



CRACKING THE CODE

HARNESSING THE EXPONENTIAL POWER OF TECHNOLOGY

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PARTNERSHIP FOR PUBLIC SERVICE

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Executive Summary

The President's Management Agenda identifies technology modernization as a principal tenet of government transformation. To advance this priority, the Trump administration, with help from Congress, is taking advantage of emerging technologies to achieve agency missions now and in the future.

Artificial intelligence, immersive technologies and edge computing, along with dozens of other technologies ranging from quantum computing to synthetic biology, are called emerging or exponential technologies because of the speed with which they evolve.

As agencies continue to cope with current and future public health crises, emerging technologies could magnify the impact government's preparation and response have on countering these crises. AI could help trace the spread of the disease and analyze patient data and scientific studies to help doctors better understand its causes, characteristics and symptoms. Immersive technologies could help first responders and federal employees train for different outbreak scenarios without jeopardizing their health and safety. And edge computing could help ensure that information networks remain stable and operational during crises as health professionals collect and transmit information about potentially hundreds or thousands of patients at the same time.

In the U.S. federal government, many leaders are building strategies to harness emerging technologies for a variety of mission outcomes. The Department of Veterans Affairs is using artificial intelligence to get benefits to veterans faster and to redirect staff time to higher-value tasks. The Federal Emergency Management Agency is using immersive technologies to change how local officials approach flood mitigation. And at the local level, the city of San Diego, California, is using edge computing to make evidence-based decisions for its residents on traffic safety and other issues.

Application of emerging technologies at federal agencies must begin with a clearly defined problem statement and a business case that documents the desired outcome. They should build a digital foundation upon which to deploy these technologies, including investment in data, computing power and technical expertise, as well as explore ways to use existing flexibilities in purchasing rules and regulations to acquire them. They also should

consider how to secure their technologies, while recognizing that new technologies might boost overall cybersecurity. Finally, agency leaders should be prepared to communicate the benefits of emerging technologies and their value to the mission to ensure employee buy-in.

The Partnership for Public Service and Booz Allen Hamilton assessed the use of AI, immersive technologies and edge computing in government. We reviewed the technologies, what they can and cannot do at present, and how agencies could accelerate their adoption and use in the future. Through current government examples, this report also identifies issues the government should consider if it is to maximize the benefits of these technologies.

By thoughtfully adopting these technologies and following the recommendations outlined in this report, the government will be better positioned to serve its customers in an increasingly interconnected and interdependent world.

Introduction

Emerging technologies, such as artificial intelligence, augmented and virtual reality, and edge computing are advancing the federal government's ability to deliver services and address next-generation challenges in areas ranging from public health to national security to payment processing.

As far as we have come, we have only begun to capitalize on the innovative technological opportunities that are continuing to rapidly emerge. Singularity University, a research and educational organization headquartered at the NASA Research Park in Silicon Valley, California, believes that these opportunities will continue to accelerate; it characterizes AI and edge computing as “exponential technologies” because they double in power or speed each year, or their respective costs drop by half. The government has an extraordinary opportunity to use these technologies to advance agency missions while continuing to plan for future applications on the horizon.

Agencies are already experiencing substantial improvements in operations and customer service as a result of adoption of these technologies. For example:

- The Department of Veterans Affairs uses AI technology to process disability benefit claims, which expedites financial relief to our nation’s veterans, limits administrative burden on the VA, and enables the federal workforce to focus on more complex tasks or tasks that require human judgment.
- The Office of Personnel Management used AI to address a major 2015 cybersecurity incident. The organization’s algorithm was able to detect and remove bad actors from its network as well as inform proactive cybersecurity measures that will reduce vulnerabilities in the future.
- The Federal Emergency Management Agency uses virtual reality to help local officials mitigate flood damage. Virtual reality places individuals in a computer-generated flooded environment where they can see how different mitigation techniques could affect future flooding.

“In the past decade, technology has transformed how the government operates in the service of the American people” said federal Chief Technology Officer Michael Kratsios at a 2019 White House summit on artificial intelligence. “Technology is helping make sure that taxpayer dollars are being used more efficiently, with technology reducing redundancies and streamlining processes. But this is just the beginning of what technology can do to improve government operations and empower Americans.”

As these technologies continue to mature, government and industry will be empowered to advance their capabilities exponentially. Quantum computing will enable massive increases in the speed of data analysis, new platforms will bring data science capabilities to individuals without coding backgrounds, and machine learning and artificial intelligence will become more successful at algorithm training using synthetic data when large data sets are not available. Immersive technologies will continue to advance users’ perception of realism. Edge computing will continue to enable data processing at the point of data collection, establishing mechanisms to inform decision-making in real time.

This report by the Partnership for Public Service and Booz Allen Hamilton includes information gathered during a series of meetings with federal senior executives and 15 interviews with technology experts from federal, state and local governments, and academia.

The pages that follow discuss artificial intelligence, immersive technologies and edge computing, their current applications, and potential for future growth within government. Each of the three technology chapters discusses challenges agencies may face when implementing the technologies, while the final chapter offers solutions to each of those challenges.

Learning from Agencies' Successful Use of Emerging Technologies

This report focuses on three emerging technologies already in use across the federal government and likely maturing further in the near term:



Artificial Intelligence
for speeding up processes and
boosting cybersecurity defenses



Immersive Technologies
for training employees for challenging
and dangerous work scenarios



Edge Computing
for enabling secure data
analysis near real-time



Artificial Intelligence

OVERVIEW OF THE CURRENT STATE OF AI

Federal agencies are under pressure to meet the public's expectations for seamless and effective government services, but are often impeded by budget constraints, legacy information technology, and outdated rules and processes. Artificial intelligence, perhaps more than any other emerging technology, could help agencies solve some of their toughest problems. Investing in AI will not only help the government design better experiences for the public, it will help leaders come to more informed decisions faster.

AI refers to the ability of machines and software to perform tasks typically undertaken by humans, such as recognizing speech or images, predicting events based on past information, or making decisions. Machine learning, a subset of AI, uses algorithms to perform problem-solving operations such as classifying data or detecting anomalies at a rate much faster than humans.

AI applications in the federal government will not only help systems run more efficiently, they will introduce opportunities for analysis that would have previously been impossible. For instance, the National Geospatial-Intelligence Agency estimated it would need eight million imagery specialists to analyze the satellite data the agency will gather over the next two decades—"clearly not a viable solution" without the use of emerging technologies, according to former Director Robert Cardillo.¹

While this technology is not new to government—the first contract for an AI tool was awarded by the Social Security Administration 35 years ago to automate data processing—the Trump administration recently launched a coordinated effort to encourage federal adoption of AI technologies. Among other steps, in 2018, the administration created the Select Committee on Artificial Intelligence to help organize federal AI efforts. In 2019, the White House issued an executive order to coordinate national AI research and development, while the National Institute of Standards and Technology released a plan outlining the role federal agencies should play in developing AI standards around safety, privacy, security and other issues. These steps will help maintain American leadership in AI research and application for the future, and place federal agencies—such as the Department of Defense and NIST—at the center of supporting AI development and deployment across the country.

¹ National Geospatial-Intelligence Agency, "Remarks as prepared for delivery by Robert Cardillo, Director, National Geospatial-Intelligence Agency," Aug. 7, 2017, 1. Retrieved from <https://bit.ly/37FjZM1> (PDF)

CASE STUDIES: AI IN ACTION

The computing power behind AI enables machines to complete tasks faster than humans, and machines do not tire after hours or days of repetitive tasks. AI is continuing to improve at tasks such as digitizing information from paper to computer, answering questions by quickly finding relevant information in large databases or long documents, detecting patterns in troves of data, and predicting someone's behavior based on past conduct.

Some agencies already are investing heavily in AI. For example, the Census Bureau has several AI projects underway. One compiles information from millions of company websites to confirm classification codes assigned by the Census to companies, such as "Drycleaning and Laundry Services" or "Full-Service Restaurants." Correct classification codes lead to correct economic statistics on industries and sectors. Census' goal is to determine whether the way company websites describe their businesses matches the description of their assigned classification code. This is designed to improve the accuracy of the codes, and perhaps one day to even assign codes using AI.²

² Brian Dumbacher and Demetria Hanna, "Using Passive Data Collection, System-to-System Data Collection, and Machine Learning to Improve Economic Surveys," U.S. Census Bureau, 2017. Retrieved from <https://bit.ly/3dFnKEK>

The National Technical Information Service is working with the U.S. Agency for International Development on the President's Malaria Initiative to integrate multiple datasets so the staff can pursue the steps most likely to mitigate the spread of the disease. And the Department of Health and Human Services is applying AI alongside human experts to identify language used in regulations that might indicate outdated, duplicative or burdensome rules that could be rescinded or reformed to reduce the regulatory burden.³

While AI benefits from using as many rows of data as possible, overseen by experts, the AI community has made great strides in using computer-generated data to train algorithms and researching AI that works with smaller datasets. In any algorithm training scenario, however, it is critical to ensure that the data is accurate, organized and unbiased in a way that is useful for AI and statistical modeling. And agency staff must be knowledgeable about the data and the technology to guide the machine through its processing and catch errors along the way.

<https://bit.ly/3dFnKEK>

³ The White House, "Summary of the 2019 White House Summit on Artificial Intelligence in Government," Sept. 9, 2019, 4. Retrieved from <https://bit.ly/33TPn8C>

The Department of Veterans Affairs uses artificial intelligence to better serve veterans

The Department of Veterans Affairs uses AI technology to improve its internal disability benefit claim processing and shorten the time between the department receiving and deciding on claims. These claims can number in the tens of thousands and range across 100 different types of disabilities, from a severe back injury to post-traumatic stress disorder.

Veterans submit claim forms directly to the VA, but before the claim can be reviewed and adjudicated, staff members must transcribe the information into computer systems. This is both time consuming and poses the risk of error.

Charles Worthington, the chief technology officer at VA, saw the opportunity to improve the system through AI. Now, an algorithm analyzes the information on a veteran's paper disability claim form, transfers it into the department's disability claim management system and matches the information from the form with one of VA's disability classifications, such as interpreting "ringing in my ears" as hearing loss.⁴

The VA set aside about five million past claims to train the tool and teach it how to discern one claim type from another based on certain keywords. Two staff analysts trained in advanced mathematics and statistics took

about two months to organize the data and make sure it was ready for the AI tool and then find the right type of algorithm for VA's purposes.

The VA already had the data it needed, so its upfront investment of time was not substantial. The size of the data files containing five million claims was small enough to fit on a single laptop computer, Worthington said.

While an employee must still make the final approval on a claim, AI greatly expedited the process by identifying the type of disability a veteran was claiming. An employee still must verify the information and the tool's prediction about the type of claim to ensure its accuracy, but the machine makes the initial classification. During its early usage, nine out of 10 claims were accurately identified, a rate VA considered a success, Worthington said.

Since the AI tool was implemented, it has helped the department reduce the time it takes for a veteran to receive their disability compensation by three and a half days, on average.⁵

As AI takes over additional tasks, employees will be able to focus on speeding up the rest of the benefits process and doing more meaningful work.

Worthington said using AI "allows people to do higher-value work around actually adjudicating the merits of the claim, not just doing certain data entry."

"We do not want to spend staff time on something that a computer could help with," Worthington said.

⁴ Department of Veterans Affairs, "VA Launches Smart Tool to Reduce Veteran Wait Times for Disability Claims," Dec. 27, 2019. Retrieved from <https://bit.ly/3aterFh>

⁵ Ibid.

The Office of Personnel Management used artificial intelligence to respond to a major data breach

Agencies also are using AI to bolster cyber resilience, which can be defined as the ability to recover and continue to effectively deliver on the mission after a cyberattack or data breach.

Traditional cybersecurity tools, such as those relying on humans to monitor information networks at all times, or setting up only one line of defense along the perimeter of a network, are often limited when it comes to sophisticated cyberattacks. Traditional cyber tools often rely on responding to attacks rather than preventing them, giving hackers a better chance at stealing valuable information. However, AI-based tools can go beyond traditional methods to identify and prevent cyber threats almost instantly. For example, AI can be taught to analyze millions of computer files and identify which files are safe and which are likely infected based on certain characteristics. Once the AI tool is programmed and up and running within a network, it can monitor a system with minimal updates or human intervention.⁶

In April 2015, OPM discovered that its information systems were under attack in an advanced data breach that led to the exposure of millions of current and former federal employee personnel records, background investigation data and fingerprints. Malicious actors were able to exploit vulnerabilities in existing anti-virus and anti-malware tools, which could not keep pace with new attacks intended to infiltrate the agency's network to obtain and steal massive amounts of sensitive data, said Lisa Schlosser, former deputy federal chief information officer. The existing tools needed to be manually

⁶ Cylance, "Artificial Intelligence: The Smarter Approach To Information Security," 2019. Retrieved from <https://bit.ly/37nnUMq>

updated at regular intervals, which put OPM at a disadvantage in staying ahead of a potential attack.

After OPM detected the breach and recognized its severity, the agency and its partners worked to deploy, through a pilot, an AI-powered tool that identified and addressed what files or users did or did not belong in the system.⁷ After initially requiring a human to determine whether a file identified as malicious should be quarantined and destroyed, OPM later allowed the AI software to automatically remove malicious activity from virtually all of the agency's networks. The automatic detection and removal contained much of the attack and continued to protect OPM's system.

OPM later purchased the tool to help identify any remaining threats.⁸ OPM's difficulties motivated a government-wide effort to significantly improve cybersecurity, such as agencies working to identify networks and data that need special protections, implement two-factor authentication, limit how many users can access systems or files, or encrypt databases.⁹ OPM's breach also highlighted the importance of technologies such as AI in cyber resilience. For example, government-wide cybersecurity programs offered to agencies through the Department of Homeland Security now incorporate AI capabilities, such as using machines to identify to which cyber incidents human analysts should respond.¹⁰

⁷ Committee on Oversight and Government Reform, "The OPM Data Breach," Sept. 7, 2016, 93–94. Retrieved from <https://bit.ly/31Kwx2E>

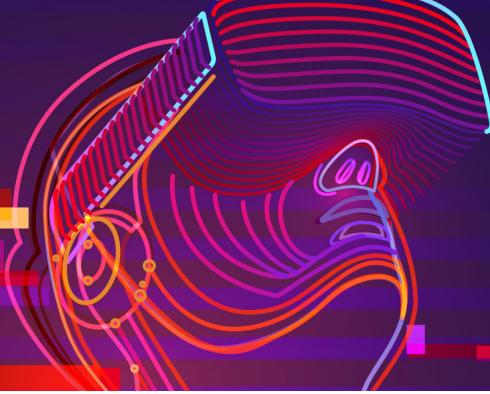
⁸ Ibid.

⁹ Government Accountability Office, "Information Security: OPM Has Improved Controls, but Further Efforts Are Needed," GAO-17-614, Aug. 2017, 8. Retrieved from <https://bit.ly/33VVaul>

¹⁰ GovLoop, "How Artificial Intelligence Combats Fraud and Cyberattacks," 2019, 12–13. Retrieved from <https://bit.ly/38kbari> (PDF)

SUMMARY

As stewards of taxpayer dollars, government agencies constantly search for new ways to deliver better and faster services with fewer resources. Whether it's curing disease, increasing our security or speeding up disaster response, AI technologies can help agencies cut costs and free employees from mundane tasks to focus on more critical, value-added work. The result is an improved customer experience.



Immersive Technologies

OVERVIEW OF THE CURRENT STATE OF IMMERSIVE TECHNOLOGIES

Federal agencies operate in an increasingly fast-paced world in which employees must address complex threats to Americans' safety and well-being, from rogue actors and nations threatening national security to emerging viruses endangering global health to a changing climate compromising our environment. Agencies risk falling short without emerging technologies that can help them prepare their employees and communities for challenging situations. And perhaps no emerging technology is more suited for that purpose than immersive technologies, those that change or enhance our physical world and can be used to plan and conduct more effective operations in areas that require high-risk, rapid decisions.

On one end of the spectrum is augmented reality, which adds digital content to a real-world environment, such as displaying vehicle registration information above a car that can be seen by a police officer wearing augmented reality glasses who has stopped a motorist. On the other end is virtual reality, which completely replaces the real world and immerses the user in a recreated or imaginary environment, such as a security screening area at an airport hundreds of miles away. Immersive technologies also include mixed reality, which allows people to use physical hardware or items in a virtual world.

Immersive technologies help in situations that require individuals to experience an environment or activity first-hand. Rather than being exposed to a dangerous, stressful or unpredictable situation, users can experience and prepare for such situations in a risk-free environment. Instructors can assess trainees' performance in real-time and provide feedback on how to improve. Using augmented and virtual reality also could cut training costs since employees can be trained anywhere without needing to travel to potentially far-off locations.

A unique challenge with immersive technologies is the need to involve user experience and instructional specialists to make sure the interactions and content are tailored to the needs of the user. If the experience is not well-designed or if it is not made appropriate for the specific user, the technology will not lead to a meaningful and lasting change in behavior. Without controlling the flow of information to the user, individuals might retain less information than they would from a real-world setting or could feel disoriented or distraught, countering the potential benefits of AR or VR tools.¹¹

¹¹ Michael Karlsson, "Challenges of designing Augmented Reality for Military use," Umeå University Department of Informatics, 2015, 22–26. Retrieved from <https://bit.ly/2ScC0w2>

CASE STUDIES: IMMERSIVE TECHNOLOGIES IN ACTION

Agencies are already realizing these benefits. The Food Safety and Inspection Service at the Department of Agriculture is using virtual reality to improve hiring and employee retention by distributing VR headsets to place candidates in challenging work environments, such as slaughterhouses, and gauge their comfort with the job before they are hired.¹² In another example, NASA built a virtual reality air traffic control tower to train air traffic controllers to respond to emergencies, help airport planners determine the best location for emergency facilities

12 Erin Brereton, "Virtual Reality Helps FEMA, VA Bring Their Missions to Life," FedTech, July 2019. Retrieved from <https://bit.ly/2vfEuOS>

and test ways to optimize air traffic flow to minimize delays for travelers.¹³ And the National Institutes of Health has funded several research studies that use immersive technologies, including using augmented reality to help adults stop smoking.¹⁴

13 NASA, "Aviation Systems Division Facilities and Capabilities: FutureFlight Central Applications," Sept. 13, 2017. Retrieved from <https://go.nasa.gov/2RRtORG>

14 National Institutes of Health, "Project Information: Utilizing Augmented Reality as an Adjunct for Smoking Cessation: Development and Initial Validation," 2020. Retrieved from <https://bit.ly/2uYWXBk>

The Federal Emergency Management Agency uses immersive technologies to help prepare for floods

The Federal Emergency Management Agency has turned to virtual reality to help community officials prepare for floods, which are one of the most common and costly natural disasters. Every major flood causes, on average, \$4.6 billion in damages, according to the National Oceanic and Atmospheric Administration.¹⁵ And FEMA gets more funding from Congress for managing floods than for any other type of disaster.

FEMA's VR tool, aptly named "Immersed," puts the person wearing a headset in various virtual flooding situations, such as a flooded home or school, or a washed-out road intersection. The experience runs on a commercially available VR product, which consists of a computer, goggles, headphones and handheld controllers. Since 2016, FEMA has presented the tool to local officials at conferences, conventions and community meetings, and more than 4,000 people have used "Immersed" at about 200 events, according to the agency's estimates.

As the goggles display the flood scenarios, the viewers can immerse themselves in the virtual environment by walking through the flooded house or directing traffic on the flooded road. But to help users learn and not just experience, the goggles also show how different steps could have resulted in different outcomes.

"Immersed" was created specifically for local government officials who are responsible for flood preparedness and deciding what flood mitigation projects to finance based upon the severity of the potential flood environment. "The goal is for community officials to walk away inspired and armed with the information needed to start

mitigation projects," said Peter Herrick Jr., communications specialist at FEMA.

Officials might see how building storm water runoff channels could alleviate flooding or how building power stations on higher ground could keep electrical systems intact, Herrick said. The agency worked with contractors during 2016 to design, build and roll out the tool. The teams worked together on the technological and behavioral aspects of the device—ensuring that going through the experience leads to changed behaviors—and providing subject matter expertise for accuracy. FEMA also sought input from potential users when they started developing "Immersed."

Anecdotal feedback shows that "Immersed" is having the effect FEMA hoped, with the immersive encounter at meetings and conferences providing a behavioral nudge for local officials to consider how they could mitigate floods similar to the virtual ones they just experienced, Herrick said. The potential return on investment is substantial, as "every dollar spent on mitigation saves a community an average of \$6.00" in flood damages, according to Multihazard Mitigation Council figures cited by FEMA.¹⁶

As a next step, FEMA is working on new immersive technology tools, such as "Floodwalk," that aim to further educate users about the dangers of floods and how to mitigate and manage them. FEMA also is considering how to collect feedback about the immersive tools—through a short survey, for instance—so the agency might better demonstrate the tools' impact, Herrick added.

15 National Centers for Environmental Information, "Calculating the Cost of Weather and Climate Disasters," Jan. 8, 2020. Retrieved from <https://bit.ly/2RFwPVd>

16 Federal Emergency Management Agency, "Immersed: A VR Experience," Aug. 28, 2019. Retrieved from <https://bit.ly/36AUH0p>

SUMMARY

Every day, immersive technology is becoming more powerful and accessible. The industry is now seeing the integration of real objects and hand tracking to allow users to engage more naturally and to increase the sense of realism. Haptic technology, which can create an experience of touch by applying forces, vibrations, or motions to the user, is making it possible to feel the environment and interact through users' real equipment and hands—rather than through a controller.

In the health care sector, immersive technology will open the door to lifesaving collaboration among medical professionals. For example, surgeons will be able to practice procedures together in virtual environments and researchers from all over the world can use immersive technology to model and prepare for scenarios into the future.

Immersive technologies also can be made more impactful by incorporating artificial intelligence. AI's computing prowess can customize the experience of virtual reality for users by adjusting the environment based on skills and needs. AI also can be used to create new virtual backgrounds as well as interactive smart agents in the virtual space that all lead to a more realistic experience.



Edge Computing

OVERVIEW OF THE CURRENT STATE OF EDGE COMPUTING

Technology enables government agencies to achieve their mission, from the Transportation Security Administration's use of video cameras at airports to keep travelers safe, to the Census Bureau's use of phones and tablets to ensure everyone is counted. This reliance comes at a time when the American public uses handheld computing power to create and store data more than ever before. As devices and data proliferate, the ability of information systems to store and analyze data becomes paramount.

Our current information networks, however, are not designed to handle exponentially growing amounts of data, whether in government or the private sector. Data today is predominantly processed at a central location, such as on a legacy computer or in the cloud, or where it was collected, such as on a smartphone.

Edge computing pushes data processing from a central location closer to where the data is collected, to the “edge” of an interconnected network of devices. Only a smaller amount of processed data is sent to a legacy computer system or the cloud for further analysis. This technology will allow data to be processed at the point of collection without relying on a central enterprise.

Mahadev Satyanarayanan, professor at Carnegie Mellon University and one of the founders of edge computing, cited as an example the use of a surveillance video camera for security or traffic control. He said the camera “can’t process the video feed because it doesn’t have the computing power to do it.” Instead, the data is “shipped to the cloud” for processing.

Satyanarayanan said this approach is not scalable if you have hundreds or thousands of cameras recording video for long periods of time—such as those at airports. Moving and analyzing that amount of data could cripple information systems, he said.

“It is much better to ship this data to a nearby intermediate tier, which we call the edge tier, and do the processing there,” Satyanarayanan said. Edge computing gets its name from this intermediate tier, which is at the “edge” of the interconnected devices, close to, say, the camera, smartphone or sensor.

Keeping the data closer to where it is collected means large amounts of data are not sent to and stored in a central system that is potentially vulnerable to cyberattacks. Decentralized data adds “a certain degree of local control” and can increase privacy and security, Satyanarayanan said. More devices processing information at the edge also means that agencies might rely less on centralized data centers and servers. This could allow government to save money and slow the growth of data centers.

Agencies also should be mindful of potential issues related to edge computing. Though these devices can boost information security, they still need to be secured just like any other technology. And with edge computing, there are more devices to safeguard compared to one central computer. Cybersecurity becomes even more paramount when edge devices process sensitive data. Another potential challenge is confirming that the data these devices use is trustworthy. With more devices generating more data than before, questions of trust become paramount. Agencies must consider where and how the data was collected, cleaned, organized and transferred between devices, as well as how it is being used, to ensure data accuracy and maintain privacy and confidentiality.

CASE STUDIES: EDGE COMPUTING IN ACTION

Federal agencies are already realizing the benefits of edge computing. The Department of Agriculture, for example, uses edge computing to analyze soil sample data collected by its inspectors. And the Department of Defense uses edge

computing to allow warfighters to analyze information they gather in the field without having to transmit data to a central location through often unreliable communications systems.

San Diego uses edge computing to make better decisions for the public

The local government of San Diego, California, recently turned to edge computing methods to process data to make smarter decisions about serving the community.

Historically, the city determined where to increase road capacity or install bicycle lanes based on generalized studies or information provided from the public. To tailor decision making to a particular location and improve traffic monitoring and public safety, San Diego in 2014 decided to pilot a network of edge computing-enabled smart sensors on 49 streetlights in the city's downtown.

The sensors collect information on the number of pedestrians who use a certain road during the day, the number and types of cars that drive in that area, the speed and direction they are driving and whether bicycles use that road. The information is processed on the streetlight using edge computing. The bulk of the data from the sensors stays on the smart streetlight while metadata—data that describes the collected data—is transferred to a central cloud computing network for further analysis. With edge computing, the amount of data leaving the streetlight sensors is small enough to travel through a mobile network. Without edge computing, the city would need a physical information system connecting 3,200 streetlights so sensors could transmit the data to a central location without crashing the network.

The city did not initially have technical experts on staff to manage the edge computing streetlight project, and instead engaged contractors, said Erik Caldwell, the city's deputy chief operating officer for smart and sustainable communities. Since then, the city hired a data

scientist and software development expert who understands the technology and can partner with contractors to ensure success and communicate the technology's benefits to city employees. Caldwell said having technology experts on board for governments looking to use emerging technologies "is a must."

In one instance, engineers used data collected by the sensors to develop an app that helps individuals find real estate for their businesses based on, for instance, the number of pedestrians who walk in front of a potential storefront.¹⁷ Other uses of the data included developing apps to help identify drunk drivers or find parking, according to the city.¹⁸

The city's Performance and Analytics Department, which oversees the edge computing network, is now working with other departments across the city to connect the data from the streetlights to other existing data sources, Caldwell said. The city hopes to use the more comprehensive and accurate data to improve services and further solve public safety, economic and infrastructure challenges, as well as make certain aggregated data available to the public so private citizens can use it to develop applications that benefit the community.¹⁹

The city now plans to install 1,000 more connected edge devices on streetlights in addition to the existing 3,200, Caldwell said.

¹⁷ Robert Moss, "Building a Smart City? Start with Street Data," March 19, 2019. Retrieved from <https://bit.ly/32KSzmi>

¹⁸ City of San Diego, "City of San Diego Sparks Innovation with Digital Infrastructure." Retrieved from <https://bit.ly/38k7chx>

¹⁹ The City of San Diego, "Smart Streetlights Program." Retrieved from <https://bit.ly/2UF9N2i>

SUMMARY

The federal government is moving towards an "edge" mindset, away from amassing and analyzing data at central locations and instead pushing processing to the edge for stable, secure and prompt analysis. This mindset enables new technologies that depend on huge amounts of data to be processed quickly, such as 5G, the next generation of wireless communication, and the internet of things, a network of interrelated devices. Edge computing also is changing the nature of communications from a centralized to a decentralized system.

For the military, edge computing is shortening the time from data to decisions, so warfighters do not have to wait for

validation from central command or a distant server. With or without connectivity, an edge computing framework can power devices that are already in the field—wearables, vehicles, unmanned aerial systems or other operational platforms—to communicate across a network, and collect and analyze data for the moments that matter most to the mission. This technology can open up new possibilities for humanitarian assistance and disaster recovery as well.

Further, while many in the technology industry still consider "edge" to be computing and processing that occurs at the edge of the IT enterprise, a transformation is now underway, where edge computing can happen at the device itself and at the point of data collection.

Key Considerations for Implementation of Emerging Technologies

Agencies at the center of government are ready to provide support for the adoption of emerging technologies. The General Services Administration hosts a variety of communities of interest to share and spread best practices. There are communities focusing on artificial intelligence and augmented and virtual reality, among others. And the Office of Management and Budget is “going to supply money and support...to have people demonstrate these capabilities within the agencies and show the use cases and then try to promulgate that across the federal government,” according to October 2018 remarks by Margie Graves, then deputy federal chief information officer.²⁰

This section provides an overview of the key issues and best practices agencies should consider as they increase their rate of adoption of these emerging technologies.

CONSIDERATION 1

Agencies should assess whether technology is the right solution for their problem

Agencies should start by defining the problems they are facing and then determining whether technology can provide the right solution, said Alex Cohen, director of emerging technology at the GSA. Cohen said agencies also should assess how solving a problem will help achieve the mission so technology can be tied directly to an agency’s work. Avi Bender, director of the National Technical Information Service, echoed Cohen’s sentiment, saying, “before you can have a robust technical discussion, you have to know the why” behind the technology application.

In the Federal Emergency Management Agency example, the agency looked for technology solutions after it identified a need to better convey information to local officials about the risks of flooding. The agency chose virtual reality because it provides an immersive and behavioral nudge to users to better prepare for floods.

The Central Intelligence Agency has selectively used emerging technologies when it has been the most effective option. “We do not seek technology for technology’s sake. We assess mission needs and use technology to meet mission goals,” said Juliane Gallina, the CIA’s chief information officer.

Other agencies looking to assess whether technology offers the right solution might turn to the GSA’s Emerging Citizen Technology Office. This office was created to help

²⁰ Billy Mitchell, “OMB wants to support ‘first movers’ to emerging technologies,” May 9, 2018, FedScoop. Retrieved from <https://bit.ly/2OcuTfT>

federal adoption of emerging technologies, including artificial intelligence and augmented and virtual reality.²¹

Another set of reference material created by the American Council for Technology and Industry Advisory Council, a nonprofit educational organization established to improve government, includes a questionnaire for agencies to assess whether AI is best suited to address agency-related challenges. The guide includes 13 questions, such as, “Have other technologies successfully been applied to address elements of the use case?” and “Has sufficient data been identified for the use case?” Answering these and other questions gives a score based on the extent to which AI is applicable to the agency’s problem, and whether there will be potential operational improvements and a return on the investment.²²

CONSIDERATION 2

Agencies should build a digital foundation before adopting new technologies

Interviewees agreed that agencies must have certain resources—data, computing power and technical expertise—before they can successfully adopt emerging technologies. “Agencies need to have a digital foundation,” said Dean Souleles, chief technology advisor to the principal deputy director of national intelligence at the Office of the Director of National Intelligence.

Data

One must-have resource is data, which is perhaps more critical when using artificial intelligence tools than other technologies. “With AI, it’s all about the data. You have to be prepared that 80% or more of your time and treasure is going to be spent on getting the data right,” Souleles said. Efforts to prepare data involves gathering, organizing and reshaping data into a format useful for AI.

AI tools often learn how to perform a task by analyzing large sets of training data, sometimes requiring millions or billions of rows of information to operate. Each new piece of data or information can help make an AI system more adept at a task.

However, the research and development community is working to address the challenge of requiring massive amounts of data to train an algorithm, which is prohibitive for some organizations and processes. Additionally,

²¹ General Services Administration, “What is GSA’s Emerging Citizen Technology Office?” Retrieved from <https://bit.ly/2RYywNs>

²² ACT-IAC, “AI Playbook for the U.S. Federal Government,” Jan. 22, 2020, 14–16. Retrieved from <https://bit.ly/37Y9xfz> (PDF)

using computer-generated datasets for training AI algorithms is on the rise, while experts also have been creating AI tools that can function with only small amounts of data, perhaps even just dozens of rows of information.

Agencies must ensure that data intended for the purpose of training an AI system is properly identified in a way that is understandable to the machine. “Training data means data that has been curated by humans and properly tagged and labeled,” Souleles said.

For example, a potential Department of Agriculture AI system would have to be able to distinguish between farmland and other types of land to determine the boundaries of farms eligible for subsidies. To be effective, the AI system would have to discern the features of farmland by sifting through images that an employee previously labeled as either a “farmland” or “not farmland.” There are other considerations as well, such as making sure the data is unbiased and properly balanced. Data on farms only from California would be unrepresentative of farmland in other states and having a dataset that is 99% “not farmland” could lead to inaccurate results.

The Federal Data Strategy of 2020 action plan outlines steps for developing and cataloguing data standards, designing new data collection with future uses in mind, identifying barriers to sharing data between programs and agencies, and protecting data privacy. The data strategy points out that preparing data for artificial intelligence is one of the “emerging priority data governance areas” for OMB and other agencies.²³

Computing power

Information systems that provide the right amount of power to analyze large amounts of data must also be part of an agency’s digital foundation. On the high end of the spectrum, the Department of Energy’s Lawrence Livermore National Laboratory might use a cluster—or connected network—of high-performance computers to run between 100,000 and 100 million computer simulations per project to build a database of experiments that AI systems can analyze as part of its nuclear fusion research. To build those simulations without AI, a single computer might have to run for 100 million hours on full processing power, said Brian Spears, principal investigator at the national laboratory.

However, a national laboratory’s need for computing power likely dwarfs the requirements of other agencies. For example, the VA’s artificial intelligence tool for disability claims processing was built using a single laptop computer, which had enough computing power to process the five million cases required to train the tool

²³ Office of Management and Budget, “Federal Data Strategy 2020 Action Plan,” Dec. 2019. Retrieved from <https://bit.ly/2UFqjzH> (PDF)

within a few hours to discern different types of disability claims. And San Diego's edge computing system is able to handle the data collected on the streetlight smart devices with certain processed data then pushed to the city's cloud computing network so that it is accessible to city departments for further analysis.

One strategy that agencies could use to boost their computing power is moving to cloud computing—data storage and processing capability accessible to many users at once over the internet—from legacy information systems. In 2017, 112 agencies were using federally accredited cloud services, according to GSA,²⁴ but the extent of cloud computing adoption varies greatly among the agencies.²⁵

The cloud provides on-demand computing power and an ability to handle large amounts of data and information, according to the National Institute of Standards and Technology. "Cloud systems automatically control and optimize resource use," and agencies "can unilaterally provision computing capabilities" in the cloud, according to NIST.²⁶ These features could enable agencies to use emerging technologies.

Technical expertise

Technical expertise is crucial for agencies looking to deploy new technologies. Agencies need to "recruit people who are experts, but also have to train the existing workforce to deal with these rapidly advancing technologies," said Brian Spears, principal investigator at the Department of Energy's Lawrence Livermore National Laboratory.

Not all employees need to have detailed technical knowledge—those working most closely with edge computing, for example, are likely to need the most edge computing know-how. But because of the potential reach and widespread application of new technologies in agencies, the government should plan to increase the overall technical literacy of its entire workforce, from leadership to analysts.

Acquisition leadership should know whether it is better to buy a technology or build it in-house, how to contract for it, and how to interpret and apply the results the technology produces, said Erik Caldwell, deputy chief operating officer for smart and sustainable communities in San Diego.

"As we interject more technology into the day-to-day running of the business of government, it is something

²⁴ Frank Konkel, "How FedRAMP Keeps Getting Faster," July 12, 2017, NextGov. Retrieved from <https://bit.ly/2PGvIbx>

²⁵ Government Accountability Office, "Cloud Computing: Agencies Have Increased Usage and Realized Benefits, but Cost and Savings Data Need to Be Better Tracked," GAO-19-58, April 2019, 14. Retrieved from <https://bit.ly/32L61Xv>

²⁶ National Institute of Standards and Technology, "The NIST Definition of Cloud Computing," Sept. 2011, 2. Retrieved from <https://bit.ly/2SrIztl> (PDF)

that we need to think about more," Caldwell said. San Diego recently hired a data scientist with a strong software development background to manage the city's work with edge computing devices.

The Lawrence Livermore National Laboratory is one agency that has been building a technical talent pipeline. The laboratory and its Data Science Institute, established in 2018, has built a robust undergraduate and graduate summer internship program for about 150 students with a background in data science who are interested in advancing their skills in areas such as data science for artificial intelligence, Spears said. The agency hopes that once former interns graduate, they will consider the national laboratory as a potential employer. However, "it will be a few years before we see that pipeline really turn on," Spears said.

In the meantime, the national laboratory is building on its existing relationships with colleges and universities to attract talent. For example, the laboratory often sends its researchers and experts to give seminars and lectures to faculty and students around the country to get them interested and involved in working with or at the laboratory, Spears said.

And in 2018, the White House launched a Federal Cybersecurity Reskilling Academy to improve the cybersecurity skills of federal employees across government, with thousands of applicants applying for only a handful of slots for the first two rounds of training.²⁷ The government could expand the academy to include more classes relevant to working with technology, including AI or data-related skills, and enlarge the program to train more federal employees.

CONSIDERATION 3

To maximize employee buy-in, agencies should frame emerging technologies as tools to achieve the mission

Agency messaging should frame any new technology as a tool that will help employees achieve the mission by allowing them to do their jobs more effectively. Open and frequent communication is important during any organizational change, including when implementing emerging technologies.

Leadership will get buy-in from employees to implement new technologies if they "frame the technology in terms of what it will do, what is the benefit and value to the organization, to the mission, to the individual," said GSA's Cohen. "When you are doing innovation in

²⁷ Shannon Vavra, "Government cyber reskilling programs are just getting started, Federal CIO says," Sept. 18, 2019. Retrieved from <https://bit.ly/3arGfd8>

government, it is very important to communicate as much as possible.”

Previous research by the Partnership for Public Service found that connecting innovation efforts to the mission and strategic goals of an agency is a critical attribute of innovative government organizations.²⁸

For example, San Diego’s team overseeing its edge computing devices is working with multiple city departments to convey the benefits of the technology and explore further uses for the processed data. Communication is central to the city’s strategy to “bridge the gap” and “provide answers to particular problems or questions,” Caldwell said.

Additionally, when talking about emerging technologies, agency leaders need to address a two-headed problem, Souleles said. On the one hand, they should seek to dispel the uncertainty and doubt some employees might feel about the technologies that stem from concerns about workforce displacement. On the other hand, he said, leaders should not overpromise or overestimate what the technology is able to do.

“There is no magic AI dust that we spread on a problem and it solves it,” Souleles said.

The Government Accountability Office and National Academy of Medicine, reviewing the role AI could play in health care, both agreed about the need to provide a balanced picture about the new technologies generally and AI specifically. “As the communication on the potential wonders of AI pervades social consciousness, it is easy for misguided fears and optimism to obscure its legitimate near-term possibilities. Although AI is certainly limited in its capacity to match the problem-solving capacity of humans, AI-enabled automation is poised for disruptive workplace innovations,” according to the two organizations.²⁹

CONSIDERATION 4

Agencies should use existing flexibilities in the acquisition process to buy new technologies

Given the pace of technological change, emerging technologies do not lend themselves to large-scale years-long contracts, still the traditional way of buying goods and services in government. With emerging technologies, “We do not have a Manhattan Project, we do not have the luxury of locking up our best AI scientists in the desert behind our guards and our gates to work on developing a technology for years,” Souleles said.

Flexibilities in federal procurement regulations enable agencies to buy in a modern, agile way. For example, the GSA’s Schedule 70—existing long-term government-wide contracts with approved vendors and a simplified process for buying a variety of information technology services—offers off-the-shelf solutions for federal agency contact centers that include several AI tools, including chatbots, voice or speech recognition software and text-to-speech readers.³⁰

Contracting methods available to agencies include challenges, other transaction authorities and incentive-based contracts. Challenges are an acquisition method that allows government to test products and services before buying them. Agencies outline a problem they want challenge contestants to solve, and rather than contracting for a pre-determined solution, bidders propose products or services they think would be best suited to the challenge the agency is facing.³¹

Other transaction authorities are available to 11 agencies ranging from the departments of Health and Human Services and Homeland Security to the Federal Aviation Administration and NASA. These authorities generally allow agreements with commercial partners under rules and requirements that are tailored specifically to the contract, rather than blanket rules that apply to all government purchasing, for the most part.³²

New acquisition models can help industry deliver solutions more creatively, with greater efficiency and less

28 Partnership for Public Service and Slalom, “Risk and Reward: A Framework for Federal Innovation,” Nov. 2019, 7. Available at <https://bit.ly/2ScUMDA> (PDF)

29 Government Accountability Office and National Academy of Medicine, “Technology Assessment: Artificial Intelligence in Health Care,” GAO-20-215SP, Dec. 2019, iv. Retrieved from <https://bit.ly/2RUXzpk> (PDF)

30 General Services Administration, “IT Schedule 70: General Purpose Commercial Information Technology Equipment, Software, and Services.” Retrieved from <https://bit.ly/2GOOL9v>

31 Partnership for Public Service and Booz Allen Hamilton, “Innovation is a Contract Sport: Ways that agencies can achieve innovative outcomes through acquisitions,” Feb. 2016, 13. Available at <https://bit.ly/2OpsvqX> (PDF)

32 Government Accountability Office, “Federal Acquisitions: Use of ‘Other Transaction’ Agreements Limited and Mostly for Research and Development Activities,” GAO-16-209, Jan. 2016, 4–7. Retrieved from <https://bit.ly/2OEds5T> (PDF)

risk. Government and industry each have a role to play in ensuring that modernization is successful.

FEMA, for example, used an incentive-based contract to develop its virtual reality tool to help communities better mitigate floods, according to government's contracting database.³³ Incentive contracts encourage contractors to improve their performance and allow agencies to pay a fee for better performance beyond the base contract award, according to the Partnership and Booz Allen's previous research on innovative acquisition methods.³⁴ Incentive contracts are suitable for buying technologies since the incentive payment can be tied to the delivered technology's performance, according to Federal Acquisition Regulations.³⁵

Additionally, GSA offers agencies a new way to fund buying and implementing emerging technologies through the Technology Modernization Fund. Established in 2017, TMF finances modern technology projects that improve government information systems, including through emerging technologies. To secure funding, agencies submit a technology proposal to a board of government information technology experts in two steps—an initial high-level proposal and a detailed proposal, if the board approves the initial plan.³⁶

Buying new technologies also presents an opportunity for the private and public sectors to modernize acquisitions. In traditional acquisition models, the agency's future technology needs can be difficult to estimate at the time of solicitation. Government often needs to forecast what labor and talent will be required to deliver a technology solution; new models may enable agencies to acquire solutions more creatively, with greater efficiency and less risk. The most successful acquisition mechanisms deliver the right talent at the right times to achieve mission and modernization outcomes.

³³ General Services Administration, "Federal Procurement Data System." Retrieved from <https://bit.ly/2UHuueh>

³⁴ Partnership for Public Service and Booz Allen Hamilton, "Innovation is a Contract Sport: Ways that agencies can achieve innovative outcomes through acquisitions," Feb. 2016, 13. Available at <https://bit.ly/2OpsvqX> (PDF)

³⁵ "Federal Acquisition Regulation Subpart 16.4 - Incentive Contracts." Retrieved from <https://bit.ly/2tRqw7H>

³⁶ General Services Administration, "The Technology Modernization Fund." Retrieved from <https://bit.ly/2Up34cT>

CONSIDERATION 5

Agencies should ensure the security of emerging technologies while recognizing how the technologies could, in turn, boost cybersecurity

Emerging technologies, like any other technologies, are vulnerable to cyberattacks, with cyber risks amplified if agencies use them for mission-critical tasks, such as using virtual reality to train defense personnel for military operations or edge computing-enabled devices to test the safety of our food.

One way to secure information networks that connect several devices—such as those using edge computing—is zero trust security, according to the federal Chief Information Officers Council. A zero trust approach assumes "that the network is inherently hostile and that internal and external threats exist at all times, and therefore, all devices, users, and traffic must be continuously authenticated and authorized," according to the council. Agencies exploring the use of zero trust security include the Department of Defense and NASA.³⁷

Most security measures focus on protecting a network from the outside, but once a hacker finds an access point, they are free to move around the system and cause damage throughout. Zero trust security assumes that the security around the network's perimeter is already compromised and builds defenses around the different elements of the network. It also grants access to users only to the parts of the network they need for their jobs or completing a task, rather than allowing everyone to see and access every part of an information system.³⁸

At the same time, emerging technologies can help agencies boost their cybersecurity. They can predict potential threats, visualize cyber vulnerabilities, help respond to hacks, and offer new and immersive ways to train security experts. During the 2015 cyber breach, the Office of Personnel Management used a commercially available artificial intelligence tool to identify the hackers within OPM's information network and the data they were stealing. Elsewhere, DOD is now looking to use AI to boost its own cyber defenses. "AI can enhance our ability to predict, identify, and respond to cyber and physical threats from a range of sources," according to the department.³⁹

³⁷ Chief Information Officers Council, "White Paper: Networks of the Future," Dec. 2019, 10. Retrieved from <https://bit.ly/2OsNgCh> (PDF)

³⁸ Defense Innovation Board, "The Road to Zero Trust (Security)," July 9, 2019, 3. Retrieved from <https://bit.ly/2vI9Yj1> (PDF)

³⁹ Department of Defense, "Summary of the 2018 Department of Defense Artificial Intelligence Strategy," Feb. 2019, 6. Retrieved from <https://bit.ly/36WWHQB> (PDF)

Additionally, edge computing might boost cybersecurity by creating a decentralized network of devices in which attacking a single device lowers the risk of all data within the network being compromised. Isolating one device after an attack or to prevent a security breach does not hamper the rest of the system from operating. Each device might also be changed, replaced or upgraded without compromising the integrity of the entire network. Distributing data among devices through edge computing thus adds a necessary layer of security and privacy.

CONSIDERATION 6

Agencies should not assume emerging technologies are too difficult to implement

While agencies must have a digital foundation—data, computing power and technical expertise—to fully realize the potential of emerging technologies, they should not assume that gathering these resources and implementing the technologies will present challenges too difficult to overcome.

Charles Worthington, the Department of Veterans Affairs chief technology officer, said many people “think of emerging technologies as being extremely complex, but they do not necessarily have to be.”

“We are doing a disservice by making these things sound complicated or focusing on buzzwords instead of actual solutions,” Worthington said. For example, “many solutions branded as ‘artificial intelligence’ are at their core just statistical models applied to operations.”

Worthington said that two employees, a mathematician and a business analyst, spent only about two months on data analysis and statistical modeling to create the AI tool that is helping VA process disability benefit claims by assisting humans with one part of the claims process. “Technology projects do not need to be complex and time- and resource-consuming to be impactful,” he explained. “Success requires investing in people more than in big technology platforms.”

Other agencies looking to use emerging technologies have several resources at their disposal to make technology implementation easier. For one, GSA’s Emerging Citizen Technology Office offers guidance on technology issues surrounding “privacy, security, accessibility, transparency, accountability, and performance,” according to the agency.⁴⁰

Additionally, OMB and the Chief Information Officers Council created a resource library to help agencies modernize technology, including adopting emerging technologies. Resources on the site relevant to preventing and addressing potential issues concerning these technologies include federal data privacy best practices and information on the Federal Risk and Authorization Management Program, or FedRAMP, the government-wide standards for assessing cybersecurity. The site also offers project management guidance for managers leading technology projects.⁴¹

⁴⁰ General Services Administration, “What is GSA’s Emerging Citizen Technology Office?” Retrieved from <https://bit.ly/2RYywNs>

⁴¹ Chief Information Officers Council, “Resource Library: Publications, Playbooks, Guidance, and More.” Retrieved from <https://bit.ly/2H9jQ8d>

Conclusion

The federal government must continue to capitalize on the opportunity to use emerging technologies to address complex challenges to America's national and domestic security, its energy needs, public health and environment.

The government has a responsibility to explore and adopt emerging technologies that serve a useful function as well as oversee the safe and efficient use of these technologies in the private sector. Numerous agencies are expected to adopt emerging technologies and reap their benefits in the coming years, including artificial intelligence, immersive technologies and edge computing.

Artificial intelligence allows government agencies to speed up processes, analyze their data to make better decisions and provide services to the American public more effectively. Immersive technologies allow agencies to prepare employees and customers for challenging scenarios they might face. And edge computing allows agencies to process the growing amount of data necessary to operate in an interconnected world more quickly and securely, without crippling agency information networks.

Federal agencies need to be bold in their thinking and explore available opportunities for the use of these

technologies. The starting point must be a clearly defined problem statement and business case. Agencies need to build the necessary digital foundation, from data to computing power to technical expertise, and use existing flexibilities in the federal acquisitions process to purchase the technologies more easily. Government must also prepare to address employee concerns by communicating clearly and frequently about the benefits of new technologies.

To better coordinate its current emerging technology initiatives, the White House should consider placing them under the umbrella of the President's Management Agenda. This could encourage further adoption of the technologies government-wide and provide leadership support to agencies seeking ways to become more effective. By thoughtfully adopting new technologies, the federal government can better serve the public and safeguard the nation's safety, health and well-being. The technologies and examples in this report present an outline and offer ideas to help agencies meet this challenge.

Appendix I

Acknowledgments

The individuals listed below generously offered their input on how government could benefit from emerging technologies. We greatly appreciate their time and counsel. The contents of this report do not necessarily reflect the views of those with whom we engaged, and the views of participating federal, state and local officials do not necessarily reflect positions or policies of the federal, state and local governments or their agencies.

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