# GAME CHANGERS: ARTIFICIAL INTELLIGENCE PART II, ARTIFICIAL INTELLIGENCE AND THE FEDERAL GOVERNMENT

## HEARING

BEFORE THE

SUBCOMMITTEE ON
INFORMATION TECHNOLOGY

OF THE

COMMITTEE ON OVERSIGHT
AND GOVERNMENT REFORM
HOUSE OF REPRESENTATIVES

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# GAME CHANGERS: ARTIFICIAL INTELLIGENCE PART II, ARTIFICIAL INTELLIGENCE AND THE FEDERAL GOVERNMENT

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**Wednesday, March 7, 2018**

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON INFORMATION TECHNOLOGY,
COMMITTEE ON OVERSIGHT AND GOVERNMENT REFORM,
*Washington, D.C.*

The subcommittee met, pursuant to call, at 2:03 p.m., in Room 2154, Rayburn House Office Building, Hon. Will Hurd [chairman of the subcommittee] presiding.

Present: Representatives Hurd, Mitchell, Amash, Farenthold, Kelly, Lynch, Connolly, and Krishnamoorthi.

Mr. HURD. The Subcommittee on Information Technology will come to order. And without objection, the chair is authorized to declare a recess at any time.

Good afternoon. Welcome to the Oversight and Government Reform hearing on artificial intelligence. This is the second hearing in a series of hearings on artificial intelligence, and this series is an opportunity for the subcommittee to take a deep dive into this issue.

I have three main objectives when it comes to AI in government. First, it should make every interaction an individual has with the Federal Government take less time, cost less money, and be more secure. I have wonderful caseworkers on staff who spend their time working to help constituents receive their veterans' benefits or to help with Social Security. They are speaking every day with people who are frustrated with how long it takes to resolve problems in the Federal Government. I believe with the adoption of AI, we can improve the response time and, in some cases, prevent these problems in the first place.

Second, AI should produce efficiencies and cost savings that will help us do more for less money and help to provide better, more transparent citizen-facing services. This should help to restore the bonds of trust between citizens and their governments. We have innovative companies, brilliant minds, hardworking people, and the rule of law. So we, the United States, should lead on AI, and the Federal Government needs to be an active participant. Whether it is through basic and applied research and development that DARPA, NSF, and DHS are doing, or GSA's work on procurement, the AI within the government needs to benefit those whom the government serves.

I thank the witnesses for being here today, and I look forward to the hearing and learning from all of you. And I will be honest, at the beginning of this endeavor I was prepared to see not much use of AI throughout the Federal Government, and I think our panelists here today are going to show how we are doing some very interesting things in the government.

Mr. HURD. And, as always, it is an honor to explore these very important issues in a bipartisan fashion with my friend and ranking member, the one and only Robin Kelly from Illinois.

Ms. KELLY. Thank you, Mr. Chairman.

Mr. Chairman, thank you for calling today's important hearing on Federal agencies' adoption of artificial intelligence, or AI. This is the second hearing in a three-part series of hearings on AI. Today's hearing focuses on the Federal Government's adoption of this technology.

AI has the potential to make government more efficient and decrease costs across agencies. To fully realize the benefits of AI, the U.S. must maintain its leadership role in promoting technological innovation, yet preserving the United States' leadership role in technologies like AI will require robust Federal funding for research and development.

But at our first hearing on AI, Intel's chief technology officer for AI warned us that, quote, "Current Federal funding levels are not keeping pace with the rest of the industrialized world." In fact, President Trump's proposed budget for fiscal year 2019 cuts or flattens nonmilitary agency budgets for R&D.

[Slide.]

Ms. KELLY. As you can see on the screens, the trend is so clear that the National Science Board and the National Science Foundation believe that China will surpass the United States in R&D investments by the end of this year. The chart displayed demonstrates China's rapidly growing investment and the U.S. ceding its position as a leader in AI.

The future of U.S. innovation is at stake. This should be a cause of concern for everyone. Outside of the Department of Defense, the President's budget proposes an overall cut to research and development of 21.2 percent. Consider, for example, the National Science Foundation whose investments in R&D have led to innovations that improve our everyday life. From Google to Lasik eye surgery to cloud computing all can be traced to NSF investments in technology.

[Slide.]

Ms. KELLY. This chart shows President Trump's precipitous drop in nondefense R&D spending. In an agency like the National Science Foundation which supports basic research in colleges and universities and in the private sector, this budget represented almost a 29 percent decrease from the agency's actual spending levels in 2017. These budget cuts take the United States in the wrong direction.

Another troubling trend for the U.S. is that we are not making the critical investments today to educate the workforce we need to sustain these industries of the future.

[Slide.]

Ms. KELLY. The displayed chart shows a number of science and engineering undergraduates in China compared to the United States. As you can see, we are not keeping pace with China, which is displayed in red.

Yet another troubling factor is this administration's hostility to immigrants. Until recently, the U.S. was able to attract Ph.D. students from other countries to help supplement the domestic workforce. The New York Times reported last year that not only is Google opening AI innovation hubs in Canada because of concerns with American immigration policies but that the U.S. has already turned away promising people in the AI field. Unfortunately, this administration's science, immigration, and education policies are all working together to reduce the U.S. lead in AI technologies. I hope today we can discuss the policies and funding necessary to ensure we remain competitive in this area.

Again, I thank you, Mr. Chairman, for having this hearing.

Mr. HURD. Thank you.

And I am pleased now to introduce our witnesses. Our first is Dr. John Everett. He is the deputy director of the Information Innovation Office for DARPA. Mr. Keith Nakasone, he is the deputy assistant commissioner for the Office of Information Technology Category for the Federal Acquisitions Service at GSA. Say that three times fast. Dr. James Kurose is the assistant director for Computer and Information Science and Engineering at National Science Foundation. It is always a pleasure to have you here, sir. And last but not least, Dr. Douglas Maughan is the division director of the Cybersecurity Division in the Homeland Security Advanced Research Project Agency at DHS.

Welcome to you all. And pursuant to committee rules, all witnesses will be sworn in before you testify, so please rise and raise your right hand.

[Witnesses sworn.]

Mr. HURD. Thank you. Please let the record reflect that all witnesses answered in the affirmative.

In order to allow time for discussion, please limit your testimony to five minutes. Your entire written statement will be made part of the record. And as a reminder, the clock in front of you shows the remaining time you have. It is going to turn yellow when you have 30 seconds left, and when it flashes red, that means your time is up. And also remember to press the button to turn your microphone on before speaking.

Now, I would like to recognize Dr. Everett for your five minutes of opening remarks.

## WITNESS STATEMENTS

### STATEMENT OF JOHN O. EVERETT

Mr. EVERETT. Good afternoon, Chairman Hurd, Ranking Member Kelly, and distinguished members of the committee. I appreciate the invitation to give testimony on the state of AI research today. My name is John Everett, and I'm the deputy director of the Information Innovation Office at the Defense Advanced Research Projects Agency, DARPA.

DARPA's mission is to create and prevent technological surprise. We do so by funding research programs, each with a specific goal to advance the state of the art in a particular area. This strategy has served the country well by leveraging academia and industry R&D labs to develop the enabling technologies for new defense capabilities and to plant the seeds for new industries such as the internet and self-driving cars.

Since the 1960s, we have funded more than 50 programs in AI. AI technologies have developed in two waves. The first wave focused on abstract logic and reasoning tools that require explicit representations of knowledge in the form of handcrafted rules. The second wave, machine learning, uses algorithms to extract implicit representations of knowledge from large amounts of data.

The first wave started in the 1950s and explored many hard problems in reasoning, understanding natural language, and robotics. It produced many algorithms that are in common use today such as planning and scheduling systems.

Researchers quickly discovered the importance of world knowledge in solving problems and created expert systems that use rules to represent knowledge about a particular subject area such as diagnosing infectious diseases. An early DARPA-funded expert system rivaled human performance in this area. However, as we all know, for every rule, there's an exception, and the work necessary to capture sufficient knowledge proved impractical in many cases.

The second wave started in the 1990s in reaction to the difficulty of capturing world knowledge by writing it down. The most successful form of machine learning today is called the neural network because it is inspired by the structure of the human brain. Machine learning uses large amounts of data to train an algorithm to do a specific task such as recognize speech, drive a car, or search for pictures of, say, people playing frisbee on a beach. However, these algorithms cannot explain their conclusions, which makes them hard to trust. Also, researchers have shown that sometimes imperceptible changes to an input image, say, of a panda, can cause the algorithm to confidently misclassify it as a monkey.

Nonetheless, the second wave of AI has yet to crest, and researchers will continue to improve the technology and develop interesting and innovative applications. We believe that the next wave of AI will combine insights from the first and second waves to produce systems that are aware of context so they can interact more effectively with people. This will require major advances in commonsense reasoning and natural language processing.

Context in—is the shared understanding that people have with each other and enables highly concise communication through speech, intonation, facial expressions, and gestures. Such communication is extremely difficult for current algorithms to understand, making this an ideal area for DARPA research. Thank you.

Mr. HURD. Thank you, sir.

Mr. Nakasone, you are now recognized for five minutes.

## STATEMENT OF KEITH NAKASONE

Mr. NAKASONE. Good afternoon, Chairman Hurd, Ranking Member Kelly, and members of the subcommittee. Thank you for the opportunity to appear before you today. My name is Keith Nakasone,

and I am the deputy assistant commissioner for acquisition operations in the Office of Information Technology Category at GSA. I've been a participant in the growth of emerging technologies in government over the past 20 years, including during my years at the Defense Department.

Mr. Chairman, at the first hearing in this series you stated that it was your hope agencies would use today's discussion to inform Congress how we plan to use artificial intelligence to spend taxpayer dollars wisely and make each individual's interactions with government more efficient, effective, and secure.

I would like to discuss four ways in which our agency is supporting government AI evaluation and adoption to accomplish that. First, our Federal Acquisition Service provides contracting vehicles and mechanisms, including Schedule 70, as well as several other governmentwide acquisition contracts, which encourage competition and help connect agencies and businesses to allow government to efficiently procure the most effective new AI services and capabilities. GSA's IT Schedule 70 contracts provides Federal, State, local, and tribal government agencies with access to over 7.5 million best-value IT and telecommunications products, services, and solutions for more than 4,600 pre-vetted vendors, including firms whose offerings use AI and similar technologies.

Since emerging technology businesses frequently tend to be startups, Schedule 70 offers two shortcuts, Startup Springboard, and FastLane, as part of the Making It Easier initiative, which aims to streamline the process for younger innovative companies and suppliers to do business with government.

Second, GSA is piloting robotic process automation and related technologies designed to augment our workforce and achieve more with less while establishing a foundation for greater data-driven decision-making through AI.

GSA has developed a new pilot using AI for prediction of regulatory compliance, the solicitation review tool uses natural language processing, text mining, and machine learning algorithms to substantially alleviate the human resources needed to identify, audit, and enforce compliance of solicitations posted on FBO.gov.

Further, GSA recently launched two pilots exploring the use of robotic process automation and distributed ledger technology, foundational technologies that can open our programs to better decision-making through AI. These pilots aim to increase GSA's operational efficiency, reduce costs, improve processes, increase accuracy, and redeploy staff to higher-value functions.

Third, our interagency Emerging Citizens Technology Office unites more than 2,000 government managers from over 300 Federal, State, and local agencies and representatives from businesses, startups, and research and civic organizations to support and coordinate governmentwide development of citizen-facing AI and other emerging technology programs, including through resources at Emerging.Digital.gov. Recent initiatives include the launch of an interagency venture capital advisory group and a new education and training pilot.

Fourth, along with our private sector and Federal agency partners, we are pursuing a greater understanding alignment of ID modernization through cloud adoption, data services, and emerging

technologies, including AI, that deliver the greatest benefit to the American people. For instance, through Data.gov and ECTO, we are learning how to improve the standardization and accessibility of government open data to help fuel innovation. We have solicited input from industry partners on how to improve data hosting so data sets are more easily digestible for AI and machine learning.

GSA is essentially a shared service, and we are constantly seeking ways to develop government faster, better, and smarter. AI is a tool that can expand the value proposition for Federal agencies, vendors, and the American people alike.

Thank you again for the opportunity to testify. I look forward to your questions.

[Prepared statement of Mr. Nakasone follows:]

**Statement of Keith Nakasone**
**Deputy Assistant Commissioner, Acquisition Operations, Office of Information Technology Category (ITC), U.S. General Services Administration**
**Before the Subcommittee on Information Technology**
**of the Committee on Oversight and Government Reform**
**Wednesday, March 7, 2018 at 2:00 p.m.**
**2154 Rayburn House Office Building**

**Game Changers: Artificial Intelligence Part II; Artificial Intelligence and the Federal Government**

Chairman Hurd, Ranking Member Kelly, and members of the subcommittee, thank you for the opportunity to appear before you today. My name is Keith Nakasone, and I am the Deputy Assistant Commissioner for Acquisition Operations in the Office of Information Technology Category (ITC) at the U.S. General Services Administration (GSA). I have previously served in various roles at the Defense Information Systems Agency (DISA) and the Defense Information Technology Contracting Organization-Pacific (DITCO-PAC), so I have seen the growth of emerging technologies in government over the past twenty years.

Mr. Chairman, at the first hearing in this series, you stated that it was your hope agencies would use today's discussion to inform Congress how we plan to "use AI [Artificial Intelligence] to spend taxpayer dollars wisely and make each individual's interactions with the government more efficient, effective, and secure." I am pleased to be here today to tell you how GSA is doing just that, and how it plans to continue doing so.

GSA is proud of the innovative and cross-cutting work our team is undertaking to bring artificial intelligence to bear in the work we do, as well as the considerable effort we have engaged in to share best practices and use cases among partner agencies.

In its most recent strategic plan, the U. S. Government Accountability Office (GAO) identified AI as one of the "five emerging technologies [that] will potentially transform society." What we have seen from our unique government-wide perch at GSA is that agencies are tremendously interested in AI and other emerging technologies - not because they are the latest fad, but because people recognize the potential to transform and simplify the way Americans interact with their government.

The modernization of the Federal government's IT infrastructure and applications including emerging technologies such as Artificial Intelligence is an important priority for GSA. We are supporting government AI evaluation and adoption in four ways that I will introduce here and discuss further in my testimony.

1. First, our Federal Acquisition Service (FAS) provides contracting vehicles and mechanisms including Schedule 70 and its associated programs, Startup Springboard and FAStlane, as well as several other government-wide acquisition contracts, which encourage competition and help connect agencies and businesses to allow government to efficiently procure the most effective new AI services.

2. Second, we are piloting within our agency Robotic Process Automation (RPA) and other related technologies that are designed to augment our workforce to achieve more with

less and establish a foundation for greater data-driven decision-making through AI.

3. Third, through the interagency Emerging Citizen Technology Office (ECTO), we are helping support and coordinate government-wide development of citizen-facing AI programs, both public-facing as well as for internal agency use, with active participation from both the public and private sectors.

4. Fourth, along with our private sector and federal agency partners, we are pursuing a greater understanding and alignment of IT modernization through cloud adoption, data services, and emerging technologies, including AI, that deliver the greatest benefit to the American people.

**The Business of Artificial Intelligence Acquisitions in Government**

Innovative companies across the country are using emerging technologies such as AI to build faster, smarter, and better products and services. GSA's IT Schedule 70 contracts provide Federal, state, local, and tribal government agencies with access to over 7.5 million best-value IT and telecommunications products, services, and solutions from more than 4,600 pre-vetted vendors, including firms whose offerings use AI and similar technologies.

Since emerging technology businesses frequently tend to be startups or newer businesses, Schedule 70 offers two shortcuts - the FAStlane and Startup Springboard programs - as part of the Making It Easier (MIE) initiative, whose goal is to streamline the process for younger, innovative companies and suppliers to do business with government. This is a particular priority for GSA's recently confirmed Administrator, Emily Murphy, who has a lengthy history of working with and helping small businesses, including as a staffer on the House Small Business Committee and as the Associate Administrator for Government Contracting at the U.S. Small Business Administration.

The FASt Lane program ensures Federal agencies have quicker access to emerging technologies and innovative AI suppliers. With FAStlane, suppliers get shorter processing times for IT Schedule 70 contract actions that directly support federal customer agency requirements, including 48-hour turnaround for contract modifications and turnaround in as quick as 45 days for new contract offers. Examples of AI are included in the Earth Observation SIN 132-41 with machine learning and algorithms that can be applied to globally scaled data, and the Cloud SIN 132-40 among others.

With Startup Springboard, AI vendors can now use their executives' and key professionals' experience to substitute for two years of corporate experience. Startup Springboard has one primary objective: helping Federal agencies quickly gain access to the latest innovative technologies from fresh, vibrant private sector firms. Schedule 70 is the government's largest IT contract vehicle, and provides a pathway for qualified innovative companies to partake in the $15 billion federal, state, and local IT contracting market.

Beyond Schedule 70, a variety of emerging technology offerings, including those employing AI, are available under several other GSA acquisition vehicles:

- The Enterprise Infrastructure Solutions (EIS), a $50 billion information technology telecommunications vehicle and infrastructure solution, which is consolidating 93 separate contracts into a single contract with a 15-year period of performance.

- The Alliant/Alliant Small Business Governmentwide Acquisition Contracts (GWAC) provide flexible access to customized IT solutions for a large, diverse pool of industry partners.
- The VETS 2 (SDVOSB) Governmentwide Acquisition Contract (GWAC) was awarded Best-in-Class on October 26, 2017.
- The 8(a) STARS II Governmentwide Acquisition Contract (GWAC) is a small business set-aside that provides access to customized IT solutions from a large, diverse pool of 8(a) industry partners.

**Robotic Process Automation and Data-Driven Decisionmaking**

We are not only helping Federal agencies and businesses advance AI capabilities; our agency is bringing these best practices home to our own programs in order to provide the most effective and efficient services for our customers.

GSA's Office of Government-wide Policy (OGP) has developed a new pilot using AI for Prediction of Regulatory Compliance, known as the Solicitation Review Tool (SRT). The SRT AI platform uses natural language processing, text mining, and machine learning algorithms to automatically predict whether federal solicitations posted on fbo.gov are compliant with Section 508 of the Rehabilitation Act and alert responsible parties of non-compliance so that corrective actions could be taken. Through independent review, the predictions have an accuracy rate of 95 percent. This innovation substantially alleviates the human resources needed to identify, audit, and enforce compliance.

The SRT platform is innovative because it helps GSA focus the limited resources available on the non-compliant solicitations identified and alert contracting staff to make the changes for compliance. The SRT tool is currently slated to go into production in cloud.gov in the spring of 2018. Future plans for the SRT AI platform include a scope expansion to predict whether solicitations contain other federal regulatory requirements such as cybersecurity or sustainability.

Furthermore, GSA launched two pilots in fiscal year 2018 exploring the use of Robotic Process Automation (RPA) and Distributed Ledger Technology (DLT), foundational technologies that can open our programs to better decision making through AI.

These pilots, in both our Office of the Chief Financial Officer (OCFO) and FAS, aim to:

- Increase GSA's operational efficiency;
- Reduce cost;
- Improve processes;
- Increase accuracy; and
- Redeploy staff to higher-value functions.

GSA has established an inter-office RPA team, including OCFO, FAS, ECTO, and the Public Building Service, to provide governance of emerging technologies, including managing a common infrastructure and technical approach and helping business offices address process selection, prioritization, and implementation.

We look forward to continuing to share outcomes from these programs with our stakeholders and partners as they develop.

**Emerging Citizen Technology Office Government-wide Services**

GSA's interagency ECTO unites more than 2,000 government managers from over 300 federal, state, and local agencies, and representatives from industry technology startups, small businesses, and leading research and civic organizations to develop government-wide IT modernization initiatives through the evaluation and strategic management of emerging technologies including AI, Robotic Process Automation, Blockchain, and Virtual and Augmented Reality. Our participants grow by at least six federal managers per day on average, underscoring the demand for more guidance and support for federal emerging technology programs.

Our AI program alone includes participation from 89 government agencies and growing, as well as a public-facing listserv to share updates and opportunities. This community includes experts from our military, civilian defense, and intelligence community. By sharing openly with private-sector innovators, startups, and new entrants in the field, U.S. businesses gain increased transparency into the modernization of federal information technology programs.

ECTO collaborates with experts on all aspects of appropriate use of AI including the Federal Privacy Council and the U.S. Data Cabinet, and serves on the U.S. National Science and Technology Council's Subcommittee on Machine Learning and Artificial Intelligence.

ECTO also creates new opportunities for participation in our programs through mentorship in the Dcode emerging technology accelerator and U.S. Department of State's Boldline public-private partnership accelerator.

We host an open source repository of potential use cases, programs, and resources for AI in the Federal government at Emerging.Digital.gov in the form of the Emerging Citizen Technology Atlas. This includes publicly reporting the action items from our monthly inter-agency meetings in order to help our partners in both the public and private sectors easily track the status of our AI initiatives, and soon will include reporting findings from our monthly "NewTech10" data call designed to provide an evolving snapshot of federal agencies' programs and needs.

Public services are increasingly powered through the combination of greater access to data and practical advances in AI and Machine Learning that deliver solutions from research and development laboratories into the hands of programs everywhere.

From early experiences supporting an emergency response effort after a natural disaster that resulted in more requests received through digital services than could be processed by staff, ECTO finds the practical and immediate use cases for AI that help the American people today, from modernizing contact centers to empowering our teams with new and better ways to operationalize data for decision-making and operations.

For example, ECTO's first initiative in AI for CItizen Services was to work with more than two dozen government agencies to use our open data to test new, automated 24-7 customer services in commercially available intelligent personal assistants.

Today, ECTO supports strategy and management of a wider spectrum of uses for AI based on proven need and demand from agencies and businesses, including workforce development, citizen customer service, and data analysis to target fraud, waste, and abuse.

We look forward to launching a new shared resource on Emerging.Digital.gov in the near future called "Emerging Technology Pathways to Acquisition." This resource will increase transparency on ways agencies can acquire AI services by providing a simple roadmap businesses can use to open their solutions to government, including GSA schedules, prizes and competitions on Challenge.gov, and Joint Venture Partnerships.

ECTO also launched new initiatives this quarter to further support the advancement of AI in public services including an interagency Venture Capital Advisory Group, an Academic Research Outreach initiative to better open the breadth of government-wide programs to the leading U.S. research facilities, and an Education and Training pilot through GSA's DigitalGov University that all agencies will be able to use.

**Forecast: IT Modernization Alignment**

The AI technology landscape includes interdependencies with many other technology areas. There are several foundational technology areas that must be aligned for government to successfully implement AI including data services, cybersecurity, and cloud. In this spirit, GSA is working to improve alignment of these technology areas internally, within GSA, and is providing improved guidance to partners across the Federal government.

This is in support of one of the key goals in GSA's current Strategic Plan for Fiscal Years 2018-2022: to improve the way Federal agencies buy, build, and use technology. Work is already underway in this area within and across several GSA programs.

First, through Data.gov and ECTO, we are learning how to improve the standardization and accessibility of the government open data that is a critical fuel of innovation. Through this work, we have solicited input from companies on how to improve data hosting so datasets are more easily digestible for AI and machine learning.

Second, through Federal Risk and Authorization Management Program (FedRAMP) and its standardized process, we help vendors utilizing AI achieve cyber security authorizations so that Federal agencies can easily and affordably buy them to improve citizen-facing services.

Third, through cloud.gov, Federal partners are able to easily acquire and deploy cloud-based AI services and products within their technology environment.

GSA will continue to develop strategies and approaches to further coordinate internal processes and programs for streamlining AI products and services to support the missions of Federal agencies. We see an opportunity for greater collaboration and coordination across government to help institutionalize the spread of these insights and best practices.

**Challenges**

What are the challenges we face, as both an agency and a government? AI can and does mean different things to different people, different groups, and different agencies, in large part due to the plethora of very specific problems and solutions AI can be utilized for. While this is a challenge, it is also an opportunity, because it can help broaden our perspectives on AI, and give agencies a deeper understanding of the useful role this technology can play in so many spaces.

Additionally, when people hear "artificial intelligence," their minds often wander to the realm of science fiction. Because it is difficult to explain what is and is not artificial intelligence, there could be a reluctance among some in society to embrace this technology. There is also a belief that AI is in the future, rather than in the present. Concerted effort by policymakers of all levels to help change this narrative will be critical in promoting acceptance and adoption of AI by more and more entities - which makes hearings like today's all the more important.

Finally, while Americans now have access to more data than at any point in our history, the biggest challenge is how to harness this data make sense of these reams of information. GSA operates the Data.gov website, which is a centralized hub to access and use open Government datasets. At its launch in May of 2009, Data.gov had 47 datasets; it now features over 230,000 datasets. This provides citizens, businesses, researchers, and other agencies access to a vast array of critical information, and AI can help make sense of this data in a far quicker manner than is possible with human effort alone.

**Conclusion**

At end of day, GSA is essentially a shared service, and the Federal Acquisition Service is constantly seeking ways to make government faster, better, and smarter. AI is a tool that can expand the value proposition for federal agencies, vendors, and the American people alike.

Thank you again for the opportunity to be a part of this important hearing. I am confident that, together with you and the private sector, we can ensure that the United States of America retains the mantle of leadership on emerging technology for generations to come. I would be happy to answer any questions you might have.

Mr. HURD. Dr. Kurose, you now have five minutes.

**STATEMENT OF JAMES F. KUROSE**

Mr. KUROSE. Thank you very much. Good afternoon, Chairman Hurd, Ranking Member Kelly, and members of the subcommittee. My name is Jim Kurose. I'm the assistant director at the National Science Foundation for the Directorate of Computer and Information Science and Engineering.

As you know, NSF contributes to national security and economic competitiveness by supporting fundamental research in all areas of science and engineering, as well as education for the next generation of discoverers. I welcome this opportunity to highlight NSF's AI investments.

Federal investments in foundational AI research are critical to achieving and sustaining U.S. science and technology leadership. Fundamental AI R&D challenges can be broadly classified into two categories. First, there's narrow AI that is focused on solving specific tasks in well-defined domains such as speech recognition or image classification. Here, NSF-funded researchers have pioneered new machine-learning techniques and applied these techniques, for example, to analyze breast cancer and predict sepsis.

To your opening remarks, Chairman Hurd, NSF is piloting the use of AI clustering techniques in its own business processes to help program managers select proposal reviewers.

The second broad category, general AI, is about transferring what is learned in one setting to another and ultimately appreciating intent, meaning, and understanding. Several witnesses in your earlier panel have noted that these goals remain an AI grand challenge in which we're also investing.

In fiscal year 2017, the National Science Foundation invested more than $120 million in core AI research. AI will continue to be an important part of our research portfolio, including NSF's Big Ideas. Indeed, NSF Director Dr. France Cordova, my boss, recently described AI as, quote, "the universal connector that interweaves all of our big ideas. Data science is changing the very nature of scientific inquiry, and AI's use of data has the potential to revolutionize everything we do in science.

The AI innovations that we are seeing today are built on earlier fundamental research. For example, NSF's investments in reinforcement learning decades ago are enabling today's deep learning systems in autonomous vehicles. As Eric Schmidt, former Google Alphabet CEO, has said NSF is, quote, "where all interesting research gets started." Well, you know, yes, we're a starter, but we're also more than that. We're part of the larger very uniquely American research and innovation ecosystem among academia, industry, and government with the flow of ideas, artifacts, and people across these sectors. This ecosystem has given rise to multibillion-dollar industries including AI, but truly, it all begins with investment in fundamental long-term research often made with Federal research dollars.

At NSF, we're constantly exploring new partnership models to grow this ecosystem. We've partnered with industry on joint research solicitations. Recently, we combined $50 million from the National Science Foundation with an equivalent amount from an

industry consortium to advance wireless technologies. These public and private partnerships serve as models for potential future AI R&D collaborations.

Federal agencies like my colleagues here are other partners. NSF co-chairs the Networking and Information Technology Research and Development Subcommittee of the National Science and Technology Council, and we co-chaired an NST committee that developed the 2016 National AI R&D Strategic Plan.

You've heard that much of the AI revolution has been enabled by the availability of large data sets in computing. NSF has invested in open training data sets and is committed to public access to data resulting from federally funded research. NSF has also long invested in high-performance computing. To complement these investments, we recently announced a partnership with three commercial cloud providers—Amazon, Google, and Microsoft—to make $12 million in cloud resources available to academic researchers through our BIGDATA program.

Beyond data and computation, there remains the most valuable resources of all: people. NSF investments here include research that builds the foundations for rigorous, engaging computer science education at all levels, K through 12, university, and lifelong learning. For example, working with the teaching community and many partners, NSF's support led to a new advanced placement computer science principal's course whose launch last year was the largest ever in the College Board's history. More than 50,000 students took the exam. We saw remarkable strides in participation of groups long underrepresented in computing as well. More than double the number of African Americans, Hispanics, and women took this new AP exam in 2017 as compared to the existing CS AP exam the year before.

NSF's investments and partnerships have helped sustain the Nation's leadership in AI and enhanced our nation's economic competitiveness and security. We at the NSF are committed to continuing this investment in fundamental AI research, infrastructure, and workforce to maintain U.S. global leadership.

This concludes my remarks, and thank you again for the opportunity to address this subcommittee.

[Prepared statement of Mr. Kurose follows:]

**Testimony of**

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**Assistant Director of the**
**National Science Foundation for**
**Computer and Information Science and Engineering**

**Before the**

**Subcommittee on Information Technology**

**For the**

**Committee on Oversight and Government Reform**
**U.S. House of Representatives**

**March 7, 2018**

**Game Changers: Artificial Intelligence Part II**

Good afternoon, Chairman Hurd, Ranking Member Kelly, and members of the Subcommittee. My name is Jim Kurose and I am the Assistant Director of the National Science Foundation (NSF) for Computer and Information Science and Engineering (CISE).

As you know, NSF is dedicated to advancing progress in all fields of science and engineering. NSF funds fundamental research across all science and engineering disciplines; supports education of the next generation of innovative thinkers, discoverers, and leaders; and contributes to national security and U.S. economic competitiveness. I welcome this opportunity to highlight NSF's investments in artificial intelligence (AI).

Federal investments in fundamental, long-term, transformative AI research as well as education are critical to achieving and sustaining U.S. technological leadership in this area. The recent *National Artificial Intelligence Research and Development Strategic Plan*[1], developed by a National Science and Technology Council (NSTC) Subcommittee on Machine Learning and Artificial Intelligence (MLAI), noted the important role of the Federal Government in the broader AI innovation ecosystem. The strategic plan identified scientific and technological needs in AI, established priorities for federally-funded research and development (R&D) in AI, and articulated a path forward that looked beyond near-term AI capabilities toward the long-term transformational impacts of AI on our Nation.

[1] https://www.nitrd.gov/PUBS/national_ai_rd_strategic_plan.pdf

Over the last several years, we have witnessed AI begin to have broad and deep impacts on our daily lives, ranging from precision medicine to intelligent transportation, to personalized education and learning, and beyond. Importantly, the many powerful AI innovations being led by industry today are predicated on the fundamental research outcomes generated with federal funding, including NSF funding, over the last several decades. Similarly, sustained investments now will lay the foundations for future innovations in the decades to come.

NSF is continuing to fund pioneering innovations that will help the U.S. capitalize on the full potential of AI to strengthen our economy, advance job growth, and better our society. Looking forward, NSF will continue to bring the problem-solving capabilities of the Nation's best and brightest minds to bear on the AI challenges of today and tomorrow.

**A Brief History of AI**

Let me begin with a brief history of AI. AI innovations date back to the early 1940s, when researchers constructed the first Boolean circuit model of the human brain. In 1950, Alan Turing published the seminal paper *Computing Machinery and Intelligence*[2], in which he considered the question, "Can machines think?" In that paper, Turing introduced his concept of what is now known as the "Turing test," or the test of a machine's ability to exhibit intelligent behavior equivalent to, or indistinguishable from, that of a human. The Turing test called for a human evaluator to judge natural language conversations between a human and a machine designed to generate human-like responses; if the evaluator cannot reliably tell the machine from the human, the machine is said to have passed the test.

Early AI programs were developed in the 1950s, and the term "artificial intelligence" was officially adopted at a meeting at Dartmouth College in 1956 to reflect the study of machines capable of intelligent behavior. Development of knowledge-based systems in the 1970s led to an expert systems boom in the 1980s. That, however, was followed by a period known as the "AI winter" in the late 1980s and early 1990s, when there was reduced interest in the field. Beginning in 2005, the broad availability of very large data sets combined with advanced, scalable computing systems catalyzed a new era of deep learning, and since 2013, AI systems have begun to surpass human capabilities in image processing, speech recognition, and even the game of Go[3].

Importantly, beginning in the 1960s, NSF supported the very first computer science departments at U.S. colleges and universities. Often growing out of mathematics departments, establishing computer science as a mainstream area of scientific and engineering pursuit helped to provide a fertile training ground for the first (and subsequent) generations of computer scientists and engineers, including AI pioneers. Today, NSF provides 83 percent of all federal support for fundamental research in computer science, including AI, conducted at our Nation's colleges and universities.

At the same time, the pursuit of the formal and theoretical foundations of AI has been a highly interdisciplinary endeavor, spanning many fields beyond computer science and engineering, to include philosophy, mathematics and control theory, economics and game theory, psychology, linguistics, and ethics. By bringing together these varied disciplines, NSF has been uniquely positioned to drive advances in the foundations of AI.

[2] https://academic.oup.com/mind/article-pdf/LIX/236/433/9866119/433.pdf
[3] https://www.nytimes.com/2017/05/23/business/google-deepmind-alphago-go-champion-defeat.html

**NSF's Sustained Investment in AI: The Foundations for Future Advances**

In keeping with its mission "to promote the progress of science; to advance the national health, prosperity, and welfare; [and] to secure the national defense," NSF has long supported fundamental research related to AI. Importantly, NSF prioritizes its AI investments through a proven, "bottom-up" philosophy: the best ideas for research come directly from the science and engineering community. As Eric Schmidt, former Chief Executive of Google and more recently Alphabet, Inc., Google's parent company, has said, NSF is "where all interesting research gets started."

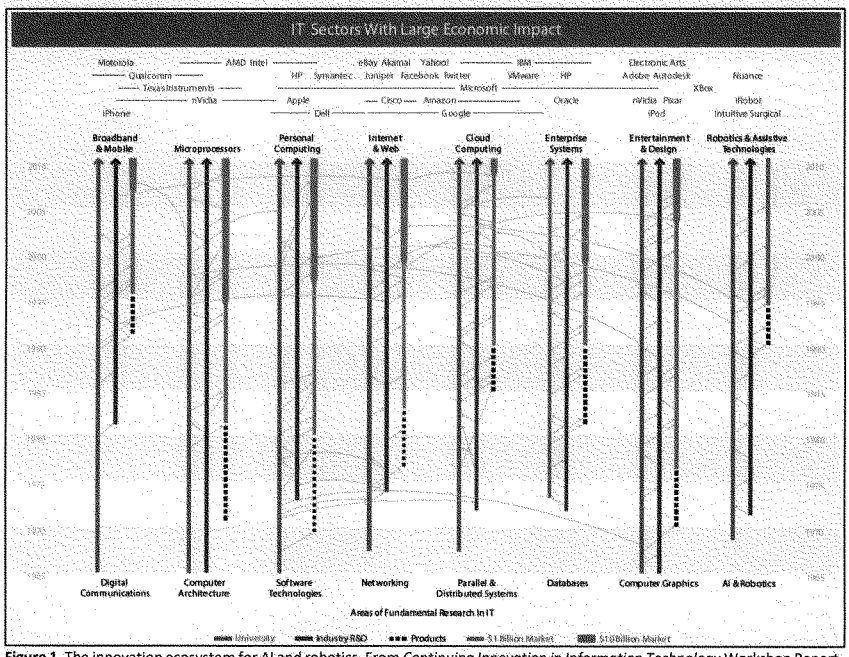


**Figure 1.** The innovation ecosystem for AI and robotics. From *Continuing Innovation in Information Technology* Workshop Report, National Academies of Sciences, Engineering, and Medicine, 2016.

Figure 1, a so-called "tire tracks" diagram, from the *Continuing Innovation in Information Technology* Workshop Report[4] published by the National Academies of Sciences, Engineering, and Medicine, illustrates this point. The figure shows how fundamental research in information technology, conducted at universities with federal funding, as well as in industry, has led to the introduction of entirely new product categories that have resulted in multi-billion-dollar markets. The figure reflects the information technology research ecosystem in which concurrent advances across multiple sectors have been mutually reinforcing, stimulating, and enabling one another, and ultimately leading to a vibrant, innovative industry exemplified by top-performing firms.

[4] https://www.nap.edu/catalog/23393/continuing-innovation-in-information-technology-workshop-report

Specifically, the vertical red track represents university-based (and largely federally-funded) research, and the blue track represents industry R&D (some of which is also government-funded). The dashed and solid black line indicates a period following the introduction of significant commercial products resulting from this research, and the green line represents billion-dollar-plus industries (by annual revenue) stemming from this research. The top rows list the present-day information technology market segment and representative firms whose creation was stimulated by the decades-long research represented by the red and blue vertical tracks.

Importantly, the arrows between the vertical tracks represent known instances of cross-fertilization resulting from multi-directional flows of ideas, technologies, and people across academic research, industry research, and products. In other words, they are examples of the rich interplay between academia, industry, and government that characterizes the unique American information technology innovation ecosystem that has given rise to multi-billion-dollar markets, including in the case of AI and robotics (shown on the far right of the figure).

As a concrete example of this innovation ecosystem, consider how pairing AI research with the growth of the Internet in the 1990s enabled the creation of e-commerce, a crucial driver of today's economy. NSF-funded researchers began working on what is now known as collaborative filtering, developing and refining the origins of this technique. Today, collaborative filtering fuels the recommender engines on popular websites like Netflix and Amazon – the "you might also like" suggestions that propel a significant proportion of e-commerce activity[5].

Neural networks constitute another key innovation rooted in AI research. Although this modeling approach emerged in the late 1980s, there were not enough data available at the time for neural networks to make accurate predictions. With the rise of big data and today's data-intensive scientific methods, together with conceptual advances in how to structure and optimize the networks, neural networks have re-emerged as a useful way to improve accuracy in AI models. For example, in recent years, neural networks have helped reduce the error rate in speech recognition systems, enabling innovations such as real-time translation[6].

Similarly, NSF's investments in reinforcement learning – an approach rooted in behavioral psychology that involves learning to associate behaviors with desired outcomes – have led to today's deep learning systems. By getting computers to learn like humans, without explicit instruction, reinforcement learning is driving progress in self-driving cars and other forms of automation where machines can hone skills through experience. Reinforcement learning was the key technology underlying AlphaGo, the program that defeated the world's best Go players[7].

These are but a few of the many NSF-funded AI innovations that impact our lives today.

[5] https://www.nap.edu/catalog/23393/continuing-innovation-in-information-technology-workshop-report
[6] https://www.nap.edu/catalog/23393/continuing-innovation-in-information-technology-workshop-report
[7] https://www.technologyreview.com/s/603501/10-breakthrough-technologies-2017-reinforcement-learning/

**The Frontiers of AI Research**

Going forward, long-term, fundamental AI R&D challenges can be classified into two categories known as "narrow AI" and "general-purpose (general) AI." Narrow AI is focused on solving specific tasks in well-defined domains, such as speech recognition or computer vision. Examples of narrow AI advances include facial recognition and AlphaGo. Narrow AI R&D challenges include robustness, adaptability, trust and safety, taskability, interaction and collaboration, knowledge richness, and scalability. By contrast, general AI is about exhibiting flexibility and versatility in a broad range of cognitive domains, including learning, reasoning, creativity, and planning; it involves transferring what is learned or experienced in one task to another, and ultimately appreciating "intent," "meaning," and "understanding" in AI systems. General AI R&D challenges span cognition and metacognition, visual intelligence, and lifelong planning and learning.

Research in AI can be broadly categorized as follows:

- **Reasoning and problem solving:** the ability to imitate the step-by-step reasoning that humans use when they solve puzzles or make logical deductions;
- **Knowledge representation:** the ability to represent extensive knowledge about the world, including objects, properties, categories, and relations between these; situations, events, states, and time; causes and effects; and knowledge about knowledge;
- **Planning:** the ability to describe a set of possible actions that will yield a desired result, based on descriptions of the initial state, desired goals, and possible actions;
- **Learning:** the ability to improve automatically through experience;
- **Natural language processing:** the ability to read and understand human language;
- **Perception:** the ability to use input from sensors, such as cameras, microphones, tactile sensors, sonar, and others, to deduce aspects of the world; an example of perception is computer vision, which is the ability to analyze visual input; and
- **Motion and manipulation:** the ability to determine how to get from one point to another, and to execute that movement, including maintaining appropriate physical content with one or more objects; and
- **Social intelligence:** the ability to predict the actions of others by understanding their motivations and emotional states.

To advance the above fundamental research areas, NSF invests over $100 million annually through a broad array of core as well as crosscutting programs. These investments span the "AI technology stack," including real-time sensing and data acquisition, massive data management, machine learning, domain-specific modeling, AI infrastructure, human-AI interaction, and autonomy. Advances across the AI technology stack in turn contribute to innovations in a myriad of sectors.

For example, a team of NSF-funded computer scientists and pathologists at Stanford University has developed a model to teach computers to analyze breast cancer[8]. By assessing numerous novel morphological features of images of breast cancer tissue, the machine learning model can more accurately determine cancer diagnosis and prognosis than trained clinicians. A particularly striking revelation was that the cellular features that were the best predictors of patient survival were not from the cancer tissue itself, but rather from adjacent tissue, a discovery previously undetected by medical teams.

[8] http://stm.sciencemag.org/content/3/108/108ra113

Similarly, an NSF-funded team of researchers at Johns Hopkins University have developed an AI program integrating data from the health records of more than 16,000 patients to identify 27 factors capable of predicting septic shock. Septic shock is a rapid immune response to infection that can cause organ failure, leading to more than 200,000 U.S. deaths annually. Early symptoms of septic shock are notoriously difficult to spot. But by combining and analyzing the 27 routine health factors – such as urine output and white-blood-cell counts – the program was able to accurately predict septic shock 85 percent of the time, usually before it harmed any organs.

NSF-funded researchers at the Texas Advanced Computing Center, the University of Texas Center for Transportation Research, and the City of Austin have also developed a new deep learning tool that uses raw camera footage from City of Austin cameras coupled with high-performance computing to recognize objects – people, cars, buses, trucks, bicycles, motorcycles, and traffic lights – and characterize how those objects move and interact[9]. This information can then be analyzed and queried by traffic engineers and officials to better determine traffic patterns and potential safety issues. For example, researchers were able to automatically identify a number of cases where vehicles and pedestrians were in close proximity, demonstrating how the system discovers dangerous locations without human intervention.

Machine learning approaches are increasingly used in security-sensitive applications such as malware detection and network intrusion detection. However, classical machine learning algorithms are not designed to operate in the presence of adversaries – and intelligent and adaptive adversaries may actively manipulate the information that they present in attempts to evade trained classifiers, leading to a cat-and-mouse game between the designers of learning systems and attackers who wish to evade them. A research team at the University of Virginia is actively developing automated techniques for predicting how well classifiers will resist adversaries' evasion attempts, along with general methods to automatically harden machine learning classifiers against adversarial evasion attacks[10].

**Big Data and Advanced Computing: Drivers of Modern AI**

As noted earlier, advances in AI rely upon the availability of deep, high-quality, and accurate training datasets as well as advanced, scalable computing resources.

Indeed, we heard during the first AI hearing before this subcommittee several weeks ago that agencies across the Federal Government are being called upon to prioritize open training data and the release of federal data for this purpose[11,12]. NSF is contributing to this effort, and to open science more broadly, through a variety of approaches. Since 2011, NSF has required all proposals to provide information about plans for data management and sharing of results of NSF-funded research. Prospective principal investigators must provide sufficient information to enable reviewers and program directors to assess both current plans and past performance. The research community, through merit review and program management, assesses the reasonableness of proposed data management and access. In 2015, NSF published a plan outlining a framework for activities to increase public access to scientific publications and digital scientific data resulting from NSF-funded research. The plan, *Today's Data, Tomorrow's*

[9] https://www.tacc.utexas.edu/-/artificial-intelligence-and-supercomputers-to-help-alleviate-urban-traffic-problems
[10] https://www.nsf.gov/awardsearch/showAward?AWD_ID=1619098
[11] https://oversight.house.gov/hearing/game-changers-artificial-intelligence-part/
[12] https://www.nitrd.gov/PUBS/national_ai_rd_strategic_plan.pdf

*Discoveries*[13], sets forth the requirement that NSF-funded investigators are expected to share with other researchers, at no more than incremental cost and within a reasonable time, the primary data, samples, physical collections, and other supporting materials created or gathered in the course of work under NSF grants. Grantees are expected to encourage and facilitate such sharing. Pursuant to that plan, NSF also requires that articles derived from NSF-funded research appearing in peer-reviewed scholarly journals and juried conference proceedings or transactions be deposited in a public access-compliant repository and be available for download, reading, and analysis within one year of publication. In early 2017, NSF issued a "Request for Input on Federal Datasets with Potential to Advance Data Science[14]," encouraging identification of possible datasets held by federal departments, agencies, and offices that would be useful in furthering research in machine learning and AI.

Beyond data, access to advanced, scalable tools and computational resources is critical to the success of NSF's investments in AI R&D. NSF has long supported high-performance computing resources to accelerate fundamental science and engineering. Key NSF foci have included fundamental discoveries to support future generations of advanced computing; research and cyberinfrastructure promoting cohesive platforms and interoperability for large-scale data analytics as well as modeling and simulation; and support for a comprehensive advanced computing ecosystem for science and engineering research. Collectively, these foci emphasize a holistic approach to America's science and engineering computational infrastructure, spanning both human and technical dimensions. More recently, NSF has partnered with commercial cloud providers, namely Amazon Web Services, Google Cloud Platform, and Microsoft Azure, to make available $12 million in cloud resources to the academic research community over a three-year period[15,16]. This public-private collaboration represents a powerful step forward in broadening access to the unique capabilities of the commercial cloud for data storage, processing, and analytics. It also allows NSF to balance various computational workloads across the full portfolio of advanced computing infrastructure.

**AI Education and Workforce Development**

NSF's investments in AI research are accompanied by investments in education and workforce development. Research undertaken in academia not only engages some of our Nation's best and brightest researchers, but because these researchers are also teachers, new generations of students are exposed to the latest thinking from the people who understand it best. Further, as these students graduate and transition into the workplace, they bring this knowledge and understanding with them.

NSF is funding research and development that is building the necessary foundations for implementing rigorous and engaging computer science (CS) education at all levels: preK-12, colleges/universities, and continuing education programs. These investments are predicated on the importance of a diverse workforce that understands foundational concepts of CS and computational thinking, knows how to creatively use and develop new methodologies and tools including in AI, has the capacity to interact with all sectors of our society, and is prepared to lead the global information economy.

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[13] https://www.nsf.gov/pubs/2015/nsf15052/nsf15052.pdf
[14] https://www.nsf.gov/pubs/2017/nsf17049/nsf17049.jsp
[15] https://www.nsf.gov/news/news_summ.jsp?cntn_id=244450
[16] https://www.microsoft.com/en-us/research/blog/microsoft-boosts-nsfs-big-data-regional-innovation-hubs-3m-cloud-computing-credits/

Over the last decade, NSF investments have laid the groundwork for rigorous and engaging computer science education at the preK-12 level for all students in all parts of the U.S.. For example, sustained NSF support for nearly a decade has enabled the development of a new Advanced Placement® (AP®) Computer Sciences Principles (CSP) framework and exam, along with a number of aligned curricula and associated teacher professional development resources. The first official AP CSP exam was administered in May 2017, and proved to be the largest launch of any AP course in the 60-year history of The College Board: over 2,500 schools offered AP CSP courses, and they combined to enable more than 50,000 students to take the exam. Additionally, compared to participation in the existing AP computer science exam (CS A), African American participation was 7% in CSP (versus 4% in CS A); Hispanic participation was 19% (versus 11%), and female participation was 30% (versus 25%). Today, NSF is continuing to grow the knowledge base and capacity for high-quality preK-12 computer science education, as well as scalable and sustainable models of professional development for educators. In achieving these results at the preK-12 level, NSF has partnered with other federal agencies including the U.S. Department of Education and the U.S. Department of Defense. In addition, NSF has worked with private partners, resulting in a number of NSF projects being scaled nationally.

NSF has also made significant investments at the undergraduate level, where computer science departments are experiencing a surge of non-major students in their mid-level and advanced courses. Over the last several years, NSF has sought to support computer science departments and universities in responding to this changing landscape, restructuring departments and universities to better prepare students to employ the power of computing across the interdisciplinary and multidisciplinary collaborations of the future. A key focus has been on "CS+X" – with "X" constituting another discipline, sector, or societal grand challenge – and the dynamic needs of many industry sectors.

These efforts at the undergraduate level have been complemented by NSF's longstanding support for Research Experiences for Undergraduates (REU) Sites[17] in the area of AI. REU Sites are based on independent proposals that seek to initiate and conduct projects engaging a number of undergraduate students in research. Each REU Site must have a well-defined common focus, based in a single discipline or spanning interdisciplinary or multidisciplinary research opportunities with a coherent intellectual theme, which enables a cohort experience for participating students. NSF recently awarded an REU Site to Carnegie Mellon University that is providing high-quality guided research experiences for undergraduate students in computer vision, field and space robotics, artificial intelligence, manipulation, and machine learning[18].

NSF supports graduate students through research grants to individual investigators, as well as through the Graduate Research Fellowships (GRF) program. Beginning in January 2018, in the evaluation of GRF applications submitted to NSF, applicants with "computationally- or data-intensive" research plans are identified as a priority. This focus on computational or data-intensive research spans applicants across all of NSF. In fiscal year (FY) 2017, more than 6,500 graduate students in computer and information science and engineering (and closely related fields) were supported on NSF awards.

[17] https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5517
[18] https://www.nsf.gov/awardsearch/showAward?AWD_ID=1659774

NSF has also funded early-career investigators through the Faculty Early-Career Development (CAREER) program[19], which offers NSF's most prestigious research award in support of early-career faculty. One active award at the University of California, San Diego is supporting research to develop private and highly efficient machine learning tools for classification and clustering of patient medical records[20]. This research could help lead to the discovery of population-wide patterns enabling advances in genetics, disease mechanisms, drug discovery, healthcare policy, and public health.

NSF's Cyberlearning for Work at the Human-Technology Frontier program[21] is seeking to respond to the pressing need to educate and re-educate learners of all ages (students, teachers, and workers) to ultimately function in highly technological environments, including in collaboration with intelligent systems. An important direction of this program is to foster lifelong learning with and through technology, particularly in preparation for and within the context of the work setting. This program invites transformative proposals that integrate advances in what is known about how people learn (individually and in groups) with the opportunities offered by new and emerging technologies such as AI to prepare future learners and workers.

**NSF's Ten Big Ideas: Harnessing Data for 21st Century Science and Engineering and The Future of Work at the Human-Technology Frontier**

In FY 2016, NSF announced a set of bold questions that will drive the agency's long-term research agenda – questions that will ensure future generations continue to reap the benefits of fundamental research. These 10 "Big Ideas" aim to capitalize on what NSF does best: catalyze interest and investment in fundamental research, which is the basis for discovery, invention, and innovation, along with education. The Big Ideas define a set of cutting-edge research agendas and processes that are suited for NSF's broad portfolio of investments, and will require collaborations with industry, private foundations, other agencies, science academies and societies, and universities. These ideas will push forward the frontiers of US research and provide innovative approaches to solve some of the most pressing problems the world faces, as well as lead to discoveries not yet known. They will provide platforms to bring together every field of study, from science and education, to engineering and astrophysics, to radically alter the conduct of science and engineering across the scientific enterprise in a manner that is not possible by simply continuing discipline-specific efforts at current levels.

Two of the 10 Big Ideas have a strong AI focus. First, Harnessing the Data Revolution for 21st-Century Science and Engineering engages NSF's research community in the pursuit of fundamental research in data science and engineering; the development of a cohesive, federated, national-scale approach to research data infrastructure; and the development of a 21st-century data-capable workforce. Second, The Future of Work at the Human-Technology Frontier aims to help build an understanding of how constantly evolving technologies are actively shaping the lives of workers and how people in turn can shape those technologies, especially in the world of work. This Big Idea will bring together NSF research communities to conduct fundamental scientific research on the interaction of humans, society, and technology that will help shape the future of work to increase opportunities for workers and productivity for the American economy.

[19] https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503214
[20] https://www.nsf.gov/awardsearch/showAward?AWD_ID=1253942
[21] https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504984

**Engaging with Industry: Transitioning Research Innovations to Practice**

In addition to the partnership with leading cloud providers mentioned previously, NSF has several focused programs to create and expand partnerships with the business community. The Industry-University Cooperative Research Centers (IUCRC) program was created in 1973 to develop long-term partnerships among industry, academia, and government. NSF invests in these partnerships to promote research of mutual interest, contribute to the Nation's research infrastructure base, enhance the intellectual capacity of the engineering and science workforce, and facilitate technology transfer. NSF currently supports 77 IUCRCs involving over 200 university sites. Each center has, on average, approximately 17 industrial partners. For every dollar provided to a center from the NSF IUCRC program, approximately seven dollars are provided by the industry members and other sources. More than 2,000 students conduct research at IUCRCs each year, and approximately 30% of those students graduating each year are hired by the center's member companies. For example, the NSF IUCRC for Big Learning[22], located at the University of Florida and the University of Missouri at Kansas, seeks to create state-of-the-art deep learning methodologies and technologies and enable intelligent applications. This IUCRC is pursuing deep learning algorithms in embedded systems for mobile and Internet-of-Things (IoT) applications in a number of domains, including healthcare and cybersecurity.

NSF also provides a much-needed bridge across the so-called "valley of death" between R&D and commercialization. NSF-funded AI research has led to the formation of numerous start-up companies, enabling transition of research results to deployment and implementation. NSF has supported these start-ups through its Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, which stimulate technological innovation in the private sector by strengthening the role of small business concerns in meeting federal R&D needs. Similarly, the NSF Innovation Corps™ (NSF I-Corps™) program has provided AI grantees with entrepreneurial education so that they can conduct customer discovery and successfully pursue valuable product opportunities that emerge from their academic research. Since the inception of the NSF I-Corps program in 2011, several I-Corps Teams in the AI domain have participated in the curriculum. For example, an I-Corps project at the Massachusetts Institute of Technology is investigating the commercial applications of a machine learning system that ingests, aggregates, processes, and learns mappings about buildings and their environments from multiple data sources[23]. This system would allow users to make inferences about built and energy infrastructure and their surroundings where data are not available in a low-cost, large-scale, automated way, removing the need for certain expensive sensor deployments or manual surveys.

Finally, NSF is constantly exploring new models of partnership with industry. Over the last decade, NSF has increasingly partnered with industry, including with the Semiconductor Research Corporation, Intel Labs University Collaboration Office, and VMware, Inc., on programs that jointly fund research projects advancing the state of the art in specific areas. Additionally, in 2016, NSF helped catalyze the formation of a new industry consortium comprising over 25 companies and associations in the wireless networking sector to support the design, development, deployment, and initial operations of city-scale testing platforms that will accelerate fundamental research on wireless communication and networking technologies. This collaboration combines $50 million from NSF over seven years with $50 million in cash and in-kind contributions from the industry consortium to advance wireless technologies beyond fifth-generation ("5G") networks. This new public-private partnership serves as a compelling model for potential future government-industry collaborations in AI R&D.

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[22] https://www.nsf.gov/awardsearch/showAward?AWD_ID=1747751; https://www.nsf.gov/awardsearch/showAward?AWD_ID=1747783

[23] https://www.nsf.gov/awardsearch/showAward?AWD_ID=1820773

**Coordination and Collaboration Across the Federal Government**

NSF's close coordination and collaboration with other federal agencies pursuing AI R&D is another critically important factor in shaping its long-term investments. NSF serves as co-chair of the Networking and Information Technology Research and Development (NITRD) Subcommittee of the NSTC, which coordinates all investments in fundamental networking and information technology R&D across more than 20 member departments, agencies, and offices of the Federal Government[24]. The full NITRD portfolio spans more than $4 billion annually. As part of the NITRD program, NSF co-chairs a number of interagency working groups, including one focused on Intelligent Robotics and Autonomous Systems (IRAS)[25].

Since spring 2016, NSF has actively participated in the NSTC MLAI Subcommittee, and co-chaired the *National Artificial Intelligence Research and Development Strategic Plan* that the subcommittee published in 2016[26]. NSF's investments in AI are also strongly aligned with the FY 2019 Administration R&D Budget Priorities[27,28], and the *National Security Strategy of the United States of America* published in December 2017[29].

**Renewing NSF**

Apart from its support of extramural research at the frontiers of science and engineering, NSF also strives to be a model federal agency operationally. Given that the landscape in which NSF executes its mission is constantly evolving – for example, research questions are becoming increasingly interdisciplinary in nature, and thus they require new levels and forms of scientific and engineering collaboration – NSF constantly pursues organizational reforms to optimize its efficiency and effectiveness, including its customer service standards.

NSF's current set of operational reforms, collectively called "Renewing NSF," includes a focus on *Making Information Technology (IT) Work for Us*. This focus area seeks to accelerate modernization of NSF's IT infrastructure via adoption of cloud offerings, consolidated computing platforms, software-defined network infrastructure, and automated change management processes to improve overall resilience of NSF's systems. It also aims to promulgate adoption of automated, intelligent tools to substantively evolve NSF's business processes, including merit review of submitted proposals. For example, beginning in FY 2018, NSF is conducting a pilot in two of its divisions to leverage AI technologies, including natural language processing and machine learning, to automate the selection of peer reviewers for proposals – traditionally a time-intensive and manual process – based on the contents of submitted proposals.

Ultimately, NSF strives to implement leading-edge IT solutions that can be adapted easily and quickly, and that enhance employee productivity and satisfaction by enabling access to readily available, reliable, and fully integrated data to support decision making.

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[24] http://www.nitrd.gov/

[25] https://www.nitrd.gov/nitrdgroups/index.php?title=Subcommittee_on_Networking_and_Information_Technology_Research_and_Development_(NITRD_Subcommittee)

[26] https://www.nitrd.gov/PUBS/national_ai_rd_strategic_plan.pdf

[27] https://www.whitehouse.gov/sites/whitehouse.gov/files/ostp/fy2019-administration-research-development-budget-priorities.pdf

[28] https://www.whitehouse.gov/wp-content/uploads/2018/02/ap_18_research-fy2019.pdf

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

**Conclusions**

NSF has made significant investments in foundational and multidisciplinary AI research over the last several decades. These investments have enhanced our Nation's economic competitiveness and national security, in direct alignment with NSF's mission "to promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense." They have also given rise to fundamentally new research directions and opportunities for the future. NSF's interdisciplinary education research portfolios are contributing to a next-generation workforce capable of pursuing AI research and taking on new jobs that will soon be created across multiple sectors of the economy. Across our research and education investments, NSF partnerships with other federal agencies and industry are also helping to advance machine learning and AI, and transition innovations into the marketplace.

The development of AI is advancing at a rapid pace, and NSF will continue to invest in fundamental AI research, infrastructure, and workforce development to maintain U.S. global leadership in this field. With sustained support for AI R&D in both the executive and legislative branches, there is a unique opportunity to generate breakthroughs that can further our national priorities. AI holds the potential to transform the lives of Americans through increased economic prosperity, improved educational opportunities and quality of life, and enhanced national and homeland security. A just-published strategic plan by the U.S. Government Accountability Office describing *Trends Affecting Government and Society*[30] identified AI and automation as one of five emerging technologies that will potentially transform society and noted, "The extent to which the United States is able to focus R&D investment in key technology areas will be a key factor in U.S. competitiveness in the global economy."

Allow me to leave you with four key characteristics about AI:

- **AI is broad:** it involves many areas of study, including decision making, natural language processing, machine learning, and robotics, and is closely allied with other fields of computer and information science and engineering, including data science, algorithms, and advanced computing systems;
- **AI is impactful:** it has strong impacts across all application domains, ranging from precision medicine to energy to transportation to education and learning;
- **AI is challenging:** it offers many open R&D challenges, and these provide rich intellectual domains of study with many long-term challenges; and
- **AI is growing:** it is engaging ever-growing numbers of students and faculty who are joining the AI R&D community.

Thank you for the opportunity to testify before the Information Technology Subcommittee on this very important and timely topic. I would be happy to answer any questions at this time.

[30] https://www.gao.gov/assets/700/690262.pdf

Mr. HURD. Thank you, sir.

Dr. Maughan, you are now recognized for five minutes.

**STATEMENT OF DOUGLAS MAUGHAN**

Mr. MAUGHAN. Chairman Hurd, Ranking Member Kelly, and members of the subcommittee, good afternoon, and thank you for this opportunity today.

I will be sharing important aspects of how the Department of Homeland Security's Science and Technology Directorate, or S&T as it is known, is using artificial intelligence-based technologies in research and development and working across all DHS mission areas to integrate innovative technologies into everyday use.

As the R&D arm of DHS, S&T develops the tools, technologies, and knowledge products for DHS operators and State and local first responders, ensuring the R&D coordination across the Department to develop solutions for the needs of today and tomorrow.

S&T partners with Federal agencies, as Jim said, industry, academia, and international government, to create and test solutions that help the Nation's homeland security officials prevent, respond to, and recover from all hazards and threats. S&T's goal is to provide real-world solutions in a realistic time frame.

AI offers much promise. From a government perspective, it holds the potential for enhanced insight into public service operations and improved delivery of citizen services. Examples span the range from helping people navigate immigration systems to predicting and preempting threats and enabling resilient critical infrastructures that today are under attack.

AI technology is improving our knowledge and actions. Fueled by sensors, data digitization, and ever-increasing connectedness, AI filters, prioritizes, classifies, measures, and predicts outcomes which can have significant impact on people.

Private industry is leading the way in AI development because many see its implementation as a key competitive advantage. Government must be informed and ensure AI technology is being used to create efficiencies and enhance the public good.

At DHS S&T, AI is a part of several ongoing cybersecurity division research initiatives, which are using AI and machine-learning techniques for predictive analysis of malware evolution against future malware variance; detecting anomalous network traffic and behaviors to inform decision-making; and helping identify, categorize, and score adversarial telephony denial-of-service techniques. For example, S&T developed a machine-learning-based policy engine capable of blocking more than 120,000 calls per month, including robocalls. This same technology can be used to defend 911 centers against life-threatening distributed denial-of-service attacks.

DHS S&T also is working closely with the Nation's startups on AI through our Silicon Valley Innovation Program, or SVIP. Launched in 2015, the Department is connecting with innovation communities across the Nation to harness the commercial R&D ecosystem for technologies with government applications and help accelerate transition to market with the goal of reshaping how government entrepreneurs and industry work together to find cutting-edge solutions for the Department operators.

SVIP and Customs and Border Protection are partnering on AI and machine-learning topics, including visualization, predictive models, and entity resolution and currently are funding startups to exchange information on intelligence, build capacity, and increase worldwide security and compliance standards.

Looking forward in AI, DHS continues to support the design of AI systems in a manner that makes the actions and decision-making of technologists, government officials, and other users both transparent and understandable. The design, development, implementation, and evaluation of AI solutions should generate trust that the government and industry are innovating responsibly by demonstrating that the government is balancing risks and delivering on its mission to serve the public fairly and justly and influence responsible evolution and the role for AI in the private sector.

In order for the government to be relevant in this fast-moving and competitive future that is being defined by AI, innovation should be advanced through an emphasis on responsible R&D. In addition, AI R&D should involve multiple disciplines and those perspectives that involve experts not only from computer science but also the other physical and social sciences.

Mr. Chairman and members of the subcommittee, AI is here to stay. This reality means that S&T must aggressively work with its research, development, test, and evaluation partners throughout government and industry so homeland security applications of AI and machine learning are both effective and trusted.

Thank you for your thoughtful leadership on these issues. I look forward to your questions.

[Prepared statement of Mr. Maughan follows:]

**TESTIMONY OF**
**W. Douglas Maughan, Ph.D.**
**Division Director, Cyber Security Division**
**Science & Technology Directorate**
**U.S. Department of Homeland Security**
**Before the**
**House Committee on Oversight and Government Reform**
**Subcommittee on Information Technology**

**March 7, 2018**

Chairman Hurd, Ranking Member Kelly, and Members of the Subcommittee, good afternoon and thank you for the invitation to speak with you. Today, I will be addressing the topic of "Game Changers: Artificial Intelligence and the Federal Government" and sharing with you important aspects of how we are using artificial intelligence-based technologies in research and development (R&D) and more broadly in the Department of Homeland Security (DHS) Science and Technology (S&T) Directorate.

As the R&D arm of DHS, S&T focuses on providing the tools, technologies, and knowledge products for DHS operational components, state and local first responders, and the Homeland Security mission ensuring R&D coordination across the Department for the needs of today and tomorrow. S&T's R&D focus areas cover DHS's core mission areas and use our network of industry, national laboratories, international, academic and other partners to seek solutions for capability gaps and define topics for future research.

Across all DHS mission areas, S&T helps integrate innovative technology into everyday use. S&T works directly with DHS Component operators in the field to understand their unique needs and challenges. S&T partners with federal agencies and international governments, industry, and academia to create and test solutions that help the Nation's homeland security officials prevent, respond to and recover from all hazards and threats. Our goal is to provide real-world solutions in a realistic time frame.

**The Benefits and Opportunities of Artificial Intelligence**

AI's promise can be seen in the rapid proliferation of many applications across government and the private sector. From a government perspective, it holds the potential for enhanced insight into public service operations and improved delivery of services, including through anticipatory responsiveness to inquiries, discovery of new trends, and automation of internal processes. Examples of AI applications span the gamut from helping people navigate immigration systems, to predicting and pre-empting threats, to making critical infrastructure more resilient against increasing attacks.

For AI to realize its potential, we must overcome several challenges, including the potential for widening the gap between our rapidly-changing technology capabilities.

From the DHS S&T perspective, we believe that the future AI trajectory will proceed in the following three ways:

First, AI technology is increasingly providing us with new knowledge and informing our actions. Fueled by sensors, data digitization, and ever-increasing connectedness, AI filters, associates, prioritizes, classifies, measures, and predicts outcomes, allowing the Federal government to make more informed, data-driven decisions.

Second, algorithms are ingesting and processing ever higher volumes of data. Their complexity, especially in the case of deep learning algorithms, will continue to increase, and we need to better understand how outputs are produced from the set of inputs, which may not be able to be understood or analyzed in isolation.

Finally, private industry is leading the way in AI development, as many see the implementation of AI as a key competitive advantage. The private sector's significant investments and the ability to adopt new AI models and processes faster than the public sector present the government with a key decision point on how to best participate in this growing, but still nascent field. Government should move forward with adoption of emerging technologies such as AI to improve citizen services. Government also plays an important role in promoting research and development. Government should ensure it is informed of developments in the private sector, while continuing to support AI research and development, and promote the use of AI technology to create government efficiencies and enhance the public good.

**DHS S&T and Artificial Intelligence**

AI is an integral part of several S&T Cyber Security Division (CSD) research projects funded within current resources, which are using AI and machine learning techniques for a variety of purposes, including but not limited to predictive analysis for malware evolution; enabling defensive techniques to be established ahead of a future malware variant; detecting anomalous network traffic and behaviors to inform cyber defensive decision making; and helping identify, categorize and score various adversarial Telephony Denial of Service (TDoS) techniques.

A good example of S&T's work involves demonstration of TDoS protection for a major US bank with a significant impact on its contact center that processes close to 11 million calls per week. The machine learning-based policy engine blocks more than 120,000 calls per month based on voice firewall policies including harassing callers, robocalls and potential fraudulent calls. It also blocks two to three phone-based attacks each month (computer-generation of calls into 1-800 toll free destinations in an attempt to collect a portion of the connection or per-minute charges associated with the call). This same technology can be used by 911 call centers to defend against denial of service attacks.

Another S&T research example capitalizes on the convergence of technologies such as machine learning, software defined networking, and global internet routing to help build more robust defenses against Distributed Denial of Service (DDoS) attacks. This specific application uses machine learning to create fine-grained, temporal traffic models that allow anomaly detection without preset thresholds and with low false positive rates. It then uses Software Defined Networking technology to deploy thousands of rules to instantly defend against complex DDoS attacks at very high speeds.

**S&T Engaging DHS Components and Startups**

DHS S&T launched its Silicon Valley Innovation Program (SVIP) to keep pace with the innovation community and engage that community to tackle significant problems faced by the Department's operational missions. SVIP expands DHS S&T's reach to find new technologies that strengthen national security.

Through a streamlined application and pitch process leveraging Other Transaction Authority, SVIP is seeking solutions to challenges that range across the entire spectrum of the homeland security mission space, including cybersecurity and technology solutions for Customs and Border Protection (CBP) and first responders.

**SVIP and AI**

DHS SVIP and CBP are working together to evaluate and implement innovative methods -- to include the use of AI and machine learning -- to exchange information and intelligence, build capacity, and increase worldwide security and compliance standards in support of CBP and its international partners. These efforts widen border security capabilities and support a "defense in depth" approach to combat the global threat environment, and strengthen our combined enforcement efforts.

CBP offers advanced passenger data-screening and targeting technology as an open source software project, known as the Global Travel Assessment System or GTAS. It is a turn-key application that provides to CBP's foreign counterpart agencies the necessary decision support system features to receive and store air traveler data, both Advanced Passenger Information (API) and Passenger Name Record (PNR), provide real-time risk assessment against this data based on a country's own specific risk criteria and/or watch lists, and view high-risk travelers as well as their associated flight and reservation information. The purpose of GTAS is to provide border security entities the basic capacity to ingest, process, query, and construct risk criteria against the industry-derived standardized air traveler information. The system provides border security organizations with the necessary tools to prescreen travelers entering into and leaving their countries.

Last year, DHS SVIP and CBP partnered to enhance the GTAS project with solutions from the global innovation community, namely new capabilities using AI and machine learning, and identifying the following three capabilities for consideration:

**VISUALIZATION:** This would extend the basic flight and passenger tabular list screens with geospatial, link analysis, seat map visualization, or any other concepts that improve the software by presenting data graphically

**PREDICTIVE MODELS:** These would complement GTAS rules engine with statistical and machine learning models and a "predictive model engine" that performs real-time risk assessment and

**ENTITY RESOLUTION:** This capability would enhance the basic name/date of birth and document matching algorithms to support more advanced entity identification and matching algorithms

**A Path Forward**
DHS continues to support the design of AI systems in a manner that makes the actions and decision-making of technologists, government officials, and other users both transparent and understandable. The design, development, implementation, and evaluation of AI solutions should generate trust that the government and industry are innovating responsibly, by demonstrating that the government is balancing risks in delivering on its mission to serve the public fairly and justly, and influence responsible evolution and the role for AI in the private sector.

Innovation in AI should be advanced through an emphasis on responsible R&D. In addition, AI R&D should involve multidisciplinary perspectives that involve experts from computer science, and other physical and social sciences.

In order for the Government to be relevant in this fast moving and competitive future that is being defined by AI, the following notions are essential: the use and development of datasets for AI R&D, strategic communication and engagement with industry on relevant considerations, and the development of trust in applications of AI.

**Summary**
Mr. Chairman and Members of the Subcommittee, as you heard in your Hearing last month, AI is here to stay. It is no longer a dream from decades past. It is being used for many applications in the private sector and Government and we are only at the beginning of understanding all its possible opportunities.

AI and machine learning are rapidly moving from scientific understanding to engineering application in most domain areas. This reality means DHS must aggressively work with its research, development, test and evaluation partners throughout government and industry to develop effective, trusted homeland security applications of AI and machine learning. This requirement includes strong working relationships with industry, so homeland security applications can leverage the best of industrial innovation, and homeland security capabilities can continue to support the strengthening and growth of American economic capabilities. These efforts must necessarily contribute to key areas of challenge – cyber security, screening people and cargo, risk understanding throughout the nation's critical infrastructures, valuable investment in smart infrastructure and operations – all critical missions of DHS.

Thank you for your thoughtful leadership on these issues and I look forward to your questions.

**APPENDIX: National Artificial Intelligence Research and Development Strategic Plan**

*The National Artificial Intelligence Research and Development Strategic Plan,* National Science and Technology Council, Networking and Information Technology Research and Development Subcommittee, October 2016, https://www.nitrd.gov/PUBS/national_ai_rd_strategic_plan.pdf.

Mr. HURD. Thank you, Dr. Maughan.

My first question to the panel, it is for all of you. And you all are here as the representation of some of the best things that are happening when it comes to AI across the Federal Government. And one of the things that we heard in the last panel and we have heard in conversation on this topic, two things that the Federal Government can be doing: research obviously, right, continued basic research, applied research like some of the things that Dr. Maughan is doing at DHS. I am in. We get it. We are going to try to figure out how to do that, right? This is a bipartisan issue.

Second thing we have heard is also data, you know, how do we unlock data that the Federal Government has that can be used to train and teach these various algorithms. I get those two things. But I am asking each one of you all—and this is not to apply to just your agency but across the Federal Government, what is one thing that the Federal Government should be doing now in implementing artificial intelligence, something that is available, something that can be used that we should be doing? Is that a fair question? Dr. Maughan, you are shaking your head. Yes, Dr. Maughan?

Mr. MAUGHAN. Sure. So, I mean, we—things we are doing already include, as I mentioned with our Customs and Border Protection folks, they have something called the Global Travel Assessment System, GTAS, which they make available to all of our international partners as well. And we have been working with them to add in capability into that open-source system that are AI-based. And so we're starting to see that roll out as new capability for not only CBP but all of our international partners.

Mr. HURD. Dr. Kurose?

Mr. KUROSE. Well, thank you. And thank you for mentioning the importance of funding basic research and open data as well.

You know, I had mentioned in my own testimony about what the National Science Foundation is doing testing the use of some AI techniques actually built with open software on making recommendations for panelists for program managers. And it's an example of the broader challenge, I think, and opportunity of adopting AI tools and having folks in government use AI tools to help inform decision-making that they are. It's not going to be a magic press-the-button-and-get-the-answer-out but using that to help complement already-existing activities.

Dr. Nakasone, maybe a more specific question for you, you mention 7.5 million different kinds of applications and tools that GSA makes available. Are there tools that other agencies are not taking advantage of and they should when it comes to this topic?

Mr. NAKASONE. So when we speak about the 7.5 solution sets that we're talking about, you know, it crosses the scope of telecommunications, IT services, supplies, commodities, right? So we have access and we are learning every day on how to build these solution sets by looking at use cases, best practices, and things like with of course the working groups that we have to understand how we can deliver these broader acquisition solutions to cover, you know, things like distributed ledger technology with the robotic process automation and the—and ——

Mr. HURD. So let me ask it this way. We bring in a lot of Federal CIOs when we go through the FITARA scorecard talking about how

are they modernizing their digital infrastructure. Give me a question I should be asking them, you know? Are you using—fill in the blank.

Mr. NAKASONE. Right. So what—you know, something that we could be asking is what emerging technologies are you using to do your IT modernization uplift? You know, we recently have—GSA has a big part in the IT modernization plan, and I think one of the things that we need to look at is how are we leveraging emerging technologies and injecting it into our infrastructure.

Mr. HURD. Dr. Everett, wrap it up for us.

Mr. EVERETT. I think there's a temptation to think of AI as magic and as being able to solve all our problems. When you talk about implementing something that would be effective for the Federal Government, I think we should take the perspective of first understanding what the actual problems are and then working our way back towards how AI could actually address those problems and not just up front but looking at what is the lifecycle cost of implementing those technologies.

Mr. HURD. Thank you, Dr. Everett.

The gentlewoman from Illinois is now recognized.

Ms. KELLY. Thank you, Mr. Chair.

I think we all agree that research and development is essential to continuing to improve the government's use of artificial intelligence, and in my opening statement I talked about the concern about China passing us by. Are there any other countries that you think are putting a lot of money into research and development and are passing us by or could pass us by when it comes to AI? Whoever wants to answer.

Mr. EVERETT. The one that I hear about all the time is China. Certainly the international community, however, is very broad, and the AI community started out internationally in 1970, so the basis for the technology is international. Whether or not that is an issue at the individual country level I don't know, aside from China.

Ms. KELLY. All right.

Mr. KUROSE. I would again just add I think it is international, so absolutely the comments that you had made in your opening statements about China I note that DeepMind that Google has acquired is from the U.K., that Microsoft acquired a really topflight AI research company from Canada. And so really it's a global phenomenon.

Ms. KELLY. And I think we all would agree that funding is extremely important so that you can continue the good work that you're already doing, and we can progress further.

The other question is, besides funding, finding people that are educated and trained to help us progress in this area and what are suggestions that you have on what we can do to find people interested in the field that want to get involved in the field.

Mr. MAUGHAN. So my suggestion is we need to make—so at the core of AI is computer science, and so it's making computer science attractive and so the—again, depending upon the application area, cybersecurity, which is what some of us work on, is one of the most attractive but we're still not attracting as many as we need. So we have to find those things that make it exciting. We've been, for example, funding competitions, high school and collegiate competi-

tions as a way to try to get students interested in cybersecurity and computer science as early as possible, and I think we just need to continue to push that agenda earlier in the school system. The sooner we can get youth interested in computer science as a career, they use the tools all day anyway, so let's teach them that there's a career in that direction.

Ms. KELLY. I know when you—the statistic I showed, it is amazing the difference between us and China, people in the field and the Ph.D.'s graduating.

Mr. KUROSE. So I'd like to second Doug's recommendation about the focus on pipeline and also the importance of a broad computer science education. In my testimony I had mentioned the computer science principal's AP exam and how popular that has been. There are other investments that the National Science Foundation is making in exploring computer science in the middle schools. I think at the undergraduate level also computer science now is becoming a much more popular major and also programs such as what's called Computer Science Plus X, so it's the application of computing in other disciplines and two grand challenges and two challenges that the country faces, and there's also a movement afoot of AI Plus X, so applying AI and data science for good.

So I think at both the high school and the undergraduate level that, you know, there are programs afoot and universities innovating in that space. At the Ph.D. level we always face a challenge in that keeping Ph.D. students in academia. There are lots of interesting challenges to be addressed in industry, and it's important to keep our Ph.D. pipeline cranking at full speed as well.

Mr. NAKASONE. So I guess one thing that GSA focuses on, you talked about recruiting, and we actively search out, go to universities, and also when we look at the diversity aspects, we are, you know, recruiting from minority perspective.

I just want to say for GSA's overall workforce, you know, 40 percent are minorities and 46 percent are female. And within the IT field, we have 39 percent that are minorities and 33 percent that are female, so, you know, we work hard to try to recruit talented and the best of the ability to try to get highly educated people into the workforce. And we have to—as we build out these emerging technology solution sets, I think by showing us—or we Federal Government agencies need to figure out how to get that message out there that, no kidding, we are leaning forward and building out and using emerging technology solutions.

Ms. KELLY. How much do you rely on—do you think AI relies on students educated outside of the United States to supplement the workforce? Whoever wants to answer. You can answer.

Mr. NAKASONE. Sorry.

Ms. KELLY. Don't be shy.

Mr. NAKASONE. As far as that, I don't have that data in front of me, but however, we can take that back as a question.

Ms. KELLY. Okay.

Mr. HURD. The distinguished gentleman from the great State of Michigan is now recognized for his first round of questions.

Mr. MITCHELL. Thank you, Mr. Chairman.

I think one of the issues that has arisen as we look at adoption of AI and expansion of it is really getting a broader understanding

of what it is and how impacts our lives currently. I have read a couple of articles recently where it seems to me to be an innate fear of what AI is. How do we at the Federal level overcome or get the level of understanding among the population as a whole, not the tech weenie population. They all think it is cool. It is the other folks about what AI is, how it makes decisions, and why it is of value to them if we are going to continue to expand investment and get more people into training. Anybody who wants to tackle that, please go ahead. Mr. Maughan, you smile and chuckle. You are going to pass it off to Dr. Kurose?

Mr. MAUGHAN. I am waiting to see if Dr. Kurose wants to go first.

Mr. KUROSE. Actually, I'm very happy to go first. It's a really great question, and it really comes to the question of decision-making and, you know, there's—there have been computer software-assisted decision-making for a long period of time. And when we do predictions, we do regression analysis. So, I mean, these are—there's a long history of relying on computation to help in making decisions. And I think the key phrase that you mentioned is AI making decisions. And in the end it needs to be people making decisions, and it needs to be people making decisions with AI software.

Mr. MITCHELL. How do we get enough transparency of how that happens so that people understand that in the real world outside of here and a handful of other places? How do we achieve that? Because we need to do that if we are going to get the level of acceptance and engagement and education that we want. How do we achieve that, folks?

Mr. KUROSE. Right, well, so I agree 100 percent. It's absolutely a question of outreach. I think with some AI techniques that are in use today there's an issue of explainability, which I think Dr. Everett and DARPA's had a program on explainability of AI, so maybe I could pass it down to my right.

Mr. MITCHELL. Ping-pong. Go ahead, Dr. Everett.

Mr. EVERETT. We are just starting a new program called Explainable AI, and it directly addresses the issue that a lot of the machine-learning software that we have today cannot explain why it has ——

Mr. MITCHELL. Right.

Mr. EVERETT.—come up with a particular answer, and so the objective of the research is to say tell me why you think this is a certain kind of bird, and it will tell you, well, I think it's got a red crest and a black stripe on the wing, and then it will show you that it is actually looking at the right part of the image to start to build trust.

Another aspect of this is assuring autonomous systems. So we have an autonomous ship called Sea Hunter, and to make it—to ensure that it would operate safely within shipping lanes, for example, it has to pass the commercial collision ——

Mr. MITCHELL. Right.

Mr. EVERETT.—regulations. So we're looking at ways in which to do—to use mathematical techniques to verify that the software will behave as expected in a wide range of circumstances that it might encounter in the real world.

Mr. MITCHELL. You're not likely to get beyond an autonomous ship in the near future, Doctor, but I have to be honest, how soon would that research and that information become available to the population at a broader level do you think?

Mr. EVERETT. I think it will diffuse rather slowly, particularly as the popular culture tends to portray AI with a mix of science and science fiction.

Mr. MITCHELL. Yes. And evil at some level or fear of evil. Let's put it that way. But let me get to my second question as time is running a little short. What is your agency's approach in dealing with a difficult question of ethics in the use of AI, which kind of goes to what you are suggesting? How are you approaching that with the general population or even within your agency?

Mr. MAUGHAN. Certainly, I think that in the case of the research piece, we need to look at that. As I mentioned in my testimony, you need to make sure that the—kind of the AI itself is transparent and understandable and you can actually see the decisions being made are balancing risks and are fair and just to the recipient of those, and that requires us to have not only the AI piece of it but kind of watching the AI. How do I ensure that the AI is working and doing what it wants? I think we're still early in the day, but certainly agree that the ethics question was raised in your industry panel as well.

Mr. MITCHELL. Anybody else have any input? Go ahead, sir.

Mr. KUROSE. Yes, I'd like to say that I think the ethics question is also often very tied up with data and how data is used in inferences from data. It's an active research area. NSF is funding a number of activities there. I think it also calls to the front the importance of interdisciplinary collaboration here because it's not just computer scientists and engineers. It's also social, behavioral, and economic scientists who have to be involved in this as well.

Mr. MITCHELL. I appreciate it. My time is expired. Thank you, Mr. Chair.

Mr. HURD. The distinguished gentleman from the Commonwealth of Massachusetts is now recognized for his five minutes.

Mr. LYNCH. Thank you very much, Mr. Chairman, and to Ranking Member Kelly for your persistent attention on something I think that should be a huge priority for both Democrats and Republicans in this Congress.

I do want to note that Ms. Kelly in her opening remarks had put up a good slide there that demonstrated that the Chinese recent announcement—or in the last few years announcement on AI, their intense focus and funding on that, you know, has them eclipsing the U.S. investment not only because of their additional funding but because the Trump administration has backed off somewhat on research and development funding for a number of our agencies. I know that NSF is looking at a cut in funding of I think $9 billion, and I know that DHS as well. Especially in your Science and Technology Directorate, you are looking at I think it is a $1.3 billion cut.

So I am concerned about whether we are recognizing the priority with our budget as well. And, you know, you have been very helpful in terms of demonstrating the importance of this issue, but do you see any need for additional funding? And also, you know, Dr.

Everett and Mr. Nakasone, you see this as well. I know that DARPA has been considering projects from companies in my district from, you know, underwater radar systems to, you know, enhanced antibiotics, you know, for use against these resistant strains of bacteria to climate change. And so we really do need, as Dr. Kurose has said, an interdisciplinary approach, but all of that is affected by the amount of available dollars for research and development.

And we have had such great success in the past through NASA and other agencies where basically nondefense research has really helped us enormously across society. And I am just wondering, Dr. Everett or any of you, for the whole panel, do you see that the lack of funding here could trip up or basically prevent some of the wonderful discoveries and advancements that we anticipate in this field?

Mr. EVERETT. Well, DARPA supports the President's budget request for our agency. We are a projects-based agency. Our projects last roughly four years. Our PMs are not civil service but rather they come from industry and academia for a limited period of time. So what that means is that every year 25 percent of our programs are turning over, 25 percent of our PMs are new. This enables us to rapidly shift our budget to meet current priorities that we see emerging in the technology space.

Mr. LYNCH. Okay. Do you have any opinions about the National Science Foundation or any part of HHS that also might benefit from further funding or are we just talking about DARPA?

Mr. EVERETT. I'm speaking for DARPA.

Mr. LYNCH. Okay. All right. We have got other witnesses as well. Mr. Nakasone?

Mr. NAKASONE. Sure. Thank you for your question. When it comes to funding, as far as GSA is concerned, you know, I just want to thank Emily Murphy, who is our new GSA administrator, and Alan Thomas, who's our FAS commissioner, and Kay T. Ely, who I work under, supports the efforts on the distributed ledger technology and the robotic process automation and ——

Mr. LYNCH. I am sorry. You are eating all my time.

Mr. NAKASONE. Yes, sir.

Mr. LYNCH. I can't go with this. In English, do you think more money would help?

Mr. NAKASONE. For—from a GSA perspective ——

Mr. LYNCH. Well, that is who you represent.

Mr. NAKASONE. Yes. I think ——

Mr. LYNCH. Okay. That is good. Mr. Kurose? That is all I am asking for.

Mr. KUROSE. Thank you.

Mr. LYNCH. Nothing complicated.

Mr. KUROSE. Just to say that the President's fiscal year 2019 budget request with the addendum funding NSF at $7.5 billion, which is the '17-enacted level.

But to your question, I want to stress there is capacity to do more. When I mentioned that the National Science Foundation funds $122 million in AI core research, if we look at proposals that were not funded but rated either competitive or highly competitive, that's $174 million in proposals there, so there is ——

Mr. LYNCH. Okay.

Mr. KUROSE.—capacity to do more.

Mr. LYNCH. That is helpful. Thank you very much.

Mr. Chairman, I yield back.

Mr. HURD. My esteemed colleague from the Commonwealth of Virginia is now recognized.

Mr. CONNOLLY. I thank you, Mr. Chairman. And by the way, congratulations I think on your re-nomination last night, right?

Mr. HURD. That is right.

Mr. CONNOLLY. All right. Let's stipulate you all support the President's budget and it is perfect and you wouldn't change a word or a number. Let's stipulate that so you don't have to demonstrate any further loyalty. We got it. But let's talk a little bit about the relationship between R&D and technological innovation and its impact on the economy. And I am particularly interested in Federal R&D.

So, Dr. Everett, there used to be something called DARPANET, correct?

Mr. EVERETT. That's correct.

Mr. CONNOLLY. And what is it called today?

Mr. EVERETT. The internet.

Mr. CONNOLLY. The internet. So DARPANET, when we first—when your agency was smart enough to make that critical investment, were the commercial dollars flowing into that R&D effort at the time?

Mr. EVERETT. No, certainly not.

Mr. CONNOLLY. No. It was entirely a Federal R&D effort, is that correct?

Mr. EVERETT. That's correct.

Mr. CONNOLLY. And somewhere along the line someone decided this is so nifty. This is so useful to us internally that maybe it might have some other applications. Is that correct?

Mr. EVERETT. Yes. And I'd like to point out that it became NSFNET before it became ——

Mr. CONNOLLY. And then it became ——

Mr. EVERETT.—the internet.

Mr. CONNOLLY.—NSFNET. Thank you very much. Good point. So would that be the same story of GPS technology?

Mr. EVERETT. That would be.

Mr. CONNOLLY. So GPS, which is now ubiquitous, we all take it for granted, you can't even lie about getting lost going to a meeting anymore, kind of put paper maps out of business. But GPS was also a Federal R&D investment, is that correct?

Mr. EVERETT. That's correct.

Mr. CONNOLLY. Your agency?

Mr. EVERETT. Yes.

Mr. CONNOLLY. What about robotics? Did your agency get involved in robotics at all?

Mr. EVERETT. We just concluded the DARPA robotics challenge, so yes.

Mr. CONNOLLY. Yes, so a lot of the research in robotics, again a Federal investment, your agency being one of the pioneers?

Mr. EVERETT. Yes.

Mr. CONNOLLY. Drones, developed by the private sector or was that a Federal R&D investment as well?

Mr. EVERETT. Initially, a Federal R&D.

Mr. CONNOLLY. My goodness. What about noise cancelation technologies?

Mr. EVERETT. I'm not directly familiar with that technology.

Mr. CONNOLLY. Well, for example, we did a lot—during the Cold War, we did a lot of hush-hush work, no longer hush-hush, on noise cancelation technologies for reasons you can surmise. But after the Cold War when we were looking at civilian application for R&D in our possession of the Federal Government, we took noise cancelation out of your agency and out of the Pentagon and we applied it to things like cars and even other things like parts of a room that we could cancel noise to allow privacy. We use it in courtrooms today. That all came out of Federal R&D technologies for defense at the time.

Human genome, was that your area, Dr. Kurose, human genome research?

Mr. KUROSE. Excuse me, not my personal area of research, but certainly bioinformatics and computation plays an absolutely critical role there.

Mr. CONNOLLY. But the Human Genome Project, so that was run by some private entity in New York, right? Golly. It is not a trick question, Dr. Kurose.

Mr. KUROSE. Okay.

Mr. CONNOLLY. The answer is of course not.

Mr. KUROSE. Of course.

Mr. CONNOLLY. It was a Federal ——

Mr. KUROSE. Federal.

Mr. CONNOLLY.—R&D investment. And I am trying to make a point here. Now, there is a lot of loose talk about the government can't do anything right. That is not true. You four represent the face of the Federal Government that has transformed the world with its R&D investment, and we are not even talking pharmacological research. Almost all basic research in pharmacological areas is Federal because the private sector won't take the risk. And right now, we are counting on the Federal Government to save us from antibiotic-resistant bacteria that could unfortunately transform health worldwide because it is not profitable for the private sector to engage in that R&D right now, so we got to do it.

But we have transformed the world. So when we say we are going to cut a couple of billion dollars out of Federal R&D and I look at this record, I tremble at what are we cutting? Is it the next GPS? Is it the next drone? Is it the next Human Genome Project? Is it the next internet? We don't know. But the opportunity cost I fear is enormous.

And so it may be that DARPA is happy with the budget it has got, but this Member of Congress trembles at a 21 percent cut that Ms. Kelly pointed out to us at the beginning in her opening statement because there is an opportunity cost we can't calculate. We can't even know for us. But I do know this: Whatever amount of money we spent on DARPANET, it was worth every cent. The return on that investment cannot be calculated. And that is true for GPS, and that is true for drones, and it is true for the Human Ge-

nome Project. These are investments worth making. And America does not make itself great again when it retreats from the field of R&D.

So thank you for being here and know that a number of us up here are going to continue to push hard for your budgets for the sake of the country. Thank you.

Mr. HURD. Mr. Krishnamoorthi, you are now recognized.

Mr. KRISHNAMOORTHI. Thank you, Mr. Chairman. Thank you, Ranking Member Kelly. I really appreciate the opportunity to be able to ask a few questions of our distinguished panel.

Last month, I, along with others, including my distinguished colleague Paul Mitchell, who is on this subcommittee, introduced a bill called the AI Jobs Act, which basically requires for the first time that the Department of Labor study the impact of artificial intelligence on our workforce, you know, what areas of the economy are going to be impacted the most? How do we prepare our workforce for this artificial intelligence revolution and make sure that they are ready to take advantage of it, as some of you have talked about?

I wanted to just start out with Mr. Kurose. What specific industries do you think are most likely to kind of experience the impact of artificial intelligence in our economy?

Mr. KUROSE. Well, thank you for your question and the interest here. Actually, I want to do a short promo if I might for National Academies study on information technology and the U.S. workforce that came out just late last year and was funded by the National Science Foundation. And it was actually written both by economists. The committee that chaired this was an economist Erik Brynjolfsson from MIT and the machine-learning professor from Carnegie Mellon Tom Mitchell, and what I found very interesting about this, to answer your question, is that they talk about the broad application of IT technology and AI technology specifically across the whole U.S. workforce. So it's not so much a question of which jobs will be lost, which jobs will be created but really how AI will transform work across broad, broad swatches of the U.S. workforce and again not just even in automation in terms of robots replacing jobs but also AI's software helping doctors and lawyers and high-cognitive-skilled jobs. And so I would recommend this to you and to everybody, just very insightful report.

Mr. KRISHNAMOORTHI. Right. Right. Well, thank you so much. I don't know if robots will replace Members of Congress. We might write a bill about that beforehand.

Mr. LYNCH. Sounds good.

Mr. KRISHNAMOORTHI. Well, I want to switch subjects to something that Congresswoman Kelly brought up before, which I thought it was really important which is kind of the rise of China in the field of artificial intelligence. I want to ask kind of the corollary set of questions, which is how do we catch up and overtake them? What are our strengths in this area that we need to leverage to basically come back and eclipse them over the shorter long term? Dr. Everett, can you go for it?

Mr. EVERETT. We have a very different system than China, but I think we can leverage it. So, as Mr. Connolly pointed out, a lot of the original investments came from DARPA and from other

parts of the DOD and the Federal Government that ultimately led to inventions such as the cell phone. If we look at the DARPA Grand Challenge, which in 2004 put up a $1 million prize for an car to complete 132-mile course in the Nevada desert driving autonomously, we then—no cars did, so we then had a 2005 challenge. Five cars did at that time. That laid the basis for the self-driving car industry. So I believe that we are effective in de-risking technologies at the Federal level so that we can then enable venture capitalists and well-funded companies to take on the substantial business risk to bring them to market and to make them reliable for consumers.

Mr. KRISHNAMOORTHI. Mr. Nakasone?

Mr. NAKASONE. Yes, thank you for the question. I think one of the things we can do is do a lot of cross-collaboration, leveraging the Emerging Citizens Technology Office to convene, facilitate, collaborate, and help rapidly deploy and also from an acquisitions standpoint is have this private-public engagement and provide acquisition solutions so that we can support the entire Federal, State, local government.

Mr. KRISHNAMOORTHI. If I might add, it sounds like—I mean, both your answers kind of include an element of the private sector playing a substantial role in the development of artificial intelligence. If I might, it sounds like one strength we have is that we are not necessarily going to pick and choose what is the best technology in any given sector of artificial intelligence. We may let the best one bloom and then the private sector helps to fuel it, whereas in China they might kind of decide something is the best and it may not end up being the best. Is that a fair point, Dr. Maughan? Do you want to comment?

Mr. MAUGHAN. Certainly. I believe, you know, let the market decide. Let's let these new technologies come out that are AI-based, and those that are successful in helping people in their applications, they'll survive, and things that don't, they'll die, right? So let the market decide.

Mr. KRISHNAMOORTHI. Great. Thank you so much. Thank you.

Mr. HURD. Mr. Mitchell.

Mr. MITCHELL. Dr. Everett, you know, my colleagues left unfortunately. I asked them to stay because I promised them it would be interesting. I appreciate the new things I learn every day as a new Member of Congress, better over 14 months. I found out something new you just shared with me. So the internet was invented by DARPA?

Mr. EVERETT. That's correct.

Mr. MITCHELL. So it wasn't a former politician, formerly a Vice President?

Mr. EVERETT. It might have been popularized by a former politician.

Mr. MITCHELL. Well, that helps a lot. I was confused about that up until just a few moments ago.

A question for all of you, a serious question sort of and sort of not, but I think I want to make a point. If I had a magic wand and could invent a giant wad of cash, a big bushel basketful of cash—around here, it would have to be $1,000 bills or something, maybe $1 million bills—are any of you going to turn it down? Anybody

here going to turn down more money? No takers. Exactly my point, which is priorities have to be made by your agencies, by the President of the United States, by Congress in terms of how we prioritize funding to get things accomplished on a broad range of things. And it is not a bushel basket that suddenly regenerates cash or, as I tell my teenage children, no, the cash tree out back is going to be bare. It takes priorities. And at some point in time there isn't enough cash sort of thing.

So I suggest that if people want to spend more on this—we had a hearing this morning on transportation infrastructure on the highways and putting more money in the Federal Highway Trust Fund. Decisions have to be made where that cash comes from, and I am hopeful that those concerns about artificial intelligence or how we fund our highways, that discussions can be held not just about how we either go further in debt or we tax more, how we save some money and actually find a way to pay for these things rather than expecting the American public to just go deeper in debt or pay more taxes. I have not heard a lot of that from some of my colleagues. He left. It is too bad. So I appreciate your time, and I apologize for the little bit snarky question, but I think it made the point. I appreciate it. Thank you.

I yield back, Mr. Chair.

Mr. HURD. Dr. Everett, you said earlier one of the things we should be looking at in the Federal Government what is the problem set that you have, what is the problem that you are trying to solve, and maybe there are tools that use machine learning or artificial intelligence. How do we get a senior manager in the government in that mindset? Who would they go to to say here is my problem; are there other tools that I should be using to help improve citizen-facing services?

Mr. EVERETT. Well, that's a very broad question. And ——

Mr. HURD. Does GSA have anything in their toolkit, the NSF or DHS have a way or, you know, here are some potential tools that could solve this problem that may or may not be being used? Do we need folks within the government to better define the problem set and maybe Dr. Maughan goes out and finds, you know, some company that may be doing it and do some of that applied research you guys are so good at? Is that how we should be thinking about this problem, Dr. Everett?

Mr. EVERETT. Well, a few years ago we ran a program called XDATA, and it was in the area of big data analytics. We open-sourced much of the software that we developed there. That software has subsequently been used by startups in the private sector. IBM has made a major investment in Spark, which is a big data platform. So this information that we—we have published it and made it available to the private sector directly. That doesn't get directly to your question but it does at least start to enable the private sector to create solutions in this area.

Mr. HURD. Dr. Kurose?

Mr. KUROSE. Within the National Science Foundation, we're taking up a process of agency reform, and one of the pillars there is making IT work for us. And so, for example, understanding what are the open-source tools that we may be able to combine to help us do our work more efficiently, exactly what you were saying. The

example that I mentioned earlier about using AI clustering techniques to help program managers actually identify the most appropriate—really the best panelists and reviewers for proposals is one example of that. So having those decisions made locally and knowing what's available has proven to be very valuable.

Mr. HURD. So if we had someone in the U.S. Census Bureau that wanted to learn more, how would they do that?

Mr. KUROSE. Well, for this particular project, we could certainly put them in touch with people inside the NSF who are working on this project.

Mr. HURD. Dr. Maughan, it looks like you were getting ready to say something.

Mr. MAUGHAN. Well, I was just going to say that, you know, when we talk to operators in the field and they're looking for solutions, they don't necessarily say I need an AI solution to my problem, right? They come to us and say I need a new widget or a new this, but I—it looks like this, and then our job is to go find the researchers at the universities or the companies or—and a lot of it ends up being how they think about solving it and do they think about solving it in an efficient manner that can take advantage of new technologies? Because we are in an innovative country, an innovative mindset, and I think that's one of the benefits from an earlier question is we do have an innovative community out there that really is trying to bring cutting-edge solutions to the operations community. The operations community don't know they need an AI-based solution, but if you give them a solution that solves their problem, they don't care if it's AI-based or not. They'll use it, they'll deploy it, the companies can be successful.

Mr. HURD. If we had Mr. Mitchell's cash tree and let's say we had $100 million, in what kind of basic research should we be putting that towards? And, Dr. Everett and Dr. Kurose, if you had

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Mr. KUROSE. So I will say—and I will just echo what Doug Maughan said. We have a very, very creative community, and many of the best ideas are—they're bottom-up ideas, so we say to the community, here are broad areas that are very important. I might label a couple of grand—some of the grand challenges I talked about earlier. Explainable AI, fairness, accountability, transparency, and decision-making, for example, are all really, really important areas. The ideas are going to come from the research community itself.

Mr. HURD. I think you referenced $145 million worth of research proposals that you have been given that you haven't been able to fund. I am assuming ——

Mr. KUROSE. That's right, $174 million ——

Mr. HURD. A hundred and seventy-four.

Mr. KUROSE.—in artificial intelligence.

Mr. HURD. Wow.

Mr. KUROSE. Right.

Mr. EVERETT. So in our area we are more project-driven, so we would have—reach out to the community to find people interested in starting programs in the relevant areas. One area that I think is very important for us to be looking at is commonsense reasoning.

That is what people are—it's—people are so good at it, it's hard to even describe.

Mr. HURD. I know some people that may need help with that.

Mr. EVERETT. Computers are definitely challenged in this area, but if we're going to move past graphical interfaces with computers where they're simply tools and computers are going to become more active partners in decision-making, we're going to need to imbue them with common sense.

Mr. HURD. And my last question—and whoever would like to answer it—what is the equivalent of going to the moon with artificial intelligence? I will say this, it has been interesting as we have been looking at this and talking to folks—I went out on the plaza of the Capitol and asked people what do you think about artificial intelligence? Is it good or bad? I was shocked at how many people are scared of it. You know, I think we have had too many movies where the robot with the plastic face that is getting ready to snatch you, right? You know, Will Smith. And so one of the things that we all understand the importance of this, and I always—you know, if Vladimir Putin said that whoever master's AI is going to be the sole hegemon and we should listen, but to be able to explain this in a way to folks that don't have you all's experience or background, what is that moonshot in artificial intelligence, Dr. Kurose?

Mr. KUROSE. So maybe if I could start, I'd come back to earlier in my testimony talking about narrow AI versus general AI, and in narrow AI it's what we're hearing about, image classification, speech understanding, phenomenal leaps forward on that. But if you look at, for instance, what an 18-month-old child can do and how the child can transfer learning from one environment to another, how a child can understand intent and meaning, that that's really the grand challenge. General AI still remains a very grand challenge.

Mr. EVERETT. I would second that. Right now, we're building tools, and the popular press makes it seem as if these are going to become autonomous and think for themselves, but that is very far from the actual case of things. Right now, we know that people learn by having as few as one example, and yet we need terabytes of data to get our systems to learn. We may look back on this time as the era of incredibly inefficient machine learning, so a moonshot might take us to the point where computers actually do understand us in ways that our tools today don't. But what we have today are tools.

Mr. MAUGHAN. I would just add to something earlier said by Dr. Everett, which is the program at DARPA, which is the explainable AI, it may just be that the moonshot is AI that is just in and around us all the time and we don't even think about it. We don't call it AI; it just is, it works, and it becomes part of our everyday life and we don't worry about it. And that ——

Mr. HURD. It is not locking us out of our house.

Mr. MAUGHAN. It doesn't lock you out of the house, but it might just be that explainable piece that might be the moonshot.

Mr. HURD. Excellent. Well, I appreciate that, Dr. Maughan.

I want to thank all the witnesses for appearing before us today, and we are going to hold the record open for two weeks for any

member to submit an opening statement or questions for the record.

And if there is no further business, without objection, the subcommittee stands adjourned.

[Whereupon, at 3:13 p.m., the subcommittee was adjourned.]

# APPENDIX

MATERIAL SUBMITTED FOR THE HEARING RECORD

***Game Changers: Artificial Intelligence Part II, Artificial Intelligence and the Federal Government***

**House Committee on Oversight and Government Reform**
**Subcommittee on Information Technology**
**2:00 PM, Wednesday March 7, 2018**
**2154 RHOB**
**Rep. Gerald E. Connolly (D-VA)**

Mr. Chairman, thank you for holding today's hearing to look at how federal agencies are engaging with artificial intelligence (AI), how it is currently used across a number of different industries, what it may look like in the future, and its impact on the economy.

The federal government's adoption of artificial intelligence could lead to cost savings, increased security, and better customer service. However, implementing AI systems requires an upfront investment in research and development, the right workforce that has the skill and ability to implement AI systems, and sound federal information technology (IT) acquisition and management. A report released earlier this year by the IBM Center for the Business of Government titled *Delivering Artificial Intelligence in Government: Challenges and Opportunities* notes that in order "to enable successful use of AI in government, leaders must design and implement governance and policy that promotes a skilled workforce that collaborates with academia and the private sector, risk management frameworks, secure systems, and modern technologies."

One of the toughest obstacles to implementing AI systems across the federal government is the aging legacy IT systems that date back to the Johnson Administration at some agencies. According to the Government Accountability Office (GAO), agencies spend nearly 80 percent of their IT budgets simply trying to maintain these outdated systems, limiting their ability to modernize their systems and adopt emerging technologies including AI. The MGT Act, which was signed into law last December, allows agencies to establish their own IT working capital funds that will help fund IT modernization efforts. The MGT Act also authorizes an upfront investment of $500 million over fiscal years 2018 and 2019 through the Technology Modernization Fund (TMF). This fund will provide agencies with additional funding to retire vulnerable, large scale legacy systems. Unfortunately, the Administration requested only $228 million for fiscal year 2018 and $210 million for fiscal year 2019 for the TMF, and there is concern that appropriators will not put any money in the omnibus bill towards the TMF for fiscal year 2018. Unless there is a significant amount of money agencies can use to upgrade old IT systems, agencies will not be able to get maximum value out of AI and other emerging technologies.

The federal government also needs a large upfront investment in transformative research and development to take advantage of AI capabilities. At last months' hearing on AI, Ian Buck, the Vice President and General Manager for Accelerated Computing at NVDIDIA stated that the federal government should boost research funding through agencies like the National Science Foundation, the National Institutes of Health, and Defense Advanced Research Projects Agency (DARPA). Another witness at the hearing testified that current federal funding levels are not keeping pace with the rest of the industrialized world. Unfortunately, the President's budget calls for cuts in research and development that may hamper agency efforts to adopt AI. The President's budget for fiscal year 2019 proposed reducing NSF's budget by 31 percent, from $6 billion to just under $4.2 billion.

With adequate investment, the federal government can overcome the challenges to adopting AI and open the door to greater government efficiency and customer service. AI could potentially reduce backlogs, cut costs, overcome budget constraints, free federal employees from mundane tasks, and sift through millions of documents in real time for the most relevant content. For example, AI-based applications could also reduce backlogs at agencies such as the Department of Veterans Affairs, the Office of Personnel Management, and the Social Security Administration. A study by Deloitte published last year found that millions of working hours each year could be freed up today by automating tasks that computers already routinely do. Automation could save – at the low end – 96.7 million federal hours annually, with a potential savings of $3.3 billion. At the high end, Deloitte estimates that the numbers could rise to 1.2 billion hours and a potential savings of $41.1 billion.

While AI technology holds much promise for what the federal government can accomplish, Congress and other policy makers should not underestimate the time and money it is going to take to get many of these initiatives off the ground. Robust funding of federal IT systems and additional research and development now will enable greater innovation and cost savings later. I urge Congress and the Administration to invest in these two critical areas in order to stimulate adoption of emerging technologies.



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