critical Functions, including any relevant information from the Climate Risk Analysis described in subsection (c) of this section, in developing relevant strategy, planning, and programming documents and processes. Starting in January 2022, the Secretary of Homeland Security shall provide an annual update, through the National Security Council, on the progress made in incorporating the homeland security implications of climate change into these documents and processes.

Sec. 104. Reinstatement. The Presidential Memorandum of September 21, 2016 (Climate Change and National Security), is hereby reinstated.

PART II — TAKING A GOVERNMENT-WIDE APPROACH TO THE CLIMATE CRISIS

Sec. 201. Policy. Even as our Nation emerges from profound public health and economic crises borne of a pandemic, we face a climate crisis that threatens our people and communities, public health and economy, and, starkly, our ability to live on planet Earth. Despite the peril that is already evident, there is promise in the solutions — opportunities to create well-paying union jobs to build a modern and sustainable infrastructure, deliver an equitable, clean energy future, and put the United States on a path to achieve net-zero emissions, economy-wide, by no later than 2050.

We must listen to science — and act. We must strengthen our clean air and water protections. We must hold polluters accountable for their actions. We must deliver environmental justice in communities all across America. The Federal Government must drive assessment, disclosure, and mitigation of climate pollution and climate-related risks in every sector of our economy, marshaling the creativity, courage, and capital necessary to make our Nation

resilient in the face of this threat. Together, we must combat the climate crisis with bold, progressive action that combines the full capacity of the Federal Government with efforts from every corner of our Nation, every level of government, and every sector of our economy.

It is the policy of my Administration to organize and deploy the full capacity of its agencies to combat the climate crisis to implement a Government-wide approach that reduces climate pollution in every sector of the economy; increases resilience to the impacts of climate change; protects public health; conserves our lands, waters, and biodiversity; delivers environmental justice; and spurs well-paying union jobs and economic growth, especially through innovation, commercialization, and deployment of clean energy technologies and infrastructure. Successfully meeting these challenges will require the Federal Government to pursue such a coordinated approach from planning to implementation, coupled with substantive engagement by stakeholders, including State, local, and Tribal governments.

Sec. 202. White House Office of Domestic Climate Policy. There is hereby established the White House Office of Domestic Climate Policy (Climate Policy Office) within the Executive Office of the President, which shall coordinate the policy-making process with respect to domestic climate-policy issues; coordinate domestic climate-policy advice to the President; ensure that domestic climate-policy decisions and programs are consistent with the President's stated goals and that those goals are being effectively pursued; and monitor implementation of the President's domestic climate-policy agenda. The Climate Policy Office shall have a staff headed by the Assistant to the President and National Climate Advisor (National Climate Advisor) and shall include the Deputy Assistant to the President and Deputy National Climate Advisor. The Climate Policy Office shall have such staff and other assistance as may be necessary to carry out the provisions of this order, subject to the availability of appropriations, and may work with established or ad hoc committees or interagency groups. All agencies shall cooperate with the Climate Policy Office and provide such information, support, and assistance to the Climate Policy Office as it may request, as appropriate and consistent with applicable law.

Sec.203. National Climate Task Force. There is hereby established a National Climate Task Force (Task Force). The Task Force shall be chaired by the

National Climate Advisor.

(a) Membership. The Task Force shall consist of the following additional members:

(i) the Secretary of the Treasury;

(ii) the Secretary of Defense;

(iii) the Attorney General;

(iv) the Secretary of the Interior;

(v) the Secretary of Agriculture;

(vi) the Secretary of Commerce;

(vii) the Secretary of Labor;

(viii) the Secretary of Health and Human Services;

(ix) the Secretary of Housing and Urban Development;

(x) the Secretary of Transportation;

(xi) the Secretary of Energy;

(xii) the Secretary of Homeland Security;

(xiii) the Administrator of General Services;

(xiv) the Chair of the Council on Environmental Quality;

(xv) the Administrator of the Environmental Protection Agency;

(xvi) the Director of the Office of Management and Budget;

(xvii) the Director of the Office of Science and Technology Policy;

(xviii) the Assistant to the President for Domestic Policy;

(xix) the Assistant to the President for National Security Affairs;

(xx) the Assistant to the President for Homeland Security and Counterterrorism; and

(xxi) the Assistant to the President for Economic Policy.

(b) Mission and Work. The Task Force shall facilitate the organization and deployment of a Government-wide approach to combat the climate crisis. This Task Force shall facilitate planning and implementation of key Federal actions to reduce climate pollution; increase resilience to the impacts of climate change; protect public health; conserve our lands, waters, oceans, and biodiversity; deliver environmental justice; and spur well-paying union jobs and economic growth. As necessary and appropriate, members of the Task Force will engage on these matters with State, local, Tribal, and territorial governments; workers and communities; and leaders across the various sectors of our economy.

(c) Prioritizing Actions. To the extent permitted by law, Task Force members shall prioritize action on climate change in their policy-making and budget processes, in their contracting and procurement, and in their engagement with State, local, Tribal, and territorial governments; workers and communities; and leaders across all the sectors of our economy.

USE OF THE FEDERAL GOVERNMENT'S BUYING POWER AND REAL PROPERTY AND ASSET MANAGEMENT

Sec. 204. Policy. It is the policy of my Administration to lead the Nation's effort to combat the climate crisis by example — specifically, by aligning the management of Federal procurement and real property, public lands and waters, and financial programs to support robust climate action. By providing an immediate, clear, and stable source of product demand, increased transparency and data, and robust standards for the market, my Administration will help to catalyze private sector investment into, and accelerate the advancement of America's industrial capacity to supply, domestic clean energy, buildings, vehicles, and other necessary products and materials.

Sec. 205. Federal Clean Electricity and Vehicle Procurement Strategy. (a)

The Chair of the Council on Environmental Quality, the Administrator of General Services, and the Director of the Office and Management and Budget, in coordination with the Secretary of Commerce, the Secretary of Labor, the Secretary of Energy, and the heads of other relevant agencies, shall assist the National Climate Advisor, through the Task Force established in section 203 of this order, in developing a comprehensive plan to create good jobs and stimulate clean energy industries by revitalizing the Federal Government's sustainability efforts.

(b) The plan shall aim to use, as appropriate and consistent with applicable law, all available procurement authorities to achieve or facilitate:

(i) a carbon pollution-free electricity sector no later than 2035; and

(ii) clean and zero-emission vehicles for Federal, State, local, and Tribal government fleets, including vehicles of the United States Postal Service.

(c) If necessary, the plan shall recommend any additional legislation needed to accomplish these objectives.

(d) The plan shall also aim to ensure that the United States retains the union jobs integral to and involved in running and maintaining clean and zero-emission fleets, while spurring the creation of union jobs in the manufacture of those new vehicles. The plan shall be submitted to the Task Force within 90 days of the date of this order.

Sec. 206. Procurement Standards. Consistent with the Executive Order of January 25, 2021, entitled, "Ensuring the Future Is Made in All of America by All of America's Workers," agencies shall adhere to the requirements of the Made in America Laws in making clean energy, energy efficiency, and clean energy procurement decisions. Agencies shall, consistent with applicable law, apply and enforce the Davis-Bacon Act and prevailing wage and benefit requirements. The Secretary of Labor shall take steps to update prevailing wage requirements. The Chair of the Council on Environmental Quality shall consider additional administrative steps and guidance to assist the Federal Acquisition Regulatory Council in developing regulatory amendments to promote increased contractor attention on reduced carbon emission and Federal sustainability.

Sec. 207. Renewable Energy on Public Lands and in Offshore Waters. The Secretary of the Interior shall review siting and permitting processes on public lands and in offshore waters to identify to the Task Force steps that can be taken, consistent with applicable law, to increase renewable energy production on those lands and in those waters, with the goal of doubling offshore wind by 2030 while ensuring robust protection for our lands, waters, and biodiversity and creating good jobs. In conducting this review, the Secretary of the Interior shall consult, as appropriate, with the heads of relevant agencies, including the Secretary of Defense, the Secretary of Agriculture, the Secretary of Commerce, through the Administrator of the National Oceanic and Atmospheric Administration, the Secretary of Energy, the Chair of the Council on Environmental Quality, State and Tribal authorities, project developers, and other interested parties. The Secretary of the Interior shall engage with Tribal authorities regarding the development and management of renewable and conventional energy resources on Tribal lands.

Sec. 208. Oil and Natural Gas Development on Public Lands and in Offshore Waters. To the extent consistent with applicable law,the Secretary of the Interior shall pause new oil and natural gas leases on public lands or in offshore waters pending completion of a comprehensive review and reconsideration of Federal oil and gas permitting and leasing practices in light of the Secretary of the Interior's broad stewardship responsibilities over the public lands and in offshore waters, including potential climate and other impacts associated with oil and gas activities on public lands or in offshore waters. The Secretary of the Interior shall complete that review in consultation with the Secretary of Agriculture, the Secretary of Commerce, through the National Oceanic and Atmospheric Administration, and the Secretary of Energy. In conducting this analysis, and to the extent consistent with applicable law, the Secretary of the Interior shall consider whether to adjust royalties associated with coal, oil, and gas resources extracted from public lands and offshore waters, or take other appropriate action, to account for corresponding climate costs.

Sec. 209. Fossil Fuel Subsidies. The heads of agencies shall identify for the Director of the Office of Management and Budget and the National Climate Advisor any fossil fuel subsidies provided by their respective agencies, and then take steps to ensure that, to the extent consistent with applicable law,

Federal funding is not directly subsidizing fossil fuels. The Director of the Office of Management and Budget shall seek, in coordination with the heads of agencies and the National Climate Advisor, to eliminate fossil fuel subsidies from the budget request for Fiscal Year 2022 and thereafter.

Sec. 210. Clean Energy in Financial Management. The heads of agencies shall identify opportunities for Federal funding to spur innovation, commercialization, and deployment of clean energy technologies and infrastructure for the Director of the Office of Management and Budget and the National Climate Advisor, and then take steps to ensure that, to the extent consistent with applicable law, Federal funding is used to spur innovation, commercialization, and deployment of clean energy technologies and infrastructure. The Director of the Office of Management and Budget, in coordination with agency heads and the National Climate Advisor, shall seek to prioritize such investments in the President's budget request for Fiscal Year 2022 and thereafter.

Sec. 211. Climate Action Plans and Data and Information Products to Improve Adaptation and Increase Resilience. (a) The head of each agency shall submit a draft action plan to the Task Force and the Federal Chief Sustainability Officer within 120 days of the date of this order that describes steps the agency can take with regard to its facilities and operations to bolster adaptation and increase resilience to the impacts of climate change. Action plans should, among other things, describe the agency's climate vulnerabilities and describe the agency's plan to use the power of procurement to increase the energy and water efficiency of United States Government installations, buildings, and facilities and ensure they are climate-ready. Agencies shall consider the feasibility of using the purchasing power of the Federal Government to drive innovation, and shall seek to increase the Federal Government's resilience against supply chain disruptions. Such disruptions put the Nation's manufacturing sector at risk, as well as consumer access to critical goods and services. Agencies shall make their action plans public, and post them on the agency website, to the extent consistent with applicable law.

(b) Within 30 days of an agency's submission of an action plan, the Federal Chief Sustainability Officer, in coordination with the Director of the Office of Management and Budget, shall review the plan to assess its consistency with

the policy set forth in section 204 of this order and the priorities issued by the Office of Management and Budget.

(c) After submitting an initial action plan, the head of each agency shall submit to the Task Force and Federal Chief Sustainability Officer progress reports annually on the status of implementation efforts. Agencies shall make progress reports public and post them on the agency website, to the extent consistent with applicable law. The heads of agencies shall assign their respective agency Chief Sustainability Officer the authority to perform duties relating to implementation of this order within the agency, to the extent consistent with applicable law.

(d) To assist agencies and State, local, Tribal, and territorial governments, communities, and businesses in preparing for and adapting to the impacts of climate change, the Secretary of Commerce, through the Administrator of the National Oceanic and Atmospheric Administration, the Secretary of Homeland Security, through the Administrator of the Federal Emergency Management Agency, and the Director of the Office of Science and Technology Policy, in coordination with the heads of other agencies, as appropriate, shall provide to the Task Force a report on ways to expand and improve climate forecast capabilities and information products for the public. In addition, the Secretary of the Interior and the Deputy Director for Management of the Office of Management and Budget, in their capacities as the Chair and Vice-Chair of the Federal Geographic Data Committee, shall assess and provide to the Task Force a report on the potential development of a consolidated Federal geographic mapping service that can facilitate public access to climate-related information that will assist Federal, State, local, and Tribal governments in climate planning and resilience activities.

EMPOWERING WORKERS THROUGH REBUILDING OUR INFRASTRUCTURE FOR A SUSTAINABLE ECONOMY

Sec. 212. Policy. This Nation needs millions of construction, manufacturing, engineering, and skilled-trades workers to build a new American infrastructure and clean energy economy. These jobs will create opportunities for young people and for older workers shifting to new professions, and for people from all backgrounds and communities. Such jobs will bring opportunity to communities too often left behind — places

that have suffered as a result of economic shifts and places that have suffered the most from persistent pollution, including low-income rural and urban communities, communities of color, and Native communities.

Sec. 213. Sustainable Infrastructure. (a) The Chair of the Council on Environmental Quality and the Director of the Office of Management and Budget shall take steps, consistent with applicable law, to ensure that Federal infrastructure investment reduces climate pollution, and to require that Federal permitting decisions consider the effects of greenhouse gas emissions and climate change. In addition, they shall review, and report to the National Climate Advisor on, siting and permitting processes, including those in progress under the auspices of the Federal Permitting Improvement Steering Council, and identify steps that can be taken, consistent with applicable law, to accelerate the deployment of clean energy and transmission projects in an environmentally stable manner.

(b) Agency heads conducting infrastructure reviews shall, as appropriate, consult from an early stage with State, local, and Tribal officials involved in permitting or authorizing proposed infrastructure projects to develop efficient timelines for decision-making that are appropriate given the complexities of proposed projects.

EMPOWERING WORKERS BY ADVANCING CONSERVATION, AGRICULTURE, AND REFORESTATION

Sec. 214. Policy. It is the policy of my Administration to put a new generation of Americans to work conserving our public lands and waters. The Federal Government must protect America's natural treasures, increase reforestation, improve access to recreation, and increase resilience to wildfires and storms, while creating well-paying union jobs for more Americans, including more opportunities for women and people of color in occupations where they are underrepresented. America's farmers, ranchers, and forest landowners have an important role to play in combating the climate crisis and reducing greenhouse gas emissions, by sequestering carbon in soils, grasses, trees, and other vegetation and sourcing sustainable bioproducts and fuels. Coastal communities have an essential role to play in mitigating climate change and strengthening resilience by protecting and restoring coastal ecosystems, such as wetlands, seagrasses, coral and oyster

reefs, and mangrove and kelp forests, to protect vulnerable coastlines, sequester carbon, and support biodiversity and fisheries.

Sec. 215. Civilian Climate Corps. In furtherance of the policy set forth in section 214 of this order, the Secretary of the Interior, in collaboration with the Secretary of Agriculture and the heads of other relevant agencies, shall submit a strategy to the Task Force within 90 days of the date of this order for creating a Civilian Climate Corps Initiative, within existing appropriations, to mobilize the next generation of conservation and resilience workers and maximize the creation of accessible training opportunities and good jobs. The initiative shall aim to conserve and restore public lands and waters, bolster community resilience, increase reforestation, increase carbon sequestration in the agricultural sector, protect biodiversity, improve access to recreation, and address the changing climate.

Sec. 216. Conserving Our Nation's Lands and Waters. (a) The Secretary of the Interior, in consultation with the Secretary of Agriculture, the Secretary of Commerce, the Chair of the Council on Environmental Quality, and the heads of other relevant agencies, shall submit a report to the Task Force within 90 days of the date of this order recommending steps that the United States should take, working with State, local, Tribal, and territorial governments, agricultural and forest landowners, fishermen, and other key stakeholders, to achieve the goal of conserving at least 30 percent of our lands and waters by 2030.

(i) The Secretary of the Interior, the Secretary of Agriculture, the Secretary of Commerce, through the Administrator of the National Oceanic and Atmospheric Administration, and the Chair of the Council on Environmental Quality shall, as appropriate, solicit input from State, local, Tribal, and territorial officials, agricultural and forest landowners, fishermen, and other key stakeholders in identifying strategies that will encourage broad participation in the goal of conserving 30 percent of our lands and waters by 2030.

(ii) The report shall propose guidelines for determining whether lands and waters qualify for conservation, and it also shall establish mechanisms to measure progress toward the 30-percent goal. The Secretary of the Interior

shall subsequently submit annual reports to the Task Force to monitor progress.

(b) The Secretary of Agriculture shall:

(i) initiate efforts in the first 60 days from the date of this order to collect input from Tribes, farmers, ranchers, forest owners, conservation groups, firefighters, and other stakeholders on how to best use Department of Agriculture programs, funding and financing capacities, and other authorities, and how to encourage the voluntary adoption of climate-smart agricultural and forestry practices that decrease wildfire risk fueled by climate change and result in additional, measurable, and verifiable carbon reductions and sequestration and that source sustainable bioproducts and fuels; and

(ii) submit to the Task Force within 90 days of the date of this order a report making recommendations for an agricultural and forestry climate strategy.

(c) The Secretary of Commerce, through the Administrator of the National Oceanic and Atmospheric Administration, shall initiate efforts in the first 60 days from the date of this order to collect input from fishermen, regional ocean councils, fishery management councils, scientists, and other stakeholders on how to make fisheries and protected resources more resilient to climate change, including changes in management and conservation measures, and improvements in science, monitoring, and cooperative research.

EMPOWERING WORKERS THROUGH REVITALIZING ENERGY COMMUNITIES

Sec. 217. Policy. It is the policy of my Administration to improve air and water quality and to create well-paying union jobs and more opportunities for women and people of color in hard-hit communities, including rural communities, while reducing methane emissions, oil and brine leaks, and other environmental harms from tens of thousands of former mining and well sites. Mining and power plant workers drove the industrial revolution and the economic growth that followed, and have been essential to the growth of the United States. As the Nation shifts to a clean energy economy,

Federal leadership is essential to foster economic revitalization of and investment in these communities, ensure the creation of good jobs that provide a choice to join a union, and secure the benefits that have been earned by workers.

Such work should include projects that reduce emissions of toxic substances and greenhouse gases from existing and abandoned infrastructure and that prevent environmental damage that harms communities and poses a risk to public health and safety. Plugging leaks in oil and gas wells and reclaiming abandoned mine land can create well-paying union jobs in coal, oil, and gas communities while restoring natural assets, revitalizing recreation economies, and curbing methane emissions. In addition, such work should include efforts to turn properties idled in these communities, such as brownfields, into new hubs for the growth of our economy. Federal agencies should therefore coordinate investments and other efforts to assist coal, oil and gas, and power plant communities, and achieve substantial reductions of methane emissions from the oil and gas sector as quickly as possible.

Sec. 218. Interagency Working Group on Coal and Power Plant Communities and Economic Revitalization. There is hereby established an Interagency Working Group on Coal and Power Plant Communities and Economic Revitalization (Interagency Working Group). The National Climate Advisor and the Assistant to the President for Economic Policy shall serve as Co-Chairs of the Interagency Working Group.

(a) Membership. The Interagency Working Group shall consist of the following additional members:

(i) the Secretary of the Treasury;

(ii) the Secretary of the Interior;

(iii) the Secretary of Agriculture;

(iv) the Secretary of Commerce;

(v) the Secretary of Labor;

(vi) the Secretary of Health and Human Services;

(vii) the Secretary of Transportation;

(viii) the Secretary of Energy;

(ix) the Secretary of Education;

(x) the Administrator of the Environmental Protection Agency;

(xi) the Director of the Office of Management and Budget;

(xii) the Assistant to the President for Domestic Policy and Director of the Domestic Policy Council; and

(xiii) the Federal Co-Chair of the Appalachian Regional Commission.

(b) Mission and Work.

(i) The Interagency Working Group shall coordinate the identification and delivery of Federal resources to revitalize the economies of coal, oil and gas, and power plant communities; develop strategies to implement the policy set forth in section 217 of this order and for economic and social recovery; assess opportunities to ensure benefits and protections for coal and power plant workers; and submit reports to the National Climate Advisor and the Assistant to the President for Economic Policy on a regular basis on the progress of the revitalization effort.

(ii) As part of this effort, within 60 days of the date of this order, the Interagency Working Group shall submit a report to the President describing all mechanisms, consistent with applicable law, to prioritize grantmaking, Federal loan programs, technical assistance, financing, procurement, or other existing programs to support and revitalize the economies of coal and power plant communities, and providing recommendations for action consistent with the goals of the Interagency Working Group.

(c) Consultation. Consistent with the objectives set out in this order and in accordance with applicable law, the Interagency Working Group shall seek the views of State, local, and Tribal officials; unions; environmental justice organizations; community groups; and other persons it identifies who may

have perspectives on the mission of the Interagency Working Group.

(d) Administration. The Interagency Working Group shall be housed within the Department of Energy. The Chairs shall convene regular meetings of the Interagency Working Group, determine its agenda, and direct its work. The Secretary of Energy, in consultation with the Chairs, shall designate an Executive Director of the Interagency Working Group, who shall coordinate the work of the Interagency Working Group and head any staff assigned to the Interagency Working Group.

(e) Officers. To facilitate the work of the Interagency Working Group, the head of each agency listed in subsection (a) of this section shall assign a designated official within the agency the authority to represent the agency on the Interagency Working Group and perform such other duties relating to the implementation of this order within the agency as the head of the agency deems appropriate.

SECURING ENVIRONMENTAL JUSTICE AND SPURRING ECONOMIC OPPORTUNITY

Sec. 219. Policy. To secure an equitable economic future, the United States must ensure that environmental and economic justice are key considerations in how we govern. That means investing and building a clean energy economy that creates well-paying union jobs, turning disadvantaged communities — historically marginalized and overburdened — into healthy, thriving communities, and undertaking robust actions to mitigate climate change while preparing for the impacts of climate change across rural, urban, and Tribal areas. Agencies shall make achieving environmental justice part of their missions by developing programs, policies, and activities to address the disproportionately high and adverse human health, environmental, climate-related and other cumulative impacts on disadvantaged communities, as well as the accompanying economic challenges of such impacts. It is therefore the policy of my Administration to secure environmental justice and spur economic opportunity for disadvantaged communities that have been historically marginalized and overburdened by pollution and underinvestment in housing, transportation, water and wastewater infrastructure, and health care.

Sec. 220. White House Environmental Justice Interagency Council. (a) Section 1-102 of Executive Order 12898 of February 11, 1994 (Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations), is hereby amended to read as follows:

"(a) There is hereby created within the Executive Office of the President a White House Environmental Justice Interagency Council (Interagency Council). The Chair of the Council on Environmental Quality shall serve as Chair of the Interagency Council.

"(b) Membership. The Interagency Council shall consist of the following additional members:

(i) the Secretary of Defense;

(ii) the Attorney General;

(iii) the Secretary of the Interior;

(iv) the Secretary of Agriculture;

(v) the Secretary of Commerce;

(vi) the Secretary of Labor;

(vii) the Secretary of Health and Human Services;

(viii) the Secretary of Housing and Urban Development;

(ix) the Secretary of Transportation;

(x) the Secretary of Energy;

(xi) the Chair of the Council of Economic Advisers;

(xii) the Administrator of the Environmental Protection Agency;

(xiii) the Director of the Office of Management and Budget;

(xiv) the Executive Director of the Federal Permitting Improvement Steering Council;

(xv) the Director of the Office of Science and Technology Policy;

(xvi) the National Climate Advisor;

(xvii) the Assistant to the President for Domestic Policy; and

(xviii) the Assistant to the President for Economic Policy.

"(c) At the direction of the Chair, the Interagency Council may establish subgroups consisting exclusively of Interagency Council members or their designees under this section, as appropriate.

"(d) Mission and Work. The Interagency Council shall develop a strategy to address current and historic environmental injustice by consulting with the White House Environmental Justice Advisory Council and with local environmental justice leaders. The Interagency Council shall also develop clear performance metrics to ensure accountability, and publish an annual public performance scorecard on its implementation.

"(e) Administration. The Office of Administration within the Executive Office of the President shall provide funding and administrative support for the Interagency Council, to the extent permitted by law and within existing appropriations. To the extent permitted by law, including the Economy Act (31 U.S.C. 1535), and subject to the availability of appropriations, the Department of Labor, the Department of Transportation, and the Environmental Protection Agency shall provide administrative support as necessary.

"(f) Meetings and Staff. The Chair shall convene regular meetings of the Council, determine its agenda, and direct its work. The Chair shall designate an Executive Director of the Council, who shall coordinate the work of the Interagency Council and head any staff assigned to the Council.

"(g) Officers. To facilitate the work of the Interagency Council, the head of each agency listed in subsection (b) shall assign a designated official within the agency to be an Environmental Justice Officer, with the authority to represent the agency on the Interagency Council and perform such other duties relating to the implementation of this order within the agency as the head of the agency deems appropriate."

(b) The Interagency Council shall, within 120 days of the date of this order, submit to the President, through the National Climate Advisor, a set of recommendations for further updating Executive Order 12898.

Sec. 221. White House Environmental Justice Advisory Council. There is hereby established, within the Environmental Protection Agency, the White House Environmental Justice Advisory Council (Advisory Council), which shall advise the Interagency Council and the Chair of the Council on Environmental Quality.

(a) Membership. Members shall be appointed by the President, shall be drawn from across the political spectrum, and may include those with knowledge about or experience in environmental justice, climate change, disaster preparedness, racial inequity, or any other area determined by the President to be of value to the Advisory Council.

(b) Mission and Work. The Advisory Council shall be solely advisory. It shall provide recommendations to the White House Environmental Justice Interagency Council established in section 220 of this order on how to increase the Federal Government's efforts to address current and historic environmental injustice, including recommendations for updating Executive Order 12898.

(c) Administration. The Environmental Protection Agency shall provide funding and administrative support for the Advisory Council to the extent permitted by law and within existing appropriations. Members of the Advisory Council shall serve without either compensation or reimbursement of expenses.

(d) Federal Advisory Committee Act. Insofar as the Federal Advisory Committee Act, as amended (5 U.S.C. App.), may apply to the Advisory Council, any functions of the President under the Act, except for those in section 6 of the Act, shall be performed by the Administrator of the Environmental Protection Agency in accordance with the guidelines that have been issued by the Administrator of General Services.

Sec. 222. Agency Responsibilities. In furtherance of the policy set forth in section 219:

(a) The Chair of the Council on Environmental Quality shall, within 6 months of the date of this order, create a geospatial Climate and Economic Justice Screening Tool and shall annually publish interactive maps highlighting disadvantaged communities.

(b) The Administrator of the Environmental Protection Agency shall, within existing appropriations and consistent with applicable law:

(i) strengthen enforcement of environmental violations with disproportionate impact on underserved communities through the Office of Enforcement and Compliance Assurance; and

(ii) create a community notification program to monitor and provide real-time data to the public on current environmental pollution, including emissions, criteria pollutants, and toxins, in frontline and fenceline communities — places with the most significant exposure to such pollution.

(c) The Attorney General shall, within existing appropriations and consistent with applicable law:

(i) consider renaming the Environment and Natural Resources Division the Environmental Justice and Natural Resources Division;

(ii) direct that division to coordinate with the Administrator of the Environmental Protection Agency, through the Office of Enforcement and Compliance Assurance, as well as with other client agencies as appropriate, to develop a comprehensive environmental justice enforcement strategy, which shall seek to provide timely remedies for systemic environmental violations and contaminations, and injury to natural resources; and

(iii) ensure comprehensive attention to environmental justice throughout the Department of Justice, including by considering creating an Office of Environmental Justice within the Department to coordinate environmental justice activities among Department of Justice components and United States Attorneys' Offices nationwide.

(d) The Secretary of Health and Human Services shall, consistent with applicable law and within existing appropriations:

(i) establish an Office of Climate Change and Health Equity to address the impact of climate change on the health of the American people; and

(ii) establish an Interagency Working Group to Decrease Risk of Climate Change to Children, the Elderly, People with Disabilities, and the Vulnerable as well as a biennial Health Care System Readiness Advisory Council, both of which shall report their progress and findings regularly to the Task Force.

(e) The Director of the Office of Science and Technology Policy shall, in consultation with the National Climate Advisor, within existing appropriations, and within 100 days of the date of this order, publish a report identifying the climate strategies and technologies that will result in the most air and water quality improvements, which shall be made public to the maximum extent possible and published on the Office's website.

Sec. 223. Justice40 Initiative. (a) Within 120 days of the date of this order, the Chair of the Council on Environmental Quality, the Director of the Office of Management and Budget, and the National Climate Advisor, in consultation with the Advisory Council, shall jointly publish recommendations on how certain Federal investments might be made toward a goal that 40 percent of the overall benefits flow to disadvantaged communities. The recommendations shall focus on investments in the areas of clean energy and energy efficiency; clean transit; affordable and sustainable housing; training and workforce development; the remediation and reduction of legacy pollution; and the development of critical clean water infrastructure. The recommendations shall reflect existing authorities the agencies may possess for achieving the 40-percent goal as well as recommendations on any legislation needed to achieve the 40-percent goal.

(b) In developing the recommendations, the Chair of the Council on Environmental Quality, the Director of the Office of Management and Budget, and the National Climate Advisor shall consult with affected disadvantaged communities.

(c) Within 60 days of the recommendations described in subsection (a) of this section, agency heads shall identify applicable program investment funds based on the recommendations and consider interim investment guidance to relevant program staff, as appropriate and consistent with

applicable law.

(d) By February 2022, the Director of the Office of Management and Budget, in coordination with the Chair of the Council on Environmental Quality, the Administrator of the United States Digital Service, and other relevant agency heads, shall, to the extent consistent with applicable law, publish on a public website an annual Environmental Justice Scorecard detailing agency environmental justice performance measures.

PART III — GENERAL PROVISIONS

Sec. 301. General Provisions. (a) Nothing in this order shall be construed to impair or otherwise affect:

(i) the authority granted by law to an executive department or agency or the head thereof; or

(ii) the functions of the Director of the Office of Management and Budget, relating to budgetary, administrative, or legislative proposals.

(b) This order shall be implemented consistent with applicable law and subject to the availability of appropriations.

(c) This order is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or in equity by any party against the United States, its departments, agencies, or entities, its officers, employees, or agents, or any other person.

JOSEPH R. BIDEN JR.

THE WHITE HOUSE,

January 27, 2021.

BRIEFING ROOM

Executive Order on the President's Council of Advisors on Science and Technology

JANUARY 27, 2021 • PRESIDENTIAL ACTIONS

By the authority vested in me as President by the Constitution and the laws of the United States of America, and in order to establish an advisory council on science, technology, and innovation, it is hereby ordered as follows:

Section 1. Policy. As directed in the Presidential Memorandum of January 27, 2021 (Scientific Integrity and Evidence-Based Policymaking), it is the policy of my Administration to make evidence-based decisions guided by the best available science and data. Officials and employees across my Administration shall seek from scientists, engineers, and other experts the best available scientific and technological information and advice.

Sec. 2. Establishment. (a) There is hereby established the President's Council of Advisors on Science and Technology (PCAST).

(b) The PCAST shall be composed of not more than 26 members. The Assistant to the President for Science and Technology (the "Science Advisor") shall be a member of the PCAST. The Science Advisor, if also serving as the Director of the Office of Science and Technology Policy, may designate the U.S. Chief Technology Officer as a member. The remaining members shall be distinguished individuals and representatives from sectors outside of the Federal Government appointed by the President. These non-Federal members shall have diverse perspectives and expertise in science, technology, and innovation.

(c) The Science Advisor shall serve as a Co-Chair of the PCAST. The President shall also designate at least one, but not more than two, of the non-Federal members to serve as a Co-Chair, or Co-Chairs, of the PCAST with the

Science Advisor. The Science Advisor may designate up to three Vice Chairs of the PCAST from among the non-Federal members of the PCAST, to support the Co-Chairs in the leadership and organization of the PCAST.

Sec. 3. Functions. (a) The PCAST shall advise the President on matters involving policy affecting science, technology, and innovation, as well as on matters involving scientific and technological information that is needed to inform public policy relating to the economy, worker empowerment, education, energy, the environment, public health, national and homeland security, racial equity, and other topics.

(b) The PCAST shall meet regularly and shall:

(i) respond to requests from the President or the Science Advisor for information, analysis, evaluation, or advice;

(ii) solicit information and ideas from a broad range of stakeholders, including the research community; the private sector; universities; national laboratories; State, local, and Tribal governments; foundations; and nonprofit organizations;

(iii) serve as the advisory committee identified in section 101(b) of the High-Performance Computing Act of 1991 (Public Law 102-194), as amended (15 U.S.C. 5511(b)), in which capacity the PCAST shall be known as the President's Innovation and Technology Advisory Committee; and

(iv) serve as the advisory panel identified in section 4 of the 21st Century Nanotechnology Research and Development Act (Public Law 108-153), as amended (15 U.S.C. 7503), in which capacity the PCAST shall be known as the National Nanotechnology Advisory Panel.

(c) The PCAST shall provide advice from the non-Federal sector to the National Science and Technology Council (NSTC) in response to requests from the NSTC.

Sec. 4. Administration. (a) The heads of executive departments and agencies shall, to the extent permitted by law, provide the PCAST with information concerning scientific and technological matters when requested by the PCAST Co-Chairs and as required for the purpose of carrying out the

PCAST's functions.

(b) In consultation with the Science Advisor, the PCAST is authorized to create standing subcommittees and ad hoc groups, including technical advisory groups, to assist the PCAST and provide preliminary information directly to the PCAST.

(c) In order to allow the PCAST to provide advice and analysis regarding classified matters, the Science Advisor may request that members of the PCAST, its standing subcommittees, or ad hoc groups, who do not hold a current clearance for access to classified information, receive security clearance and access determinations pursuant to Executive Order 12968 of August 2, 1995 (Access to Classified Information), as amended, or any successor order.

(d) The Department of Energy shall provide such funding and administrative and technical support as the PCAST may require, to the extent permitted by law and within existing appropriations.

(e) Members of the PCAST shall serve without any compensation for their work on the PCAST, but may receive travel expenses, including per diem in lieu of subsistence, as authorized by law for persons serving intermittently in the government service (5 U.S.C. 5701–5707).

(f) Insofar as the Federal Advisory Committee Act, as amended (5 U.S.C. App.), may apply to the PCAST, any functions of the President under that Act, except that of reporting to the Congress, shall be performed by the Secretary of Energy, in accordance with the guidelines and procedures established by the Administrator of General Services.

Sec. 5. Termination. The PCAST shall terminate 2 years from the date of this order unless extended by the President.

Sec. 6. Revocation. Executive Order 13895 of October 22, 2019 (President's Council of Advisors on Science and Technology), is hereby revoked.

Sec. 7. General Provisions. (a) Nothing in this order shall be construed to impair or otherwise affect:

(i) the authority granted by law to an executive department or agency, or the head thereof; or

(ii) the functions of the Director of the Office of Management and Budget relating to budgetary, administrative, or legislative proposals.

(b) This order shall be implemented consistent with applicable law and subject to the availability of appropriations.

(c) This order is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or in equity by any party against the United States, its departments, agencies, or entities, its officers, employees, or agents, or any other person.

JOSEPH R. BIDEN JR.

THE WHITE HOUSE,

January 27, 2021.

BRIEFING ROOM

Memorandum on Restoring Trust in Government Through Scientific Integrity and Evidence-Based Policymaking

JANUARY 27, 2021 • PRESIDENTIAL ACTIONS

MEMORANDUM FOR THE HEADS OF EXECUTIVE DEPARTMENTS AND AGENCIES

It is the policy of my Administration to make evidence-based decisions guided by the best available science and data. Scientific and technological information, data, and evidence are central to the development and iterative improvement of sound policies, and to the delivery of equitable programs, across every area of government. Scientific findings should never be distorted or influenced by political considerations. When scientific or technological information is considered in policy decisions, it should be subjected to well-established scientific processes, including peer review where feasible and appropriate, with appropriate protections for privacy. Improper political interference in the work of Federal scientists or other scientists who support the work of the Federal Government and in the communication of scientific facts undermines the welfare of the Nation, contributes to systemic inequities and injustices, and violates the trust that the public places in government to best serve its collective interests.

This memorandum reaffirms and builds on the Presidential Memorandum of March 9, 2009 (Scientific Integrity), and the Director of the Office of Science and Technology Policy's Memorandum of December 17, 2010 (Scientific Integrity).

By the authority vested in me as President by the Constitution and the laws of the United States of America, I direct as follows:

Section 1. Role of the Director of the Office of Science and Technology Policy. The Director of the Office of Science and Technology Policy (Director) shall ensure the highest level of integrity in all aspects of executive branch involvement with scientific and technological processes. This responsibility shall include ensuring that executive departments and agencies (agencies) establish and enforce scientific-integrity policies that ban improper political interference in the conduct of scientific research and in the collection of scientific or technological data, and that prevent the suppression or distortion of scientific or technological findings, data, information, conclusions, or technical results. In implementing this memorandum, the Director shall, as appropriate, convene and confer with the heads of agencies and with personnel within the offices of the Executive Office of the President, including the Office of Management and Budget.

Sec. 2. Task Force on Scientific Integrity. (a) The Director shall convene an interagency task force (the "Task Force") of the National Science and Technology Council (NSTC) to conduct a thorough review of the effectiveness of agency scientific-integrity policies developed since the issuance of the Presidential Memorandum of March 9, 2009.

(b) The Task Force shall complete its review within 120 days of the date of the appointment of its members, and shall take the following actions when completing its review.

(i) The Task Force shall ensure its review considers whether existing Federal scientific-integrity policies prevent improper political interference in the conduct of scientific research and the collection of scientific or technological data; prevent the suppression or distortion of scientific or technological findings, data, information, conclusions, or technical results; support scientists and researchers of all genders, races, ethnicities, and backgrounds; and advance the equitable delivery of the Federal Government's programs.

(ii) The Task Force's review shall include an analysis of any instances in which existing scientific-integrity policies have not been followed or enforced, including whether such deviations from existing policies have resulted in improper political interference in the conduct of scientific research and the collection of scientific or technological data; led to the

suppression or distortion of scientific or technological findings, data, information, conclusions, or technical results; disproportionately harmed Federal scientists and researchers from groups that are historically underrepresented in science, technology, and related fields; or impeded the equitable delivery of the Federal Government's programs. The scope of this review shall include the work of scientific and technological advisory committees, boards, and similar bodies. The existing policies examined by this review shall include those issued pursuant to the Presidential Memorandum of March 9, 2009, and the Director's Memorandum of December 17, 2010; any other scientific-integrity policies published on agency websites; and commonly accepted scientific-integrity practices.

(iii) The Task Force shall identify effective practices regarding engagement of Federal scientists, as well as contractors working on scientific matters for agencies, with news media and on social media; effective policies that protect scientific independence during clearance and review, and that avoid improper political interference in research or data collection; effective approaches for handling any disagreements about scientific methods and conclusions; effective reporting practices that promote transparency in the implementation of agency scientific-integrity policies and in the handling of any allegations of misconduct; effective practices for educating and informing employees and contractors of their rights and responsibilities related to agency scientific-integrity policies; promising opportunities to address gaps in current scientific-integrity policies related to emerging technologies, such as artificial intelligence and machine-learning, and evolving scientific practices, such as citizen science and community-engaged research; effective approaches to minimizing conflicts of interest in Federal Government science; and policies that support the professional development of Federal scientists in accordance with, and building on, section IV of the Director's Memorandum of December 17, 2010.

(iv) To inform the review, the Task Force shall gather input from stakeholders and the public regarding scientific-integrity practices. The Task Force shall consider obtaining such input through various means, which may include holding a virtual stakeholder summit hosted by the Office of Science and Technology Policy (OSTP), issuing a public request for information, and conducting a virtual listening tour or open forums.

(v) Upon the conclusion of its review, the Director shall publish a report on the OSTP website synthesizing the Task Force's findings. The report shall include a description of agencies' strengths and weaknesses regarding scientific-integrity policies, as well as a description of best practices and lessons learned.

(c) Within 120 days of the publication of the Task Force's initial 120-day review of existing scientific-integrity policies, the Task Force shall develop a framework to inform and support the regular assessment and iterative improvement of agency scientific-integrity policies and practices, to support the Director and OSTP in ensuring that agencies adhere to the principles of scientific integrity. This framework shall include assessment criteria that OSTP and agencies can use to inform, review, and improve the design and implementation of agency scientific-integrity policies. The Director shall publish this framework on the OSTP website.

Sec. 3. Agency Scientific-Integrity Policies. (a) Heads of agencies shall ensure that all agency activities associated with scientific and technological processes are conducted in accordance with the 6 principles set forth in section 1 of the Presidential Memorandum of March 9, 2009, and the 4 foundations of scientific integrity in government set forth in part I of the Director's Memorandum of December 17, 2010.

(b) Heads of agencies shall ensure that their agency scientific-integrity policies reflect the findings in the Task Force report produced under section (2)(b)(v) of this memorandum and apply to all agency employees, regardless of the nature of their appointment, as well as contractors who perform scientific activities for agencies. Heads of agencies shall coordinate with the Director in the development, updating, and implementation of any agency-specific policies or procedures deemed necessary to ensure the integrity of scientific decision-making. The following time frames shall apply when completing the activities described in this subsection:

(i) The head of each agency with an existing scientific-integrity policy shall submit an updated policy to the Director within 180 days of the publication of the Task Force's report.

(ii) The head of each agency without an existing scientific-integrity policy shall submit a draft agency scientific-integrity policy to the Director within 180 days of the publication of the Task Force's report.

(iii) The Director shall expeditiously review scientific-integrity policies submitted by the agencies to ensure that the policies respond to the Task Force's analysis, adhere to the policy directives in this memorandum, and uphold the highest standards of scientific practice.

(iv) The Director shall notify agencies of any deficiencies in the scientific-integrity policies and collaborate with agencies to expeditiously correct those deficiencies.

(c) In implementing this section, heads of agencies shall:

(i) Provide the Director with any information the Director deems necessary to conduct the Director's duties under this memorandum;

(ii) Publish the agency's scientific-integrity policy on the agency's website, and disseminate information about the policy through the agency's social media channels;

(iii) Develop and publish procedures, as appropriate and consistent with applicable law, for implementing the agency's scientific-integrity policy, including establishing and publishing an administrative process for reporting, investigating, and appealing allegations of deviations from the agency's policy, and for resolving any disputes or disagreements about scientific methods and conclusions;

(iv) Review and, as needed, update within 60 days of the date of this memorandum any website content, and within 300 days of the date of this memorandum any agency reports, data, and other agency materials issued or published since January 20, 2017, that are inconsistent with the principles set forth in this memorandum and that remain in use by the agency or its stakeholders;

(v) Educate agency employees, as well as contractors who perform scientific activities for the agency, on their rights and responsibilities related to scientific integrity, including by conducting routine training on the

agency's scientific-integrity policy for all employees, and by ensuring any new employees are made aware of their responsibilities under the agency's scientific-integrity policy shortly after they are hired; and

(vi) Publish, consistent with any requirements related to national security and privacy, as well as any other applicable law, an annual report on the agency's website that includes the number of administrative investigations and appeals involving alleged deviations from the agency's scientific-integrity policies, as described in section (3)(c)(iii) of this memorandum, for the year covered by the report, and the number of investigations and appeals pending from years prior to the year covered by the report, if any.

Sec. 4. Publication of Scientific-Integrity Policies and Ongoing Biennial Reporting. (a) The Director shall publish on the OSTP website, and disseminate via social media, information about this memorandum, related OSTP and NSTC reports on scientific integrity, and links to the scientific-integrity policies posted on agency websites, to ensure such information and policies can be easily accessed by the public.

(b) The Director shall publish on the OSTP website, and disseminate via social media, a biennial report on the status of the implementation of this memorandum across the executive branch. This report shall include a review of the impact on scientific integrity of diversity, equity, and inclusion practices related to the Federal scientific and engineering workforce and scientific Federal advisory committees.

Sec. 5. Evidence-Based Policymaking. (a) Heads of agencies shall ensure that the scientific-integrity policies of their agencies consider, supplement, and support their plans for forming evidence-based policies, including the evidence-building plans required by 5 U.S.C. 312(a) and the annual evaluation plans required by 5 U.S.C. 312(b).

(b) Within 120 days of the date of this memorandum, after consultation with the Director, the Director of the Office of Management and Budget (OMB) shall issue guidance to improve agencies' evidence-building plans and annual evaluation plans. Specifically, the Director of OMB shall consider whether, consistent with, and building upon, Executive Order 13707 of September 15,

2015 (Using Behavioral Science Insights to Better Serve the American People), agencies' evidence-building plans and annual evaluation plans shall include a broad set of methodological approaches for the evidence-based and iterative development and the equitable delivery of policies, programs, and agency operations. Relevant approaches might include use of pilot projects, randomized control trials, quantitative-survey research and statistical analysis, qualitative research, ethnography, research based on data linkages in which records from two or more datasets that refer to the same entity are joined, well-established processes for community engagement and inclusion in research, and other approaches that may be informed by the social and behavioral sciences and data science.

(c) The statutory positions required to be designated by agencies by the Foundations for Evidence-Based Policymaking Act of 2018 (Public Law 115-435), which include the Evaluation Officer, the Chief Data Officer, and a senior statistical official, shall incorporate scientific-integrity principles consistent with this memorandum into agencies' data governance and evaluation approaches. Similarly, the Chief Data Officers Council shall incorporate scientific-integrity principles consistent with this memorandum into its efforts to establish government-wide best practices for the use, protection, dissemination, and generation of data, and both the Chief Data Officers Council and the Evaluation Officer Council shall identify ways in which agencies can improve upon the production of evidence for use in policymaking.

(d) Consistent with the provisions of the Foundations for Evidence-Based Policymaking Act of 2018, heads of agencies shall, as appropriate and consistent with applicable law, expand open and secure access to Federal data routinely collected in the course of administering Federal, State, local, Tribal, or territorial government programs or fulfilling Federal, State, local, Tribal, or territorial government mandates, such as tax data, vital records, other statistical data, and Social Security Administration earnings and employment reports, to ensure governmental and non-governmental researchers can use Federal data to assess and evaluate the effectiveness and equitable delivery of policies and to suggest improvements. In implementing this provision, heads of agencies shall:

(i) Make these data available by default in a machine-readable format and

in a manner that protects privacy and confidential or classified information, and any other information protected from disclosure by law;

(ii) Publish an agency data plan that provides a consistent framework for data stewardship, use, and access. If publishing such a plan is not feasible, then the head of the agency shall publish guidelines outlining how the data were collected, metadata on data use, any limitations on data use, and ways for researchers to provide feedback on data shared;

(iii) Follow the mandates of the Information Quality Act (section 515 of Public Law 106-554) in assessing and making available to researchers information on the quality of the data being provided; and

(iv) Where possible, provide such data disaggregated by gender, race, ethnicity, age, income, and other demographic factors that support researchers in understanding the effects of policies and programs on equity and justice.

(e) The Director of OMB shall review whether guidance to agencies on implementation of the Information Quality Act needs to be updated and reissued.

(f) Heads of agencies shall review and expeditiously update any agency policies, processes, and practices issued or published since January 20, 2017, that prevent the best available science and data from informing the agency's evidence-based and iterative development and equitable delivery of policies and programs.

Sec. 6. Agency Chief Science Officers and Scientific Integrity Officials. (a) Within 120 days of the date of this memorandum, the heads of agencies that fund, conduct, or oversee scientific research shall, to the extent consistent with applicable law, designate a senior agency employee for the role of chief science officer, science advisor, or chief scientist ("Chief Science Officer"), who shall:

(i) Serve as the principal advisor to the head of the agency on scientific issues and ensure that the agency's research programs are scientifically and technologically well-founded and conducted with integrity; and

(ii) Oversee the implementation and iterative improvement of policies and processes affecting the integrity of research funded, conducted, or overseen by the agency, as well as policies affecting the Federal and non-Federal scientists who support the research activities of the agency, including scientific-integrity policies consistent with the provisions of this memorandum.

(b) Because science, facts, and evidence are vital to addressing policy and programmatic issues across the Federal Government, the heads of all agencies (not only those that fund, conduct, or oversee scientific research) shall designate expeditiously a senior career employee as the agency's lead scientific-integrity official ("Scientific Integrity Official") to oversee implementation and iterative improvement of scientific-integrity policies and processes consistent with the provisions of this memorandum, including implementation of the administrative and dispute resolution processes described in section (3)(c)(iii) of this memorandum. For agencies with a Chief Science Officer, the Scientific Integrity Official shall report to the Chief Science Officer on all matters involving scientific-integrity policies.

(c) To the extent necessary to fully implement the provisions of this memorandum, heads of agencies may designate additional scientific-integrity points of contact in different offices and components, who shall coordinate with the agency's Scientific Integrity Official in implementing the agency's scientific-integrity policies and processes.

(d) Heads of agencies should ensure those designated to serve in the roles described in this section, along with their respective staffs, are selected based on their scientific and technological knowledge, skills, experience, and integrity, including experience conducting and overseeing scientific research and utilizing scientific and technological information and data in agency decision-making, prioritizing experience with evidence-based, equitable, inclusive, and participatory practices and structures for the conduct of scientific research and the communication of scientific results.

(e) The Director or a designee of the Director shall regularly convene Chief Science Officers and Scientific Integrity Officials to encourage the discussion and expansion of effective scientific-integrity policies and practices among agencies.

Sec. 7. Scientific Advisory Committees. (a) Within 90 days of the date of this memorandum, heads of agencies shall review their current and future needs for independent scientific and technological advice from Federal advisory committees, commissions, and boards. The review should include an evaluation of those advisory bodies established by law, and should consider both current and anticipated needs.

(b) This review shall assess which Federal scientific and technological advisory committees should be rechartered or recreated to ensure that relevant and highly qualified external experts, with proper safeguards against conflicts of interest, can contribute to critical Federal regulations and other agency actions and decision-making. The review shall also identify any agency policies, processes, or practices that may currently prevent or inhibit relevant and highly qualified external experts from serving on such committees.

(c) In conducting this review, heads of agencies shall take steps to review the membership of scientific and technological advisory committees and, as appropriate and consistent with applicable law, ensure that members and future nominees reflect the diversity of America in terms of gender, race, ethnicity, geography, and other characteristics; represent a variety of backgrounds, areas of expertise, and experiences; provide well-rounded and expert advice to agencies; and are selected based on their scientific and technological knowledge, skills, experience, and integrity, including prioritization of experience with evidence-based, equitable, inclusive, and participatory practices and structures for the conduct of scientific research and the communication of scientific results.

(d) Upon completion of their 90-day review, heads of agencies shall provide a summary report to the Director and the Director of OMB with recommendations on which Federal scientific and technological advisory committees should be rechartered or recreated in accordance with subsection (b) of this section; which scientific and technological advisory committees should be prioritized for membership appointments to ensure they provide well-rounded and expert advice reflecting diverse perspectives, in accordance with subsection (c) of this section; and which agency policies, processes, or practices, if any, should be updated to encourage relevant and highly qualified external experts to serve on such committees.

Sec. 8. General Provisions. (a) Nothing in this memorandum shall be construed to impair or otherwise affect:

(i) the authority granted by law to an executive department or agency, or the head thereof; or

(ii) the functions of the Director of the Office of Management and Budget relating to budgetary, administrative, or legislative proposals.

(b) This memorandum shall be implemented consistent with applicable law and subject to the availability of appropriations.

(c) This memorandum is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or in equity by any party against the United States, its departments, agencies, or entities, its officers, employees, or agents, or any other person.

JOSEPH R. BIDEN JR.

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Memorandum

Date: February 2021

From: Joel Widder and Meg Thompson, Federal Science Partners

Subject: The Climate Policy Agenda: Likely Priorities for the Biden Administration and Congress

President Biden and his allies in the Congress have made climate policy a top priority. Within days of his inauguration the President issued a number of executive orders related to climate, clean energy, and environmental justice. His domestic senior advisor on climate, former EPA Administrator Gina McCarthy has suggested additional executive orders are likely to be issued on climate-related matters. We expect that once the current COVID relief legislation gets enacted into law, then the Administration and the Congress will move on an infrastructure/stimulus bill that is expected to have a number of key climate related provisions.

What follows is an overview of the climate-related ***programmatic*** issues the Biden Administration and the 117th Congress are likely to tackle. We elected to omit regulatory and organizational issues that likely to also be addressed in major climate legislation and policy developments. To develop this summary, we reviewed Biden campaign proposals on climate, the initial set of Executive Orders the Biden Administration has issued on climate issues, key climate policy reports, and proposed legislation which provide information on which aspects of the climate crisis are likely to be high priorities in the coming years. Among the materials we reviewed were the June 2020 report from the Select Committee on the Climate Crisis, Climate 21 (a series of reports developed to provide agency by agency recommendations for the incoming Administration), key legislative proposals such as the "Climate Leadership and Environmental Action for our Nation's (CLEAN) Future Act and the GREEN Act, the Ocean-Based Climate Solutions Act, and other sources.

The top public policy priorities with respect to responding to the climate crisis are:

- **Clean energy and a transformation of the energy sector that relies heavily on renewable energy sources, a modernized electrical grid, and less reliance on fossil fuels.**
- **Invest $2 trillion for a clean energy economy over 4 years -- Invest $400 billion for clean energy innovation and research over 10 years.**
- **Modernizing the nation's transportation enterprise to reduce emissions via a variety of smart infrastructure investments.**
- **Build sustainable infrastructure that will withstand the impacts of climate change and fuel an American clean energy revolution while creating new jobs and industries.**
- **Delivery of environmental justice.**
- **Evidence-based approaches to protect ocean and coastal communities, promote sustainable job opportunities, and support clean offshore energy while reducing impacts of the climate crisis.**
- **Provision of important climate services and information for decision makers at all levels of government.**
- **Support for climate science and technology programs to help achieve a goal of reaching net-zero greenhouse gas emissions economy-wide in the United States by no later than 2050 and achieving net-negative greenhouse gas emissions during the second half of the century.**

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Biden Campaign Priorities for Climate

During the Presidential campaign, President Biden laid out a set of objectives to address climate matters – some of which have been partially addressed in the first round of executive orders and others will be addressed in the coming weeks. Key priorities of the Biden Climate Plan include:

Ensure the U.S. achieves a 100% clean energy economy and reaches net-zero emissions no later than 2050. This would include legislation that: establishes an enforcement mechanism that includes milestone targets no later than the end of his first term in 2025; makes a historic investment in clean energy and climate research and innovation; and incentivizes the rapid deployment of clean energy innovations across the economy, especially in communities most impacted by climate change. President Biden's climate and environmental justice proposal will be a federal investment of $1.7 trillion over the next ten years, leveraging additional private sector and state and local investments to total to more than $5 trillion.

The Biden plan proposes to invest $400 billion over ten years to develop new technological breakthroughs that will create jobs and reduce emissions. The plan proposes the creation of ARPA-C, a new cross agency initiative that will target affordable, game-changing technologies to help achieve the 100% clean energy target; target reduction in airline emissions; Accelerate the development and deployment of carbon capture sequestration technology; identify the future of nuclear energy; improve efficiency in buildings; accelerate the deployment of electric vehicles; empower local communities to develop transportation solutions; support better agricultural practices; mitigate the climate impact driven by urban sprawl; and develop a national strategy for a low-carbon manufacturing sector

Build a stronger, more resilient nation. This includes infrastructure investments to rebuild the nation and to ensure that buildings, water, transportation, and energy infrastructure can withstand the impacts of climate change. Resources spent on rebuilding roads, bridges, buildings, the electric grid, and water infrastructure will be used to prevent, reduce, and withstand a changing climate. His plan proposes to boost climate resilience efforts by developing regional climate resilience plans, in partnership with local universities and national labs, for local access to the most relevant science, data, information, tools, and training.

Re-establish international leadership on climate. Climate change is a global challenge that requires decisive action from every country around the world. As President, he will recommit the United States to the Paris Agreement on climate change. In addition, he will lead an effort to get every major country to ramp up the ambition of their domestic climate targets. He will make sure those commitments are transparent and enforceable. President Biden intends to fully integrate climate change into foreign policy and national security strategies, as well as in the approach to trade.

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Presidential Executive Orders on Climate Change Policy

On January 27, 2021, President Biden issued two Executive Orders and a Memorandum addressing climate change policy and scientific integrity, which include a moratorium on new oil and gas lease permits on federal lands and waters. These steps build on other steps President Biden has taken, such as rejoining the Paris Agreement, revoking the permit for the Keystone XL pipeline, and establishing a moratorium on federal leases in Arctic Wildlife Refuge. The Orders represent the President's first steps to tackle climate change issues domestically and internationally and implement his $2 trillion "whole-of-government" climate plan.

The President's January 27 Executive Order, entitled **"Tackling the Climate Crisis at Home and Abroad"** announces an intent to join domestic action with international action so as to enhance global action on climate change.

In Part I, the Order reaffirms the United States' commitment to address climate change with international partners, "both bilaterally and unilaterally." The Order submits the United States to host platforms to facilitate international exchanges, such as a Leaders' Climate Summit and the major Economics forum on Energy and Climate. The Order also calls for the United States to re-enter, or enter into, existing international agreements on climate change. The Order submits "the United States instrument of acceptance to rejoin the Paris Agreement." In addition to committing domestic and foreign policy to that Agreement's broad objectives, such as safe global temperature and increased climate resilience, the Order also calls for directing the nation's financial flows in a manner aligned with a pathway toward low greenhouse gas emissions and climate-resilient development. As part of that effort, the Order commits the United States to pursue initiatives to advance the renewable energy transition and to pursue alignment of financial flows with the objectives to the Paris Agreement. The Order also pledges domestic resources and funding to target international developments. First, the Order announces that the United States will also immediately begin to *develop a climate finance plan*, making strategic use of multilateral and bilateral channels and institutions, to assist developing countries in implementing ambitious emissions reduction measures, and promoting the flow of capital toward climate-aligned investments and away from high-carbon investments. Second, the Order asks the Secretaries of State, Treasury and Energy to collaborate with the Export–Import Bank of the United States and the Chief Executive Officer of the Development of Finance Corporation (DFC) to identify steps through which the United States can promote ending international financing of carbon- intensive fossil fuel-based energy.

Part II of the Order addresses climate change measures at the domestic level, drawing on domestic resources. The Order envisages both a "government-wide approach" and a strategy centralized with the newly formed White House Office of Domestic Climate Policy, which is tasked with overseeing all domestic climate-policy decisions and programs, ensuring their consistency with the President's stated goals and drawing on all assistance as may be necessary to carry out the provisions of the order. The Office is to be supported by a Climate Change Task Force composed of most, if not all, cabinet secretaries, including the Secretary of Energy, as well as several Assistants to the President. The Task Force's mission is to facilitate deployment of a Government-wide approach to combat the climate crisis,

including measures to reduce climate pollution; conserve our lands, waters, oceans, and biodiversity; and deliver economic justice."

The Order requires a review, by the Secretary of the Interior, of the siting and permitting processes on public lands and in offshore waters to make these processes more amenable to renewable energy initiatives, with the goal of doubling offshore wind by 2030 while ensuring protection for our lands, waters, and biodiversity. It includes a pause on all new oil and natural gas leases on public lands or in offshore waters until a "comprehensive review and reconsideration of Federal oil and gas permitting and leasing practices has been submitted. The Order addresses fossil fuel subsidies and calls for the heads of agencies to take steps to ensure that, to the extent consistent with applicable law, Federal funding is not directly subsidizing fossil fuels. This section also calls for the elimination of fossil fuel subsidies from the budget request for Fiscal Year 2022 and thereafter.

A final segment of the Order addresses racial equity and the broader societal impacts reliance on fossil fuel production have had on certain communities. These impacts are addressed in a number of sections concerning environmental justice. The Order describes an initiative to ensure that 40% of the overall benefits of a renewable energy push accrue to minority communities.

Executive Order (and Memorandum) on PCAST and Scientific Integrity

This Order commits the administration to listen to science. An additional order establishes the "President's Council of Advisors on Science and Technology" ("PCAST"). PCAST comprises both federal governmental employees as well as representatives from sectors outside of the Federal Government with diverse perspectives and expertise in science, technology, and innovation. In addition, PCAST is instructed to solicit information and ideas from a broad range of stakeholders, including the private sector. PCAST's advisory function is broad and discretionary, and explicitly contains within its scope policy matters affecting energy, the environment, [and] public health.

An associated memorandum on scientific integrity addresses private sector efforts to influence energy and climate policies by the current administration. A newly formed inter-agency task force will review any instances in which existing scientific-integrity policies have not been followed or enforced, including whether such deviations from existing policies have resulted in improper political interference in the conduct of scientific research and the collection of scientific or technological data.

Select Committee on the Climate Crisis Recommendations

In January 2019, the House of Representatives created a new bipartisan House Select Committee on the Climate Crisis to "develop recommendations on policies, strategies, and innovations to achieve substantial and permanent reductions in pollution and other activities that contribute to the climate crisis." The resolution directed the Select Committee to deliver policy recommendations to the standing legislative committees of jurisdiction for their consideration and action. In June 2020, the Select Committee on the Climate Crisis delivered a majority staff report, *Solving the Climate Crisis – The Congressional Action Plan for a Clean Energy Economy and a Healthy Resilient and Just America*,

complete with recommendations for Congress and its committees that would help address the climate crisis facing the nation. The recommendations, summarized below, are impacting the development of Congressional climate-related stimulus legislation and actions being taken and planned by the Biden Administration.

The Climate Crisis Action Plan establishes a goal of reaching net-zero greenhouse gas emissions economy-wide in the United States by no later than 2050; directs the president to set ambitious interim targets to meet or exceed that goal; and calls for achieving net-negative greenhouse gas emissions during the second half of the century. The report provides 12 major recommendations, including:

Major Recommendation 1: Invest in Infrastructure to Build a Just, Equitable, and Resilient Clean Energy Economy -- The nation needs to make a deep, sustained commitment to rebuild and modernize the nation's infrastructure to reduce greenhouse gas emissions and withstand the unavoidable impacts of a warming climate. Doing so will create good-paying, high-quality jobs to expand America's middle class and lay a solid foundation for an equitable economy.

- **Build a cleaner and more resilient electricity sector to achieve net-zero emissions from power generation by 2040.** Decarbonization of the electricity sector is the linchpin of any national strategy to achieve net-zero emissions economy-wide by no later than 2050. Electrification of key end uses in the transportation, buildings, and industrial sectors will be essential to cut emissions from those sectors. Electrification only works as a decarbonization strategy, however, if the grid is as clean as possible as soon as possible. Energy efficiency can moderate the expected increase in electricity demand from electrification and reduce energy costs for consumers. As the electricity grid becomes the central feature of a comprehensive climate strategy, its reliability and resilience to climate-related threats becomes even more paramount.

- **Build a cleaner and more resilient transportation sector.** The transportation sector—including cars, trucks, buses, airplanes, ships, rail, and other modes—is the largest source of energy-related carbon dioxide emissions in the United States. Each part of the transportation sector, however, is at a different stage of zero-emission technological innovation and faces unique challenges to decarbonization and, as a result, may require a tailored policy approach. Policy development should lead to new manufacturing and supply chain innovations that create good-paying jobs at home and bolster American competitiveness. In addition to contributing to the climate problem, transportation infrastructure is heavily exposed to extreme weather and climate impacts, from floods that wash out bridges and roads to heat waves that ground airplanes. Without proactive action to build resilience, climate change will compromise the reliability and capacity of even the cleanest transportation systems.

- **Build and upgrade homes and businesses to maximize energy efficiency and eliminate emissions.** Buildings account for 40% of U.S. energy use. To fully decarbonize the building sector, new and existing buildings must maximize energy efficiency, generate clean energy onsite or nearby where feasible, electrify end uses as the grid decarbonizes, and eliminate emissions from building construction and materials. The federal government must work in partnership with state and local

governments, as they largely have authority over the design and construction of residential and commercial buildings in their jurisdictions

- **Invest in water systems to provide clean water and prevent catastrophic flooding.** Water systems across the nation are under stress due to chronic underinvestment and deferred maintenance, particularly in low-income communities and communities of color. The climate crisis threatens to increase public health and safety emergencies as conditions overwhelm water and wastewater infrastructure, levees, and dams.

- **Prepare the nation's telecommunications networks for climate impacts**. The reliability of wireless and broadband networks is critical for climate resilience and uneven access to broadband creates a "digital divide" that broadens existing inequities for frontline and rural communities most affected by the climate crisis.

Major Recommendation 2: Drive Innovation and Deployment of Clean Energy and Deep Decarbonization Technologies -- Science has shown that the world needs to deploy clean energy technologies as quickly as possible to slash greenhouse gas emissions and limit warming to 1.5°C. Market forces and state and federal policies are driving some clean energy deployment already, but substantial public and private investment would accelerate this trend. Full decarbonization of the economy, however, may require new technologies that have yet to be invented. Robust innovation policy at all process stages— research, development, demonstration, and deployment—will be critical to the timely and widespread implementation of new clean energy and other decarbonization technologies. Congress should support all stages of climate-related innovation and boost funding for federal clean energy research, development, and demonstration; prioritizing climate in the Department of Energy's (DOE's) mission; facilitating technology transfer and commercialization through initiatives like regional energy innovation partnerships; and creating a national climate bank and expanding the DOE loan guarantee program to leverage private investment for deployment of decarbonization technologies and climate- resilient infrastructure.

Major Recommendation 3: Transform U.S. Industry and Expand Domestic Manufacturing of Clean Energy and Zero-Emission Technologies -- The world is on the cusp of a manufacturing and industrial transformation inspired by the need to deploy zero-emission technologies and build cleaner, more resilient infrastructure.

- **Rebuild U.S. industry for global climate leadership.** Eliminating industrial emissions depends on the discovery of new technologies and the development and deployment of platform technologies, such as industrial efficiency, electrification, carbon capture, low-emission hydrogen, and materials recirculation and substitution. A comprehensive approach to achieve a net-zero-emissions industrial sector by midcentury would enhance U.S. competitiveness, create high-quality domestic jobs, and ensure clean, safe, fair, and equitable industrial development for workers and communities.

- **Invest in domestic manufacturing of clean energy, clean vehicle, and zero-emission technologies.** American innovation will be critical to solving the global climate crisis, but it is only one measure of

U.S. leadership. American workers also should be the ones to manufacture these American ideas, creating high-quality jobs at home and robust export markets abroad.

- **Develop, manufacture, and deploy cutting-edge carbon removal technology.** According to the IPCC, all pathways that limit global warming to 1.5°C require carbon dioxide removal, such as direct air capture, to achieve net negative emissions.17 The United States has the opportunity to lead the world in developing, deploying, and exporting this essential technology.

Major Recommendation 4: Break Down Barriers for Clean Energy Technologies -- Clean energy technology faces several structural barriers to rapid and widespread deployment. At the top of the list is a tax code that benefits oil, coal, and other incumbent energy technologies over new technologies and an economic system that fails to account for the cost of carbon pollution from fossil fuel combustion.

Major Recommendation 5: Invest in America's Workers and Build a Fairer Economy -- Tackling climate change and reaching net-zero emissions offers a unique opportunity to rebuild the economy on a stronger foundation of equity and fairness for workers and their communities. Smart climate policy must provide tangible benefits to economically vulnerable communities and deliver good-paying, high-quality jobs and accessible career pathways into them for all Americans.

Major Recommendation 6: Invest in Disproportionately Exposed Communities to Cut Pollution and Advance Environmental Justice -- Communities of color, low-income communities, and tribal and Indigenous communities are disproportionately burdened by environmental hazards that include exposure to polluted air, waterways, and landscapes. Federal climate policy needs to improve the public health and well-being of all communities while tackling the climate crisis and environmental racism head-on.

Major Recommendation 7: Improve Public Health and Manage Climate Risks to Health Infrastructure -- The impacts of climate change disproportionately affect the health of frontline communities and vulnerable populations who have fewer resources to cope with heat waves, degraded air quality, flash flooding, infectious disease, and other threats. People need a robust public health system to rely on for help when facing these threats or when hit with a natural disaster. Too often, health care systems are not prepared or equipped to respond to large-scale events, as demonstrated by the COVID-19 pandemic.

Major Recommendation 8: Invest in American Agriculture for Climate Solutions -- Many agricultural practices can provide valuable climate and ecosystems benefits. Climate stewardship practices such as no- and low-till farming, planting cover crops, diversified crop rotations, rotational grazing, and improved nutrient management, reduce emissions, enhance carbon sequestration, and make soils more resilient to extreme weather. Many farmers interested in adopting these practices would benefit from upfront financial and technical assistance from the Department of Agriculture, local conservation districts, extension services, and land-grant universities, including historically black colleges and universities and tribal colleges.

Major Recommendation 9: Make U.S. Communities More Resilient to the Impacts of Climate Change -- The effects of climate change are already manifesting across the nation and are projected to intensify, including rising temperatures, increasingly severe storms, and damaging wildfires. The federal government needs to help communities better manage land use, adopt robust building codes and development standards, and transition away from areas of growing risk to safer ground. Bridging the resilience gap will require substantial public and private investment and incorporation of climate risks into program design and priorities to ensure efficient use of funds.

- Support community leadership in climate resilience and equity.
- Build—and rebuild—based on actionable science, codes, and standards.
- Reduce climate disaster risks and accelerate disaster recovery.
- Make climate resilience planning an essential element of federal agency operations.

Major Recommendation 10: Protect and Restore America's Lands, Waters, Ocean, and Wildlife -- America's landscapes and natural resources have significant potential to sequester carbon, provide important habitat for wildlife, and make ecosystems and communities more resilient to the impacts of climate change. Ecosystems such as forests, grasslands, and wetlands are natural and efficient carbon sinks, capturing and storing carbon in roots, plants, and soils. To make America's public lands and ocean a net carbon sink and a central feature of a comprehensive climate strategy, U.S. land management agencies must increase renewable energy production and maximize deployment of natural climate solutions such as reforestation and wetland restoration.

Major Recommendation 11: Confront Climate Risks to America's National Security and Restore America's Leadership on the International Stage -- The climate crisis is an urgent threat to our nation and to global security, as extreme conditions affect defense facilities, operations, and personnel. Catastrophes at home and abroad increase the need for humanitarian response and aid. The climate crisis amplifies geopolitical threats as resource scarcity and catastrophic events fuel conflict, mass migration, and social and political strife. Federal leadership requires coordination across the science, security, and defense enterprises to confront threats to military infrastructure and operations and global security. At the same time, international engagement is crucial to addressing the climate crisis. The opportunity to advance climate solutions should be a priority for the United States in our multilateral, bilateral, international development, and humanitarian efforts. A future president committed to climate action likely will rejoin the Paris Climate Agreement, but Congress also must take steps to ensure that the United States continues to support global progress on climate change.

Major Recommendation 12: Strengthen America's Core Institutions to Facilitate Climate Action; Strengthen climate science -- Climate science is the foundation of national and international efforts to address the climate crisis. Scientists and educators need strong federal funding support to advance efforts to observe, monitor, model, and understand Earth's interconnected weather and climate system and to develop the next generation of climate scientists and a climate-literate public and workforce. Federal agencies also need safeguards to protect science from political interference.

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Climate 21 Project Recommendations

The Climate 21 Project brought together more than 150 experts to provide advice to the incoming Biden Administration on actions that should be taken by key agencies to provide a rapid start and a whole of government response to the achieve U.S. leadership on climate change. Below are highlights, by agency, of the programmatic recommendations made by Climate 21. To be sure, the Climate 21 Project also provided advice on organizational and staffing issues, but we elected to focus primarily on those recommendations with near-term programmatic and budgetary implications.

Department of Energy (DOE) -- DOE's core climate capabilities lie in its energy R&D programs and capabilities. These are fundamentally shaped by DOE's budget proposals and legislation (e.g., stimulus funding bills, appropriations bills, etc.) will likely create significant opportunities to increase funding for existing clean energy programs and R&D, as well as expand clean energy tax credits and other financial incentivizes. Key climate goals for DOE are likely to be:

- Achieve 100% *clean energy economy and net-zero emissions* by 2050.
- Establish 100% energy efficiency and clean electricity standard (EECES) by 2035.
- Invest $2 trillion for a *clean energy* economy over 4 years.
- Invest $400 billion for *clean energy innovation and research* over 10 years.
- Develop *new corporate average fuel economy standards* (CAFE) to ensure 100% of new light- and medium duty vehicle sales are electrified.
- Ensure *net-zero emissions standard for all new commercial buildings* by 2030.
- Rejoin the Paris Climate Agreement.
- Rely on American union labor and American-made materials to build infrastructure and clean energy economy.
- Set a goal that disadvantaged communities receive 40% of overall clean energy spending benefits.
- Create a *new Advanced Research Projects Agency on climate. (***FSP note: if this happens it could be a new and additional source of funding for negative emissions, food security related to climate change, droughts, relocation of people, decarbonizing cities/manufacturing/transportation***)*
- Restore Appliance Standards program.
- Reorient DOE R&D around *a deep decarbonization strategy.*
- *Expand the scope of R&D programs to include adaptation or new climate mitigation technologies* not presently under DOE's purview.
- Institutionalize climate policy and R&D throughout DOE – including the national labs taking advantage of the role national labs play within the nation's science enterprise with research into low carbon and basic climate research.
- Reorganize DOE R&D efforts with cross-cutting DOE teams on *decarbonization technology goals*
- Revamp DOE fossil energy mission that places fossil energy research within the context of DOE's core focus on climate change.

In addition to proposing a new sub-agency focused on climate called ARPA-C, the broader climate and energy plan includes:

- *Utilities, Energy Tech, Transmission*: Establish an energy efficiency and clean electricity standard for utilities to achieve carbon-free electricity generation by 2035; invest $150B over four years in RDD&D; and develop a long-term transmission siting and permitting strategy.

- *Distributed Generation and Storage*: allocate $150B on RDD&D for clean energy distributed generation and storage; formalize grid-scale storage as part of a broader net-zero carbon plan for power sector; and promote and establish streamlined permitting for rooftop solar and energy efficiency retrofits.

- *Buildings*: reduce carbon footprint of U.S. building stock 50% by 2035; create incentives/new programs for building retrofits; upgrade 4 million buildings and weatherize 2 million homes in four years; and set new appliance and building standards to improve energy efficiency.

- *Vehicles*: deploy over 500,000 EV charging stations by 2030; develop new CAFÉ standards to ensure 100% of new light-and-medium duty vehicle sales are electrified; restore the full EV tax credit, additional consumer rebates for new efficient American-made vehicles; and incentives for manufacturers to retool and build factories to produce zero-emission vehicles and parts.

- *Biofuels*: develop the next generation of advanced biofuels

- *Manufacturing*: develop a low-carbon manufacturing sector in every state, with manufacturers becoming eligible for new tax credits and subsidies to upgrade facilities and equipment

- *Carbon Capture*: Target RDD&D investments to lower the cost of carbon capture technology to ensure this technology is scalable and widely available.

Department of Interior – opportunities to maximize climate action by focusing on the four bureaus that hold the most mitigation opportunities: The Bureau of Land Management (BLM); Bureau of Ocean Energy Management (BOEM); Bureau of Safety and Environmental Enforcement (BSEE); and US Geological Survey (USGS).

Reduce emissions from federal fossil fuels:
- Adopt policies to slow/halt onshore leasing
- Defend and begin rulemakings on methane emissions, venting and flaring
- Cut venting and flaring on a case-by-case basis through permits and approvals
- Put the Outer Continental Shelf entirely or mostly off-limits to new leasing
- Reinstate compensatory mitigation; apply it to climate
- Strengthen bonding and clean up orphan wells

Boost renewable energy production and transmission on public and Tribal lands and waters:
- Instruct state and regional offices to prioritize approvals
- Approve pending offshore wind projects
- Boost staff and resources for permitting and outreach

- Work with EOP Permitting Council to speed projects
- Provide technical support for projects on Tribal lands

Enhance carbon sequestration on public lands:
- Quantify biological carbon losses and gains in NEPA reviews
- Manage for carbon sequestration through restoration and wildfire
- Boost research on biological carbon sinks and quantification

Department of Transportation -- Climate change should be integrated into the organization of each modal administration at a high level, including a climate-focused team within the administrator's office in each modal administration. DOT's authorities and programs provide significant opportunities to reduce emissions and increase resilience to climate impacts, including through *vehicle efficiency standards*, investments in *electric vehicle charging infrastructure*, support for *transit systems and other low-carbon transportation options*, and a *"climate in all policies"* approach to require consideration of climate impacts of transportation projects. Key program opportunities include:

- Utilize a Presidential Memorandum or Executive Order from The White House early on to *provide direction on vehicle standards*, including a directive to DOT/NHTSA, EPA, and DOJ to resolve pending litigation around vehicle standards, announce the administration's priorities for vehicle standards, and establish initial deadlines.
- Initiate new *transportation electrification task force to focus on electrification policy and job creation*.
- Initiate efforts to *develop climate change criteria for resilience and emission reductions*, as well as related economic analysis, to *incorporate in BUILD grant criteria and to update NEPA guidance*.
- *Develop proposal for a new ARPA-T program* to advance transportation innovation.
- Ensure USDOT leadership in the International Civil Aviation Organization and the International Maritime Organization to advance efforts to reduce global aviation and maritime emissions.

Environmental Protection Agency – Restore EPA budget with significant increases in funding, including state and tribal assistance grants targeted for climate.

- Initiate rulemaking to accelerate the pace of *decarbonization in major greenhouse gas* (GHG) emitting sectors.
- Direct EPA to create Clean Air Act rulemaking teams for *vehicles, the power sector, and the oil and gas sector.*
- Direct EPA to develop a coordinated *regulatory plan for hydrofluorocarbons* (HFCs) and a strategy to address the remaining, diverse group of emitting sources.
- Create a structured process, with rigorous criteria, to mobilize each of the agency's Offices to prioritize climate activities and highlight the most important opportunities to drive down emissions and increase *resilience*.
- Announce an EPA renewal to return EPA to its core mission of *protecting human health and the environment*.

- Seek interagency partnerships and cross-agency initiatives, such as a task force on agricultural emissions, and another to *pursue meaningful GHG reductions* in the industrial sector, including efforts to advance energy efficiency and partial electrification.

National Oceanic and Atmospheric Administration (NOAA) -- NOAA's goal in a new administration should be to expand and make climate data, products, and services even more easy to access and use, provide climate-related support to state and local governments as well as to the private sector, and connect people making specific adaptation and planning decisions with the tools and resources they need. At the same time, NOAA should expand both mitigation and adaptation opportunities for coastal communities and fisheries by expanding coastal resiliency and blue carbon habitat restoration efforts, and by establishing a mandate for climate-ready fisheries.

Department of Agriculture -- While the U.S. Department of Agriculture (USDA) has not historically been at the center of the public conversation on federal climate policy, the Department has enormous and underappreciated discretionary financial resources and agency expertise. These resources and expertise enable USDA to: (1) partner with farmers, ranchers and forest owners to reduce atmospheric greenhouse gases (GHGs) through carbon sequestration and emissions reductions; (2) reduce GHG emissions from rural energy cooperatives; (3) bolster the resilience of private working lands and public forests and grasslands to the effects of climate change; (4) promote sustainable bioenergy, wood products, and other bio-based materials (5) contribute to the scientific understanding of climate change; and (6) invest in climate-smart economic development in rural communities. Key program recommendations include:

- Issue a Secretarial Order on Climate Change and Rural Investment to signal climate change as a top priority of the department, frame USDA's interest in investing in agriculture, forestry, technology, innovation, and rural economies, and to set agendas for policy and programmatic actions needed to act on climate.
- Invest in natural climate solutions by establishing a Carbon Bank using the Commodity Credit Corporation to finance large-scale investments in climate smart land management practices; prioritizing climate smart practices in implementation of Farm Bill conservation programs; and identifying opportunities to invest in natural infrastructure.
- Incentivize Climate Smart Agriculture and Rural Investment through financial tools including crop insurance, rural development grants and loans, and USDA procurement.
- Decarbonize rural energy and promote green energy and smart grids through the vast reach of rural development grants and loans to rural utilities and by dramatically increasing use of methane digesters, biofuels and wood energy, and wood product innovation.
- Prioritize federal investment to address wildfire by establishing a Wildfire Commission, co-chaired by the Secretaries of Agriculture and Interior and a Democratic and Republican governor, to offer recommendations to increase the pace and scale of ecologically-sound forest restoration on federal, state, tribal and private forest lands, modernize firefighting response in the US, address development in the wildland-urban interface, and increase the use of prescribed fire.

The CLEAN Future Act

In the last Congress, the House Energy and Commerce Committee released a draft of the Climate Leadership and Environmental Action for our Nation's (CLEAN) Future Act – would authorize more than $300 billion in spending and clean energy plan to achieve net-zero emissions by 2050. This legislation is expected to be revised and re-introduced in the 117th Congress. The bill's priorities along with programmatic and policy changes will likely be a dominate part of the Congressional agenda with respect to climate change. The CLEAN Future Act is a comprehensive proposal of sector-specific and economy-wide solutions to address the climate crisis. The CLEAN Future Act formally adopts the goal of achieving a 100 percent clean economy by 2050. According to the United Nations Intergovernmental Panel on Climate Change, avoiding the most catastrophic outcomes of climate change requires cutting carbon pollution to net-zero by 2050. The draft legislation includes the following key areas:

Power Sector: The CLEAN Future Act proposes a nationwide clean energy standard (CES) requiring all retail electricity suppliers to obtain 100 percent clean energy by 2050. The CES in the discussion draft text mandates that all retail electricity suppliers provide an increasing supply of clean energy to consumers starting in 2022, rising to 100 percent clean energy by 2050.

Building Sector: The draft legislation aims to improve the efficiency of new and existing buildings, as well as the equipment and appliances that operate within them. The Act establishes national energy savings targets for continued improvement of model building energy codes, leading to a requirement of zero-energy-ready buildings by 2030. This section further provides assistance for states and Tribes to support adoption of updated model building energy codes and support full compliance. The CLEAN Future Act also incorporates several additional measures to reduce building emissions.

Transportation Sector: The draft legislation reduces transportation emissions, the largest source of GHG emissions, by improving vehicle efficiency, accelerating the transition to low- to zero-carbon fuels and building the infrastructure needed for a clean transportation system. The bill directs EPA to set new, increasingly stringent greenhouse gas emission standards for light-, medium-, and heavy-duty vehicles, including non-road modes of transportation. It further requires year-over-year improvements to those standards – and that the level of the standards be set in accordance with the path to net-zero emissions by 2050.

Industrial Sector: The CLEAN Future Act establishes a Buy Clean Program that sets performance targets to steadily reduce emissions from construction materials and products used in projects that receive federal funding. With the vast majority of U.S. construction projects funded by government dollars, this proposal would transform these carbon-intensive industries by ensuring that these projects only use the cleanest construction materials. The program also strengthens the competitiveness of the U.S. manufacturing sector while reducing climate pollution by promoting the use of low-carbon materials and expanding the market for cleaner products.

National Climate Target for Federal Agencies: The CLEAN Future Act directs all federal agencies to use all existing authorities to put the country on a path toward net-zero greenhouse gas emissions by

2050. It does not stipulate which energy sources or strategies qualify, instead taking a technology-inclusive approach to reaching net-zero emissions by mid-century. To ensure federal agencies' collective efforts remain on track, the draft legislation directs the Environmental Protection Agency (EPA) to evaluate each agency's plans, make recommendations and report on progress each year.

State Climate Plans: The CLEAN Future Act empowers the states to complete the transition to a net-zero economy, based on the existing federalism model in the Clean Air Act. The bill sets a national climate standard of net-zero greenhouse gas pollution in each state by 2050. States are then granted flexibility to develop plans to meet the 2050 and interim standards based on their policy preferences, priorities and circumstances. Each state must submit a climate plan to EPA, which then reviews and approves or disapproves each plan. To ensure that states have ample guidance and expertise at their disposal, the bill directs EPA to develop a set of model greenhouse gas control strategies, which states can choose to incorporate into their plans.

National Climate Bank: The CLEAN Future Act establishes a National Climate Bank to help states, cities, communities and companies in the transition to a clean economy. The Bank will mobilize public and private investments to provide financing for low- and zero-emissions energy technologies, climate resiliency, building efficiency and electrification, industrial decarbonization, grid modernization, agriculture projects, and clean transportation. The CLEAN Future Act requires that the Bank prioritize investments in communities that are disproportionately affected by the impacts of climate change, including frontline, rural, low-income and environmental justice communities.

Environmental Justice: The draft legislation requires that states' individual climate plans and state implementation plans for other hazardous air pollutants proactively consider the needs of frontline and environmental justice communities. The draft also includes grant programs to allow impacted communities to participate in the permitting and regulation of petrochemical facilities in their neighborhoods. It further protects these groups by implementing strong new coal ash disposal requirements and repealing oil and gas production exemptions from landmark environmental laws. The CLEAN Future Act also features a suite of complementary policies, including proposals to remove barriers to clean energy, reduce super pollutants like methane, and investments in grid modernization and energy efficiency programs.

The Growing Renewable Energy and Efficiency Now (GREEN) Act

On February 5, Rep. Mike Thompson, Chair of the House Ways and Means Subcommittee on Select Revenue Measures announced the re-introduction of legislation first introduced in the last Congress – the GREEN Act. This bill is a comprehensive use of the tax code focused on climate change. The legislation is designed to expand the use of renewable energy to help reduce greenhouse gas emissions. The GREEN Act:

- Builds on current successful tax incentives that promote the deployment of green energy technologies, while providing new incentives for activities that reduce greenhouse gas emissions,
- Encourages residential investments in green energy and energy efficiency,

- Expands incentives for energy efficiency and conservation in homes and buildings, with updated standards,
- Supports widespread adoption of zero-emission cars, vans, and buses through tax credits for purchasing vehicles, and supporting deployment of publicly accessible electric vehicle charging infrastructure,
- Invests in the green workforce by providing tax credits for advanced manufacturing facilities and mechanical insulation installations,
- Advances environmental justice using tax credits for research and other academic programs, and
- Prices greenhouse gas emissions.

The Ocean-Based Climate Solutions Act

Last October, House Natural Resources Committee Chair Raúl M. Grijalva (D-Ariz.) and Rep. Kathy Castor (D-FL), Chair of House Select Committee on the Climate Crisis introduced the Ocean-Based Climate Solutions Act -- legislation to address the ocean impacts of climate change and reform federal ocean management to better account for climate mitigation. This legislation is likely to be introduced in the 117th Congress. Below is a summary of some of the key provisions in this bill.

Reduces Greenhouse Gas Emissions. The bill supports the transition to a clean energy economy by reducing greenhouse gas emissions associated with ocean sectors and increasing ocean-based renewable energy—helping to reduce use of fossil fuels and protect the ocean and coastal habitats important to healthy fish, marine wildlife, and coastal economies.

Increases Carbon Storage in Blue Carbon Ecosystems. The bill recognizes the carbon storage potential and other co-benefits provided by "blue carbon" ecosystems like salt marshes, sea grasses, and mangroves.

Promotes Coastal Resiliency and Adaptation to protect coasts and communities from the climate impacts. It authorizes investment in coastal restoration and resilience that is important for the economy, frontline communities, and the environment.

Improves Ocean Protection by promoting and protecting healthy ocean systems and wildlife populations. Marine protected areas are a key part of protecting biodiversity while tackling climate change.

Supports Climate-Ready Fisheries with the development and implementation of strategies to improve the management of fisheries in a changing climate and also helps to promote U.S. seafood sourced from environmentally and climate-friendly fisheries.

Tackles Ocean Health Challenges by addressing the ocean health challenges of ocean acidification and harmful algal blooms, both of which cause significant harm to the U.S. seafood, recreation, and tourism industries, as well as human communities and ocean wildlife and ecosystems.

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Restores U.S. Leadership in International Ocean Governance by strengthening U.S. leadership in international ocean governance at a time when transboundary pressures on our ocean demands a coordinated response. These actions would both strengthen U.S. security and promote a resilient global ocean for the 21st century.

In addition, the bill:

- Protects and restores “blue carbon” ecosystems
- Promotes wetland health and restoration
- Establishes a pathway forward to protect 30 percent of our ocean by 2030
- Prohibits oil and gas leasing in all areas of the Outer Continental Shelf
- Promotes offshore wind energy and other marine energy research
- Promotes climate-ready fisheries and eliminates fishing subsidies in trade agreements
- Enhances the fuel efficiency of our fishing vessel fleet
- Establishes a climate and fisheries research management program
- Creates a restorative ocean aquaculture research and policy program
- Amends the Coastal Barrier Resource Act
- Reauthorizes the Coastal Zone Management Act
- Promotes climate resiliency of Insular Areas
- Protects marine mammals through vessel speed programs
- Expands climate mitigation efforts in the Arctic
- Promote coastal resiliency and adaptation through living shorelines, coastal community adaptation, and by other measures
- Enhances ocean health by researching, forecasting, and mitigating ocean acidification and harmful algal blooms
- Codifies a National Ocean Policy, enhances ocean data collection and monitoring, and creates a centralized website for resiliency grants
- Establishes a grant program for shovel-ready projects that promote climate resilient coastlines and fisheries

HOME | NEWS

NSF Director Lays Out Vision for Future of U.S. Science

18 February 2021

by: Adam D. Cohen

Sethuraman Panchanathan has led the U.S. National Science Foundation since June 2020. | AAAS

Addressing the "missing millions" — people who are capable of succeeding as scientists and engineers but do not have access to pathways that lead into those careers — is a key step toward enabling the American STEM enterprise to thrive in the coming decades, U.S. National Science Foundation director Sethuraman Panchanathan said last week.

An independent federal agency with an annual budget of more than $8 billion, NSF works to advance scientific discovery, technological innovation and STEM education. During a plenary address at the 2021 Annual Meeting of the American Association for the Advancement of Science, Panchanathan laid out his vision for the future of the agency. In addition to diversifying the research community, his priorities include securing global leadership and capitalizing on bipartisan support for science at time of otherwise intense partisanship in U.S. politics.

"It is a bright future that is full of opportunities across the entire science and engineering enterprise, and AAAS is going to play an important part in making it happen," Panchanathan said. "2020 was a year of enormous disruptions, but conferences like this are critical. They are how we make new professional connections and share ideas, and we come away with new energy and enthusiasm for our work."

Panchanathan began his talk by pointing out the longstanding relationship between AAAS and NSF. At the 1948 AAAS Annual Meeting in Washington, D.C., President Harry Truman gave a speech in honor of the 100th anniversary of the scientific society's founding.

"We stand at the threshold of revolutionary developments," Truman said in his address. "Scientific research daily becomes more important to our agriculture, our industry and our health."

Truman's remarks strengthened support for the creation of NSF, which Congress established with the National Science Foundation Act of 1950. The themes he cited — promoting innovation, advancing public health and securing national defense — became

the central elements of NSF's mission.

"What am I sharing with you today is resonant with President Truman's statement in 1948," Panchanathan said. "We are on the threshold of revolutionary developments in science and engineering. And the scientific enterprise is critical to our national prosperity."

Finding the "missing millions," or "the gap between the demographics of the research community and the demographics of the whole nation," is paramount, Panchanathan said. The scientific community must rapidly double the number of women, more than double the number of African Americans, triple the number of Latino Americans and quadruple the number of Native Americans in STEM careers, he said. In all, this effort would amount to adding 4 million new voices to the U.S. research enterprise.

Ensuring that anyone who wants to go into a STEM field can do so will require building new pathways and strengthening those that already exist, Panchanathan said. NSF's Inclusive Graduate Education Network, Louis Stokes Alliances for Minority Participation and other inclusion-focused initiatives serve as a foundation to build on. Panchanathan also cited the AAAS SEA Change program, which supports colleges and universities as they work to increase diversity, equity and inclusion on their campuses.

"There are transformative insights, creative new ways of thinking and brilliant ideas that are being lost when people with the drive and capability to contribute to the STEM fields don't find their way to those opportunities," Panchanathan said. "We cannot make progress if we do not bring domestic talent out to its full force."

Panchanathan also highlighted that the current period of intense international competition — scientific and otherwise — offers the U.S. an opportunity to lead with its values of openness, transparency and integrity. Meanwhile, politicians across the political spectrum continue to value the scientific spirit and recognize the research community as a vital element of the nation's future.

To conclude his address, Panchanathan discussed the need for NSF to continue to benefit society by supporting both basic, foundational research and research aimed at specific outcomes. Modern smartphones, for instance, include NSF-funded innovations in fields including lithium-ion batteries, touchscreen interfaces and geographic information systems.

“It is the double helix of exploratory research in synergy with translational research: This is the DNA of NSF,” Panchanathan said. “It is how we are going to make transformational leaps forward in discovery and innovation.”

“I have talked about the long history of fundamental research that has brought us to this point today, where so much is possible,” he added. “AAAS has been there at every step since 1848 to contribute to the foundations of our knowledge and foster the community of discoverers and innovators. And as we look ahead to building on that foundation and achieving even more, I am thrilled that AAAS will be part of that work.”

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STEM EDUCATION FOR THE FUTURE

A VISIONING REPORT

EDUCATION FOR THE FUTURE

A VISIONING REPORT

MAY 2020

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Dr. Alexandra Medina-Borja (NSF EHR/DUE)

"All citizens can contribute to our nation's progress and vibrancy. To be prepared for the STEM careers of the future, all learners must have an equitable opportunity to acquire foundational STEM knowledge. The STEM Education of the Future brings together our advanced understanding of how people learn with modern technology to create more personalized learning experiences, to inspire learning, and to foster creativity from an early age. It will unleash and harness the curiosity of young people and adult learners across the United States, cultivating a culture of innovation and inquiry, and ensuring our nation remains the global leader in science and technology discovery and competitiveness."

A **VISION STATEMENT** FOR STEM EDUCATION OF THE FUTURE


STEM

PREFACE

Rapid technological advancements and societal changes are our daily reality. While the future of work, the economy, and society is uncertain, one thing is not: To maintain the nation's leadership in science and technology discovery, we must create an approach to science, technology, engineering, and math (STEM) education that prepares and advances the U.S. for this future.

Experts agree that science, technology, engineering and math will drive new innovations across disciplines, making use of computational power to accelerate discoveries and finding creative ways to work across disciplinary silos to solve big challenges. To remain competitive going forward, our nation must continue to design and build a thriving innovation economy, supported by a citizenry that is invested in the STEM enterprise. To succeed, the nation must invest in new research and innovation infrastructures that include all people, regardless of their background.

HOW DO WE ACHIEVE THIS VISION?

We instill creativity, innovation, and a passion for STEM from an early age, and we maintain that engagement and enthusiasm throughout their lives. Doing so will unleash an innovation culture, teaching learners of all ages to take risks, be creative, and problem-solve.

Today, we are far from this goal. Many Americans are entering the workforce without a basic grasp of STEM facts and approaches. Equally worrisome, amid the stagnant or dipping numbers of U.S.-born STEM workers, there is a critical lack of women, people with disabilities and African Americans, Hispanic Americans, and Native Americans who remain underrepresented in STEM. This underrepresentation is especially evident in several strategic areas critical for U.S. progress and security, including computer science, mathematics, and engineering.

We are in dire need of STEM role models and leaders for the future. By 2060,[1] Black and Hispanic youth will comprise nearly half of all U.S. school-age children. However, STEM faculty from these backgrounds are currently scarce, and trends among the number of domestic students who pursue advanced research degrees in STEM disciplines—particularly computer science, mathematics, and engineering—provide little hope for the necessary progress toward increasing diversity, inclusion, and equity of the STEM and STEM-education workforce.

This workforce representation gap is a threat, but it's also an opportunity for the American STEM education enterprise.

To maximize the opportunity, we must consider the entire education ecosystem so that children of all backgrounds, race, ethnicity, gender, religion and income levels can learn the wonders and possibilities of STEM and maintain that interest and passion throughout their lives.

Whether or not they become scientists or engineers, all Americans should have the access, opportunity, encouragement, and tools to participate in the innovation economy, and to succeed amid technological progress and change. Likewise, it is vital to ensure that the American workforce is upskilled to thrive in a future influenced and transformed by technology.

Achieving the goals of lifelong STEM learning, equitable access to sustained success, and a strong American workforce will require answering key questions, including but not limited to:

- How can we incentivize higher education institutions to implement necessary change toward these goals, including adopting practices we know work?
- How can technology be used as a pedagogical tool and be a democratizing force?
- What non-traditional pathways are students taking to acquire skills, competencies, and credentials? How do these new pathways challenge higher education as we know it?
- How do people best learn STEM concepts at different life stages? How do different contexts, including where people live, affect learning? And how do we optimize content delivery to improve outcomes?

With these questions in mind, and with the goal that all Americans can become partners in the innovation economy, the STEM Education of the Future Subcommittee embarked on a journey[2] to understand how others have answered similar questions, to better assess what is possible, and to set a clear path for making STEM Education of the Future the cornerstone of progress and prosperity for the nation.


STEM

PRIORITIES, CHALLENGES & ACTIONS

Before creating a vision for the STEM Education of the Future, it is vital to understand the present. What are the challenges we face in current STEM education? What is working, and where are we falling short? What are our priorities now, and how can we shape them to strengthen our future?

The Subcommittee explored current examples of innovation in STEM Education, gathered information from individual experts and students, and looked for inspiration from NSF's 10 Big Ideas for Future Investment and the NSB's Vision 2030. From this work, the Subcommittee identified three priorities for a STEM Education of the Future that will ensure learners understand and are prepared for 21st century STEM knowledge and STEM careers:

- **Priority One**
  All learners at all stages of their educational pathways must have access to and opportunities to choose STEM careers and contribute to the innovation economy.

- **Priority Two**
  We must build an ethical workforce with future-proof skills.

- **Priority Three**
  We must ensure that the appropriate technological innovations make it into learning spaces, whether face-to-face classrooms or not, guided by educators who understand how modern technology can affect learning, and how to use technology to enhance context and enrich learning experiences for students.

The STEM enterprise faces major challenges within each of these three priority areas. In this section, the Subcommittee identifies seven major challenges and provides action recommendations for how the STEM Education of the Future can address each of them.

PRIORITY I

All learners at all stages of their educational pathways must have access to and opportunities to choose STEM careers and contribute to the innovation economy.

CHALLENGE 1

Access to high-quality STEM education is uneven across the nation's geography and institutions.

- **Too often, learners' zip codes and income levels are the determining factor for the quality of their STEM education, and the future of the learner.**
- **Too many under-resourced rural and urban institutions struggle to provide high-quality STEM education.**
- **The high cost of higher education is a deterrent for many learners.**

CHALLENGE 1 | ACTIONS

Create opportunities for all students to receive an accessible and high-quality STEM education and help them foster a love and curiosity for science and mathematics from an early age.

- We must challenge our beliefs about the STEM education system and look for structural changes that make it both cost-accessible and sustainable.
- We must help citizens to pursue the STEMcareer of their choice through the mechanisms and paths that best suit them.
- We must train and incentivize STEM educators to provide learners with rewarding STEM experiences.
- Instruction should be informed by factors, context and challenges in both the local community and in the global state of affairs and STEM enterprise.
- Culturally relevant and context appropriate learning experiences, coupled with modern technologies, are particularly important in rural, underserved, or under-resourced communities where access to STEM experiences can be more limited.

CHALLENGE 2

The persistent and complex dynamics of bias in STEM.

- **Despite considerable progress, the STEM enterprise still suffers from biases, which create unwelcoming and hostile environments for underrepresented racial and ethnic groups, people with disabilities, women and other groups.**

CHALLENGE 2 | ACTIONS

More research is needed to determine the most effective access, equity, and inclusion interventions to promote change.

- We must increase the number of faculty role models from underrepresented groups in STEM classrooms, from pre-K to graduate school.
- We must mitigate historical and current stereotypes by increasing the numbers of high-achieving STEM professionals from underrepresented groups in industry, academia, and government and improving the visibility of these role models.
- It is crucial that today's students represent all dimensions of America's diverse society to facilitate equity and inclusion, because today's students will become tomorrow's STEM faculty, workforce and innovators.
- We must improve our understanding of the mechanisms by which bias, both implicit and explicit, and aggressions, both micro- and macro-, impact STEM student success from an early age, including the psychology and sociology of impostor syndrome and stereotype threat.[3] Additionally, we must actively strive to address these barriers to student success and promote student resilience.

CHALLENGE 3

The pathways to attain an undergraduate degree and/or the competencies required for a STEM job are changing. Some of these shifts have the potential to challenge common academic structures.

- **The population of learners is continuing to shift from full-time STEM students to working adult learners.**
- **Today's academic structure was designed with traditional students in mind and it is not optimal for the growing number of students who are starting their postsecondary education at an older age, or for the majority of undergraduate students who opt to start at community colleges instead of a four-year university.**
- **Skills that will be needed in the future are to be earned by all learners above and beyond traditional STEM content.**
- **In some areas of the economy, industry credentialing is disrupting existing education models by replacing the need for diplomas to more competency-based skills and credentialing.**

CHALLENGE 3 | ACTIONS

Regardless of their educational pathway, students need to acquire core 21st century competencies, including the ability to adapt and be flexible, to work collaboratively, learn independently, and be lifelong learners.

- STEM education must consider the new ways that companies seek to fulfill the STEM jobs of the future, and more clearly understand the implications of these changes on how learners need to prepare.
- We need to understand how foundational STEM concepts, computational thinking, and systems thinking are best learned.
- We must understand how to instill flexibility, creativity, teamwork, problem solving, and communication skills.
- We must examine the current academic structures and see if they best respond to the needs of current and future students.

CHALLENGE 4

STEM education must be adaptable to all phases of life and be tailored to the changing ways learners may process and engage information across their lifespan.

- **More adults will require re-tooling and upskilling to continue their participation in the workforce of the future.**

CHALLENGE 4 | ACTIONS

Educators need to understand how people learn from Pre-K through adulthood.

- We must gain greater knowledge about how factors beyond age influence learning, including the impact of local communities and learning environments.
- We need to understand how learners' self-actualization and cognitive abilities at each life stage affect learning.

CHALLENGE 5

A lack of diversity of thought and of human capital in U.S. STEM graduate programs hinders the nation's ability to maintain its position as a global leader in 21st Century innovation.

- **STEM research is still largely siloed, because graduate education and research do not always reward convergent or transdisciplinary approaches. However, evidence shows creativity and innovation in STEM require researchers to navigate across disciplinary boundaries and to take risks.**
- **Access to quality graduate education for all groups does not occur evenly across all STEM disciplines. Diversity exists in some fields at the graduate school level, but women, people with disabilities, and other groups are grossly underrepresented in others.[4] Most doctoral students in computer science and engineering are international students with temporary student visas, for example, and enrollment of American students in those programs has been static or declining.[5]**

CHALLENGE 5 | ACTIONS

Graduate education should enable students to acquire core 21st century research competencies, including the ability to be creative, to solve meaningful research problems, to work across disciplinary boundaries, and to collaborate with diverse teams.

- Some research problems can only be solved by transcending STEM boundaries across disciplines, and we must reward researchers who endeavor to tackle these tough problems by engaging across disciplines.
- To accelerate impactful discovery, we must understand the mechanisms and environments that groom successful researchers and innovators.
- Mentoring and education of graduate students, whether at the master's or doctoral level, should enable a positive and safe environment, which allows all students to explore different pathways and personalize their career outcomes.

There must be opportunities and incentives for domestic students to pursue research careers in areas of national strategic importance.

- Efforts to attract American youth to research careers in certain STEM fields are crucial. We must understand and address the factors (e.g., financial aid, academic preparation, and availability of appropriate mentorship) that deter undergraduate American students from pursuing master's and doctoral programs in strategic fields.
- Graduate education should create opportunities for students to receive an accessible and high-quality graduate STEM education and address systemic bias that reduce access for underrepresented groups

PRIORITY II

It is imperative to build an ethical workforce with future-proof skills.

CHALLENGE 1

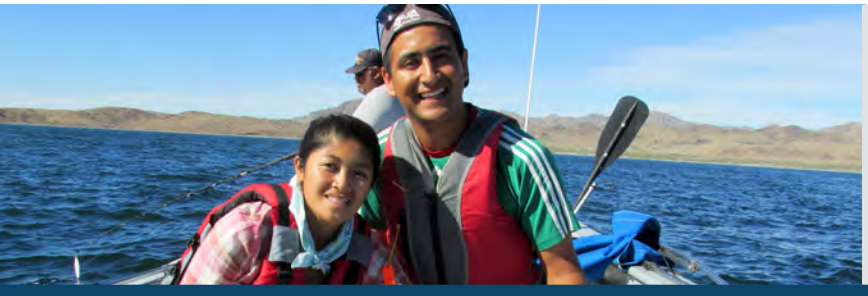
Advances in 21st century technologies present ethical issues and require new creative thinking.

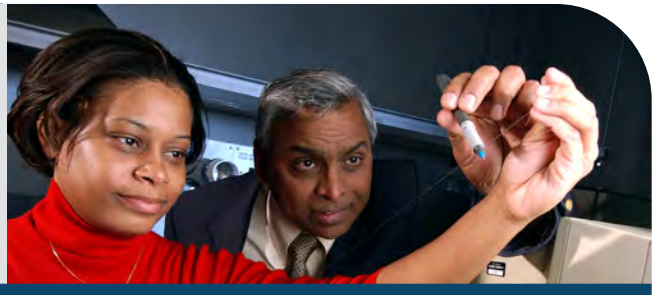
- **As technologies develop, STEM workers and researchers must be able to recognize both their potential benefits and technological threats to society.**
- **As workplaces become more automated, capabilities that include creativity and complex problem solving become more critical than manual skills or memorized content.**

CHALLENGE 1 | ACTIONS

STEM education must prepare our workforce to innovate and work with modern technologies, and also to consider their societal effects.

- It is critical to develop STEM learners' ability and willingness to acknowledge and resolve ethical issues in their work.
- The STEM education system needs to define what foundational knowledge all students need, as well as shift its emphasis from memorization of scientific facts, formulas, and definitions to understanding concepts in context and be ready to use available computational power to accomplish tasks.. This clearer definition and shift in emphasis will strengthen traits such as creativity and problem solving.





PRIORITY III

We must ensure that the appropriate technological innovations make it into learning spaces, whether face-to-face classrooms or not, guided by educators who understand how modern technology can affect learning, and how to use technology to enhance context and enrich learning experiences for students.

CHALLENGE 1

We need to understand how virtual distance learning environments affect cognition and learning.

- **Learners at all levels, including graduate students, are not always located in the same physical space, and this trend is only increasing.[6] Virtual and distance learning present new opportunities and new challenges.**

CHALLENGE 1 | ACTIONS

Research is needed to build a deeper understanding of the possibilities of virtual and hybrid distance learning environments, from how they affect the development of skills and abilities, to the pedagogies and curriculum that work best.

- Research priorities must include exploring how new educational technological infrastructures affect student outcomes, as well as their impact on structural factors such as cost, access to quality education, faculty retention, and growth of the STEM research enterprise.

- Research needs to accelerate development, testing, and understanding of technologies that facilitate and reward remote experiential learning, such as learning that traditionally happens in laboratories and field work.


STEM

3 LESSONS FOR THE FUTURE

FROM THE SUBCOMMITTEE'S INTERACTIONS WITH STEM EDUCATION INNOVATORS

As part of its work, the STEM Education of the Future Subcommittee interviewed innovators from educational institutions that have already adopted promising pedagogies. The Subcommittee examined those pedagogies that support a deeper exploration of STEM-related concepts in context, including those enabled by project-based inquiry for all students.

Institutions examined include:

- High Tech High
- Station[1]
- Minerva Schools
- Olin College of Engineering
- Harvey Mudd College
- Arizona State University
- Worcester Polytechnic Institute

Notably, these innovators, which span learning contexts from K-12 through graduate school, deploy surprisingly similar strategies that may be broadly implemented to improve STEM education.

LESSON 1

Learning environments are student-centered, project-based, and personalized.

These institutions have developed innovative instructional models that create learner-centered and project-based STEM learning environments. Students have opportunities to direct their own learning and demonstrate STEM knowledge by undertaking complex projects. Such practices are grounded in contemporary understanding of how people learn. They also use evidence-based teaching strategies, such as complex instruction,[7] inquiry-based learning,[8] and culturally responsive pedagogies.[9]

LEARNER-CENTERED

In this approach, the learner is at the center of all planning and actions. Learning environments intentionally build communities of practice between students and faculty, recognizing that learning is a social act that includes guidance and mentoring. The innovators the Subcommittee examined strive to create rewarding interactions that enhance learning for all. They mitigate the mindset that STEM disciplines are difficult and appropriate for only some to pursue. All groups, including women, low-income, first-generation, and other underserved student groups, enter learning environments that are culturally and linguistically relevant to them, and that are engaging and welcoming.

PROJECT-BASED

Project-based learning allows students to acquire knowledge and skills, to practice inquiry across multiple disciplines, and to make meaningful connections across STEM disciplines, medicine, the social and behavioral sciences, and the humanities. Project-based learning often focuses on real-world problems that can have significant social impact across society. A common thread among these innovators, from K-12 to graduate school, is the participation of their students in meaningful projects that require STEM concepts. This participation varied from projects in single courses to capstone projects that span the entire curriculum.

The innovators also changed their assessment and grading practices to align with this emphasis on project-based learning. As a result, learning becomes driven by students' motivation and their demonstrated capacity to learn, rather than mastery of specific STEM content alone, or by high-stakes examinations that determine course grades. From performance-based assessments with rubrics that help students develop competencies over time, to evaluations based on portfolios of student work, the innovators offer many opportunities for students to complete complex, technology-based projects with a variety of approaches to evaluations and grades.

PERSONALIZED

The innovators strongly feature self-directed learning. At some of these institutions, students start with a project of personal interest and decide how to acquire the knowledge needed to solve the problem, whether enrolling in classes, seeking mentoring, or accessing information through other means. Several innovators have eliminated practices that sort students into groups based on background or prior knowledge. Differences in foundational knowledge are instead mitigated individually through faculty mentoring or other strategies, allowing students to engage in self-directed learning based on individual preferences and pacing in a personalized way.

LESSON II

Equity and inclusion are foundational principles.

These innovators share a conviction that they are responsible for enabling all learners to succeed. The goal of their institutions, from administrators to faculty and staff, is to make each student feel welcomed and a part of the community. Equity and inclusion are embedded in the entire educational process.

EQUITY

These innovators have focused on models designed to enable all learners to build competencies over time, rather than more traditional models that seek to "weed out the weak." As a result, learners are finding unprecedented success as measured by meaningful metrics, such as the percentage of students who attend college, succeed in college, graduate from college, enter professional or technical jobs, or attend graduate school.

INCLUSION

The Subcommittee also examined issues of inclusion within these innovators' institutions. It spoke with scholars who study bias and examined how stereotypes can threaten students' performance, regardless of intellectual capacity (i.e. stereotype threat). Additionally, STEM students from underrepresented groups shared eye-opening testimony about their experiences in highly competitive and ground-breaking STEM programs. From these conversations,[10] it is evident that simply adopting pedagogical innovations won't ensure equitable participation in STEM.

Instead, institutions must address two important threats:

1. Unwelcoming, non-inclusive institutional environments created by administrators, faculty, and non-marginalized students that expect underrepresented students to fail.

2. The negative self-evaluation that marginalized students unconsciously make of themselves affecting cognitive performance (stereotype threat) and social and behavioral well-being (impostor syndrome) regardless of intellectual capacity.

In sum, increasing diversity and broadening participation in STEM cannot be viewed or addressed as an independent problem; instead, creating greater diversity and participation should be designed into the educational ecosystem. Every learning environment, tool, classroom, syllabus, instructor, and intervention must consider, from the beginning, how to serve all students. Only then will learners of all ages and backgrounds have equitable opportunities to participate in the STEM enterprise.

LESSON III

Technology holds promise for creating equitable learning environments, but it also alters the skills we need in the future, and changes what and how we teach.

The promise of modern technology to facilitate how people learn STEM and change inequalities in the education enterprise is captured by Fullan and Langorthy[11] in the following quote:

> *"...digital access makes it possible for students to apply their solutions to real-world problems with authentic audiences well beyond the boundaries of their schools. This is the real potential of technology to affect learning – not to facilitate the delivery and consumption of knowledge, but to enable students to use their knowledge in the world."*

The potential of technology to promote access, equity, and inclusion is inspiring. Members of the Subcommittee sought to understand trends, learning tools, and environments that technology might offer today and in the future. It explored where high-tech companies think artificial intelligence and automation will go, and the competencies and skills that learners will need over the next decades.

In particular, the promise of technology was explored in two arenas:

1. Preparing learners of all ages to work actively with technology and other contemporary tools of science and mathematics, as technology will continuously change the nature of work and STEM.
2. Technology's promise to provide tools to improve research, teaching, and learning.

In spite of its considerable promise, technology also poses challenges and threats. Educators, learners, and researchers must examine the biological, psychological, societal, and ethical implications of technological advances. New theories and models of cognition and learning are needed to fully harness technology's benefits to humankind. Where once the outsourcing of jobs to computers was a major threat, now it is a given that everyone must be able to fully leverage the computational power offered by new technologies. At the same time, we must be discerning about how technologies, particularly

those applied in computational and data intensive endeavors, influence how we engage with the world and with each other. Technology can also inadvertently exacerbate the digital equity gap that continues to exist in under-resourced communities throughout the U.S.[12, 13]

In the future, there will be a demand for humans to do work that machines cannot do or cannot do as well as humans can. Being able to think critically, reason probabilistically, and exercise logical, discerning judgement will be some of the most important human competencies. We must cultivate these qualities in young people and "re-tool" adult learners to master them as well. How we harness cognitive and emotional mechanisms to infuse an attitude of self-motivation and self-actualization, in young people and adults, will be the key to our ability to adapt to the new jobs of the future.

A VISION FOR STEM EDUCATION OF THE FUTURE

Through an examination of STEM innovators and the current education landscape, together with an assessment of future challenges and opportunities, the Subcommittee has worked to identify the principles and priorities that must define a STEM Education of the Future. Rather than provide detailed and specific recommendations, the Subcommittee has outlined these important 21st century considerations for the NSF community to weigh in shaping forward-looking strategies. The Subcommittee concludes that research, policies, and practices that elevate these essential qualities will ensure a strong STEM Education of the Future—one that allows all Americans to participate in a vital human endeavor, and ensures that our nation will remain a global leader and innovator.

The STEM Education of the Future will harness technology in ways that provide equitable access to all learners and ensure that all learners thrive. Skillful instruction aided by technological advances can overcome structural barriers such as cost, distance, opportunity, socioeconomic background, or prior STEM preparation, and allow all STEM learners to overcome stereotypes and biases with the support of their learning communities.

Well-prepared educators and mentors will use evidence-based methods, pedagogies and technologies that are informed by research on how people learn in different contexts and across their lifespans. Wherever appropriate, all new technologies, including those powered by artificial intelligence, will be used in formal and informal settings in tailored ways to ensure learners acquire competencies and STEM knowledge.

In this equitable, learner-centered environment, all learning pathways will be aligned to learners' interests and include proven, experiential activities in both physical and digital ways (for example, virtual labs and online classes). Connections to relevant, real-life problems, including those in students' communities, will be what drive STEM learning. Teachers will focus on providing knowledge and experiences, such as problem solving, ethics, and decision making, that will be needed in future work contexts and jobs. These connections to real experiences will demonstrate the tangible benefits of STEM education and empower learners to own their education and become the agents of their own futures.

The STEM Education of the Future will enable learners to participate effectively in the STEM enterprise of today, and tomorrow. In a future where STEM knowledge and technology rapidly evolve, STEM learning will not merely be about mastering a stable knowledge base. Instead, learners must be skilled at lifelong learning and adapt with ease to the changing world. From reflection to metacognition to thinking in convergent, dynamic, and computational ways about complex problems, lifelong learners will need to adapt to tomorrow's challenges, and contribute to the nation's health, safety, and success in the future.

A VISION ALIGNED WITH THE NSB & NSF

BOLD | VISIONARY | PROACTIVE | URGENT | NIMBLE

The watchwords bold, visionary, proactive, urgent, and nimble are the common threads that run through the Subcommittee's vision for the STEM Education of the Future. They also fit the NSF's 10 Big Ideas for Future Investment and the National Science Board's priorities, being united in a sense of urgency for creating a STEM-educated workforce that is not merely aware of STEM concepts and principles from an early age but is also creative and innovative.

It is imperative that the Directorate for Education and Human Resources (EHR) and the agency think boldly, nimbly, and for the long term. The Subcommittee emphasizes that the nation must be proactive and nimble in addressing the urgent challenges of today and those in the years ahead.

THE NATIONAL SCIENCE BOARD'S VISION 2030

As the NSB points out in Vision 2030, the increased globalization of science and engineering research presents both an opportunity and a pressing concern. There is an enormous need to grow a domestic STEM workforce in an era when science and technology permeate the economy. Current trends and demographic shifts in our national science and engineering indicators are not promising: Our nation's youth lack interest in research STEM careers, and progress is slow in reversing dangerous trends in low numbers of women, people with disabilities, and other underrepresented groups in the innovation ecosystem.

In other words, the U.S. is at risk of surrendering its global leadership in technological innovation. Urgent actions and long-term investments are needed in STEM Education and Workforce Development Research to establish an educational infrastructure that is modern and attracts, retains, and develops the diverse STEM talent that the United States needs for the future.

NSF'S 10 BIG IDEAS

NSF's initiative to define the cutting-edge research agendas and processes that will push forward the frontiers of U.S. research and provide innovative approaches to solving some of the most pressing problems the world faces, as well as lead to discoveries not yet known, is known as The 10 Big Ideas. These capitalize on NSF's investment in fundamental STEM research, which is the basis for discovery, invention, and innovation, and ensures that future generations can reap their benefits. This STEM Education of the Future document builds on many of the concepts present in the Big Ideas.

EHR'S STEM EDUCATION OF THE FUTURE

Development of talent to reach these goals is of utmost importance for the NSB, NSF, and EHR — for the next decade and beyond.This ambitious visioning document points the way forward, through funding STEM education innovations **from pre-K through post-doctoral experiences:**

- It aligns with NSF's 10 Big Ideas for Future Investment, in recognizing the need for convergent-, computational-, systems-, and critical-thinking for the future STEM enterprise.
- It aligns with NSF's 10 Big Ideas in its call for equity and inclusion of all learners in the STEM enterprise (NSF INCLUDES),[14] and its focus on the importance of the convergence of disciplinary knowledge, tools, methods, and approaches (Growing Convergence Research).[15]
- Further, it echoes The Future of Work at the Human-Technology Frontier[16] and the Harnessing the Data Revolution[17] Big Ideas in its call for the use of technology and data to shape learning environments and pedagogies for learners of all ages.
- In sum, the STEM Education of the Future aligns with the Big Ideas' emphasis on the importance of providing learners across their lifespan with the opportunity to develop competencies and knowledge.

In conclusion, STEM Education of the Future, NSB's Vision 2030, and NSF's 10 Big Ideas are aligned in their bold, visionary, proactive, and urgent calls to make the changes needed to STEM education today, so that the United States can remain the global technological and innovation leader of tomorrow.

FOOTNOTES

PAGE 8 [1] William Frey, "The US Will Become 'Minority White' in 2045, Census Projects: Youthful minorities are the engine of future growth," (Washington, D.C.: Brookings Institution, The Avenue, 2018)

PAGE 9 [2] Note: The subcommittee started this work in the Spring of 2018. At the time of this report's approval in the Spring of 2020, the world and the Nation are facing an unprecedented health, social, and economic emergency with the SARS-CoV-2 pandemic, which is dramatically impacting all realms of life. The unprecedented move by the majority of educational institutions to online learning to comply with social distancing measures is shaking all educational structures as we know them. This new reality is revealing both the fragility and the resilience of institutions, and putting enormous pressures on faculty, researchers, administrators, and students. A discussion about issues of access, technology, pedagogy, and appropriate faculty training in a future STEM education ecosystem where things will never be the same is now more relevant. Thus, this unsettling new reality has made the contents of this report even more pertinent and urgent than before.

PAGE 14 [3] Stereotype threat is the unconscious decrease in performance of people for which a societal stereotype predicts they are less capable. For example, women underperform on math tests in situations in which they are consciously or unconsciously made aware of their gender.

PAGE 16 [4] https://www.nsf.gov/statistics/2018/nsb20181/report/sections/higher-education-in-science-and-engineering/graduate-education-enrollment-and-degrees-in-the-united-states

PAGE 16 [5] Note: As we improve graduate education, we must continue to recognize the benefits of international experiences for students and continue to attract the best and brightest foreign-born scientists. Foreign scientists, international exchanges and collaborations are critically important in the progress of the American scientific enterprise.

PAGE 19 [6] As of March 2020, the public health-related social and physical distancing measures implemented in the wake of the SARS-CoV-2 pandemic have brought to light significant vulnerabilities in the American education system. American students and educational institutions have had to improvise, enhance, and develop remote learning plans across the country and for all ages.

PAGE 22 [7] Complex Instruction is an approach to small groupwork that promotes equitable interactions and learning, particularly effective in classroom settings where students bring multiple abilities and a range of community/cultural diversity.

PAGE 22 [8] Inquiry-based learning uses different evidence-based pedagogies to engage students by building knowledge through exploration, experience, and discussion. Instead of memorizing facts and material, students learn by doing.

PAGE 22 [9] Culturally responsive pedagogy is a learner-centered approach to teaching that nurtures the learners' unique cultural strengths to promote achievement and a sense of belonging and well-being about the student's cultural place in the world.

PAGE 23 [10] The subcommittee thanks Dr. Claude Steele, Stanford University for an open dialog about stereotype threat, Dr. Maria Klawe, President of Harvey Mudd College for an honest appreciation of leadership challenges of inclusion policies and Mr. Antonio Perez, an engineering junior at Olin College of Engineering for sharing his experience as an underrepresented student in a highly innovative STEM program.

PAGE 24 [11] Fullan, M. & Langworthy, M. (2014) A Rich Seam: How New Pedagogies Find Deep Learning, London: Pearson.

PAGE 25 [12] Moore, R; Vitale, D.; Stainoga, N. (2018), The Digital Divide and Educational Equity, ACT Research & Center for Equity in Learning, August Access online: https://www.act.org/content/dam/act/unsecured/documents/R1698-digital-divide-2018-08.pdf

PAGE 25 [13] Lee, Nicol Turner (2020) What the coronavirus reveals about the digital divide between schools and communities, Brookings Institute, March. https://www.brookings.edu/blog/techtank/2020/03/17/what-the-coronavirus-reveals-about-the-digital-divide-between-schools-and-communities/

PAGE 29 [14] https://www.nsf.gov/news/special_reports/big_ideas/includes.jsp

PAGE 29 [15] https://www.nsf.gov/news/special_reports/big_ideas/convergent.jsp

PAGE 29 [16] https://www.nsf.gov/news/special_reports/big_ideas/human_tech.jsp

PAGE 29 [17] https://www.nsf.gov/news/special_reports/big_ideas/harnessing.jsp

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